Wooing the Voters: Stochastic Dynamic Models for Political Regime Change and Economic Performance in a Democracy

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Abstract

When outcomes of developmental projects undertaken are uncertain, ruling parties in a democracy often face a difficult choice. Taking up projects that fail result in bad publicity and hence a dent in the vote bank. But on the other hand a successful project leads to more votes as well as more money in the funds. In the context of a two party model of democracy with neutrals and supporters, we set up a dynamic stochastic model to explore this situation. Using numerical methods, we show that the rate of failure of projects play a crucial role in changing the probability of a reelection. We also explore the role of other factors like rate of project arrival, party loyalty and changeover probability. The results indicate that in a strategic setting, in some situations, the ruling party would be better off by ensuring a low rate of project arrival to increase their chances of reelection. This has interesting implications for addressing the development vs. political stability conundrum.

Key words and phrases: Stochastic Dynamic Model, Political Regime, Campaigning, Uncertainty in Project Outcome, Loyalty, Election, Length of Tenure

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1 Introduction

In general, an improvement in political conditions will lead to faster and sustained growth. In this scenario of politically enhanced growth, the effects of political institutions on growth may persist over a long period of time (**Barro 1997**). For example, when a nation increases its level of economic freedom from a minimal to a maximal level as the result of political change, tremendous room will be created for long-run economic growth. The long-run growth rate of a country is determined also by politics, along with economic behavior and demographic trends.

There is indeed a school of thought that political markets are inherently inefficient and competition among the players causes excessive rent-seeking activity (**Tullock 1967, 1983, 1989; McCormick et al. 1984**). The existing literature, in the context of trade policy, also argues that competitive rent-seeking results in an efficiency loss to the economy (**Krueger 1974, Bhagwati 1982, Grossman and Helpman 1994**). **Laband and Sophocleus (1992)**, for instance, estimate that rent seeking in allocating transfers cost the US at least one-fourth of its GDP in 1985. Also growth of government debt is positively related to the frequency of government change **De Haan and Strum 1994**. **Persson and Svensson (1989)** have shown that a conservative government, which favors a low level of government spending but knows that it will probably be replaced by a government in favour of higher spending levels, will borrow more than when it was certain to stay in office. In this context see also **Alesina and Perotti 1996, Volkerink and De Haan 1999, Perotti and Kontopoulos 2002**. **Uppal (2009)**, examines the effect of legislative turnover on government expenditures in a panel of 15 Indian states during 1980-2000. He finds that political turnover promotes government expenditure (his results are ribust with respect to alternative specifications of per capita or as percentage of GDP). **De Haan and Strum 1994** have examined whether the number of government changes may help explain cross-country differences in public debt growth. It is very interesting that the frequency of government changes apparently does matter. This result is broadly in accordance with the conclusions of **Grilli, Masciandaro and Tabellini, (1991)**. **Jong-A-Pin and De Haan (2007)** finds that economic growth accelerations are preceded by economic reforms. Furthermore, they find that growth accelerations are more likely to happen after the start of a new political regime. The dataset used by them consists of 106 countries over the period 1957-1993 of which 57 countries experienced at least one growth acceleration. More specifically, the findings are that the effect of economic reform on the probability of a growth acceleration is highly significant in all specifications. However, the results for political regime changes are less clear. Political regime changes are in general not related to growth accelerations, but there is a negative and significant effect of regime duration for all specifications. This implies that growth accelerations are more likely to happen after the start of a new political regime. For a survey on the relationship between economic growth and political regimes see **Przeworski, Alvarez, Cheibub and Limongi (2000)**.

But there is also a counter literature, for instance in the development literature, that asserts the concept of antagonistic growth, which refers to a situation where democratic governments face the possibly untenable problem of resolving conflicting claims of vested interests while concurrently pursuing sustainable paths for growth (**Foxley, MacPherson and ODonnell 1986**). **Nordhaus (1975)** shows that an opportunistic incumbent, who has an informational advantage over the voters, follows a suboptimal policy right before elections to increase his or her chances of reelection, leading to political business cycles. **Besley and Burgess (2002)** argue that the resolution of informational disadvantage make the governments more accountable. They find that state governments in India respond better to natural calamities where the newspaper circulation, which mitigates the informational disadvantage of voters, is high.

Lyne (2008), in the context of democratic accountability and development in Brazil and Venezuela, argues that the project choices made by the governments in these countries were among the more economically inefficient alternatives available within an inward oriented program. But policies that are economically inefficient can be highly politically advantageous in a system where structural conditions favor the clientelistic equilibrium. If economically detrimental policies maximize the transformation of government power and resources into goods for quid pro quo exchange, then politicians competing in clientelistic systems will favor them over economically superior choices. Despite the unfavorable economic consequences, permanent subsidies, capital intensity and high and variable protection turn out to be the more competitive political choice when voters opt for quid pro quo. **Lahiri (2000)** argues competitive politics in India has damaged any chances of fiscal prudence by the states for the want of securing their vote bank.

Feng (2005) has done a very interesting study of the interplay between economic performance and political events with a simultaneous equations model with growth, government change and degree of democracy as endogenous variables. Using data from several south-east asian countries he shows that not only growth is stimulated by regime changes, in turn it also facilitates regime changes. The results found are robust with respect to specifications.

Noting the interplay between the political process and the economic process, we try to model the strategic role of elected policy makers in undertaking development projects whose outcomes are uncertain. The activities considered for the ruling party are deciding to undertake and executing development projects, whose outcomes are uncertain in nature. Thus the projects, if undertaken, can be both beneficial or detrimental to the popularity of the ruling party. Also, the budget available to the ruling party would be related to the decision of undertaking projects. A successful project adds to the populatiry of the elected government but a failed one will reduce their chances of being re-elected. Thus, the perceived or prevalent rate of success of development projects could play a key role in the government's decision to undertake such projects.

The process of a party coming to power in a democratic country depends on how the voters support them in the elections. Although the election is a discrete event taking place at pre-specified intervals of time, the whole process of alluring/increasing voters/supporters to a party (political campaigning process) goes on continuously between the elections. One usually also holds the party accountable for its deeds when in power (public works, development projects undertaken etc.) and votes accordingly. Or, at least that is the standard assumption.

Our aim is to study the voting process as a three population (X, Y, Z) model (for a two party system with support base X and Y), with third population (Z) being passive towards any party even though they cast votes during election (assumptions need be taken on their voting behaviour also). We would like to study how, in an election X or Y becomes the winner and how it depends on their deeds during the time interval between the two elections.

In this direction, understanding the dynamics of (X, Y, Z) under some suitable standard assumptions would be important. Further, we would like to investigate what happens if the standard assumptions are violated. We would develop relevant theoretical results and also simulate the dynamics to see the changing pattern at different times and in the long run.

Specific theoretical questions:

1. What are the significant events for causing government change: Investment in campaigning or new projects happening?

   What would be the dynamics under the influence of such events.

2. What are the conditions conducive to continuance (one party staying in power over repeated elections)? How to find $P(x_{t+s} > \frac{1}{2}|x_t > \frac{1}{2})$ (x_t being the share of X in the population)?

3. What are the conditions for transition?

4. What would be reliable estimates of transition probabilities and what would be the form of a long run distribution of the population in types X, Y and Z?

Section 2 describes our model with the alternative variations. The relevant theoretical discussions on results, both for passive and strategic behaviour, are presented in several subsections. The full Assembly model is discussed in section 3. In different subsections we discuss the modelling strategy, empirical results and strategic considerations. Section 4 mentions a few possible extensions to our basic model. These could be taken up in future work. Finally section 5 concludes.

2 The Two Party Model

2.1 Single Constituency (Local) Model

As mentioned above, the political parties engage in two kinds of activities. One of a developmental nature where the ruling party execute projects. These projects arrive randomly at a rate $\lambda > 0$ per unit of time. If taken up, it may result in a success or failure (with probability f). A successful project results in additional funds for the ruling party as well as positive publicity. Whereas a failed project creates negative publicity. Publicity (positive or negative) results in increased or reduced support. In case of positive outcome, neutral or opposing party supporters may join the ruling party (with some exogenously given probability p and $(1-p)$). In case of a failure the party supporters may leave the party and convert to neutral or opposing party supporters with same probabilities (p and $(1-p)$). The flow of events for this is depicted in the figure below.

The second activity that both parties engage in is political campaigning with available funds that helps in bringing opposition or neutrals to the party fold. The rate of conversion depends on the fund spent and an exogenous loyalty parameter (q). Apart from these two party based activities, there is also some switching over that happens autonomously through interaction between the three types of individuals in the population. The rates of conversion are also exogenously given.

[Please see Project tree diagram at the end]

First we start with *passive players* (non-strategic).

- Take time period $\Delta t = 1$ month, so there will be 60 periods between elections. First we study the probability of change at the first election, simulating 1000 times.
- Then we trace for 10 consecuive elections, 50 years (= 600 periods), simulating 1000 times. To calculate average tenure / number of government changes in the 50 year period.
- Look at comparative statics, for alternative choices of parameter values.

We start with a population distribution given by $\left\{ \begin{array}{ccc} X_0 & Y_0 & Z_0 \\ 40 & 35 & 25 \end{array} \right\}$

We explore the dynamics for the following choice of values of the parameters:

λ	:	0.1, 0.2, 0.3	rate of project arrival
f	:	0.5, 0.7, 0.9	probability of failure
p	:	0.2, 0.25, 0.3	probability of switching to Z due to project failure
q	:	0.7, 0.8, 0.9	probability to stay on (not switch due to campaign)

Here q is the loyalty parameter $\in (0, 1)$.

We may assume that either Z gets equally divided in time of voting or some random behaviour (e.g. β fraction vote for Y where $\beta \sim B(\lambda f + \frac{1}{2}, \frac{1}{2})$. So that $E(\beta) = \frac{\lambda f + \frac{1}{2}}{\lambda f + 1}$.)

Campaigning effects are modelled as follows:

For the ruling party, R_n : $\gamma_1(R_n)(1-q)\frac{Y_n}{N}$ (for $Y \to X$)
and $\gamma_0(R_n)\frac{Z_n}{N}$ (for $Z \to X$)

and for the Opposition, O_n : $\gamma_1(O_n)(1-q)\frac{X_n}{N}$ (for $X \to Y$)
and $\gamma_0(O_n)\frac{Z_n}{N}$ (for $Z \to Y$)

$$\gamma_1(x) = \frac{x}{2+x}$$
$$\gamma_0(x) = \frac{x}{1+x}$$

$R_n(0) = 1$ and $R_n(t+1) = R_n(t) + \lambda(1-f)$.
$O_n = 1$, constant over time.

The effect of interaction among the individuals in the population is given by the following parameters depicting the tendency to switch:

$$\begin{array}{ll} Y \to X & \beta_1 \\ X \to Y & \beta_1 \\ Y \to Z & \beta_- \\ X \to Z & \beta_- \\ Z \to Y & \beta_+ \\ Z \to X & \beta_+ \end{array}$$

The β parameters must be $o(\frac{1}{N})$ to keep the interaction effect in control. We choose the following values:

$$\begin{aligned} \beta_+ &= 0.3 \\ \beta_- &= 0.2 \\ \beta_1 &= 0.1 \end{aligned}$$

With the above, the transition probabilities in the simplified 3-dimensional model can be evaluated as follows (omitting time subscripts):

$$\begin{aligned} P(Y \to X) &= \gamma_1(R_n)(1-q)\tfrac{Y}{N} + \beta_1 \tfrac{XY}{N} + \lambda(1-f)(1-p)\tfrac{Y}{N} \\ P(Z \to X) &= \gamma_0(R_n)\tfrac{Z}{N} + \beta_+ \tfrac{XZ}{N} + \lambda(1-f)p\tfrac{Z}{N} \\ P(X \to Z) &= \beta_- \tfrac{X(Y+Z)}{N} + \lambda f p \tfrac{X}{N} \\ P(Y \to Z) &= \beta_- \tfrac{Y(X+Z)}{N} \\ P(X \to Y) &= \gamma_1(O_n)(1-q)\tfrac{X}{N} + \beta_1 \tfrac{XY}{N} + \lambda f(1-p)\tfrac{X}{N} \\ P(Z \to Y) &= \gamma_0(O_n)\tfrac{Z}{N} + \beta_+ \tfrac{YZ}{N} \\ P(\phi) &= 1 \text{ - all of the above} \end{aligned}$$

Hence, the change expectations are as follows:

$$\begin{aligned} E(\Delta X) &= -(\lambda f + \gamma_1(O_n)(1-q))\frac{X}{N} + (\gamma_1(R_n)(1-q) + \lambda(1-f)(1-p))\frac{Y}{N} \\ &\quad +(\gamma_0(R_n) + \lambda(1-f)p)\frac{Z}{N} - \beta_- \frac{XY}{N} + (\beta_+ - \beta_-)\frac{XZ}{N} \\ E(\Delta Y) &= (\lambda f(1-p) + \gamma_1(O_n)(1-q))\frac{X}{N} - (\gamma_1(R_n)(1-q) + \lambda(1-f)(1-p))\frac{Y}{N} \\ &\quad +\gamma_0(O_n)\frac{Z}{N} - \beta_- \frac{XY}{N} + (\beta_+ - \beta_-)\frac{YZ}{N} \\ E(\Delta Z) &= \lambda f p \frac{X}{N} - (\gamma_0(R_n) + \gamma_0(O_n) + \lambda(1-f)p)\frac{Z}{N} \\ &\quad +2\beta_- \frac{XY}{N} - (\beta_+ - \beta_-)\frac{XZ}{N} - (\beta_+ - \beta_-)\frac{YZ}{N} \end{aligned} \tag{1}$$

This is by construction closed, $E(\Delta X) + E(\Delta Y) + E(\Delta Z) = 0$.

The second moments can be calculated as follows:

$$\begin{aligned}
E(\Delta X)^2 &= (\lambda f + \gamma_1(O_n)(1-q))\frac{X}{N} + (\gamma_1(R_n)(1-q) + \lambda(1-f)(1-p))\frac{Y}{N} \\
&\quad + (\gamma_0(R_n) + \lambda(1-f)p)\frac{Z}{N} + (2\beta_1 + \beta_-)\frac{XY}{N} + (\beta_+ + \beta_-)\frac{XZ}{N} \\
E(\Delta Y)^2 &= (\lambda f(1-p) + \gamma_1(O_n)(1-q))\frac{X}{N} + (\gamma_1(R_n)(1-q) + \lambda(1-f)(1-p))\frac{Y}{N} \\
&\quad + \gamma_0(O_n)\frac{Z}{N} + (2\beta_1 + \beta_-)\frac{XY}{N} + (\beta_+ + \beta_-)\frac{YZ}{N} \\
E(\Delta Z)^2 &= \lambda f p\frac{X}{N} + (\gamma_0(R_n) + \gamma_0(O_n) + \lambda(1-f)p)\frac{Z}{N} + 2\beta_-\frac{XY}{N} \\
&\quad + (\beta_+ + \beta_-)\frac{XZ}{N} + (\beta_+ + \beta_-)\frac{YZ}{N} \\
E(\Delta X \Delta Y) &= -(\lambda f(1-p) + \gamma_1(O_n)(1-q))\frac{X}{N} + (\gamma_1(R_n)(1-q) + \lambda(1-f)(1-p))\frac{Y}{N} \\
&\quad - 2\beta_1\frac{XY}{N} \\
E(\Delta X \Delta Z) &= -(\gamma_0(R_n) + \lambda(1-f)p)\frac{Z}{N} - \lambda f p\frac{X}{N} - \beta_-\frac{XY}{N} - (\beta_+ + \beta_-)\frac{XZ}{N} \\
E(\Delta Y \Delta Z) &= -\gamma_0(O_n)\frac{Z}{N} - \beta_-\frac{XY}{N} - (\beta_+ + \beta_-)\frac{YZ}{N} \qquad (2)
\end{aligned}$$

2.2 Comparative Statics

We first study the probability of change P_c at the end of one five year period (= 1 unit of time).

Consider the following expressions (this will hold if $E(\Delta X) > 0$ to start with, otherwise not necessary):

1.
$$\frac{\partial E(\Delta X)}{\partial f} = -\lambda\frac{X}{N} - \lambda(1-p)\frac{Y}{N} - \lambda p\frac{Z}{N} < 0$$

and
$$\frac{\partial E(\Delta Y)}{\partial f} = \lambda(1-p)\frac{X}{N} + \lambda(1-p)\frac{Y}{N} > 0$$

Also,
$$\frac{\partial E(\Delta X)^2}{\partial f} = \lambda\frac{X}{N} - \lambda(1-p)\frac{Y}{N} - \lambda p\frac{Z}{N}$$

So, if $X > Z$ then $\frac{\partial E(\Delta X)^2}{\partial f} > 0$. Therefore, $\frac{\partial V(\Delta X)}{\partial f} > 0$ if $X > Z$. Implies $\frac{\partial P_c}{\partial f} > 0$.

2.
$$\frac{\partial E(\Delta X)}{\partial \lambda} = -f\frac{X}{N} + (1-f)(1-p)\frac{Y}{N} + (1-f)p\frac{Z}{N}$$

So $f \geq \frac{1}{2} \Rightarrow \frac{\partial E(\Delta X)}{\partial \lambda} < 0$.

$$\frac{\partial E(\Delta Y)}{\partial \lambda} = f(1-p)\frac{X}{N} - (1-f)(1-p)\frac{Y}{N}$$

Again, $f \geq \frac{1}{2} \Rightarrow \frac{\partial E(\Delta Y)}{\partial \lambda} > 0$.

Also
$$\frac{\partial E(\Delta X)^2}{\partial \lambda} = f\frac{X}{N} + (1-f)(1-p)\frac{Y}{N} + (1-f)p\frac{Z}{N} > 0$$

Therefore, $\frac{\partial V(\Delta X)}{\partial \lambda} > 0$ if $f \geq \frac{1}{2}$. Implies, if $f \geq \frac{1}{2}$, $\frac{\partial P_c}{\partial \lambda} > 0$.

3.
$$\frac{\partial E(\Delta X)}{\partial p} = -\lambda(1-f)\frac{Y}{N} + \lambda(1-f)\frac{Z}{N}$$

So, $Y < Z \Rightarrow \frac{\partial E(\Delta X)}{\partial p} > 0$.

$$\frac{\partial E(\Delta Y)}{\partial p} = -\lambda f\frac{X}{N} + \lambda(1-f)\frac{Y}{N}$$

Therefore, $f \geq \frac{1}{2} \Rightarrow \frac{\partial E(\Delta Y)}{\partial p} < 0$. So, $Y < Z, f \geq \frac{1}{2} \Rightarrow \frac{\partial P_c}{\partial \lambda} < 0$ likely.

4. No definitive answers for q

We next simulate $(\Delta X, \Delta Y)$ (in MATLAB) using N_2 (MVNRND command) with the above moments (scaled by 1 month $= dt = 1/60 = 0.0167$) and generate ΔZ using the relation $\Delta Z = -(\Delta X + \Delta Y)$. The main observations are as follows:

- If Z is bigger then P_c decreases for $f = 0.8$. For $f = 0.2$, no pattern, for $f = 0.5$, there is a mild decrease.
- For any distribution, $\frac{\partial P_c}{\partial q} > 0$.
- $\frac{\partial P_c}{\partial f} > 0$.
- For $f = 0.5$, $\frac{\partial P_c}{\partial \lambda}$ increases in q.
- For any λ, $\frac{\partial P_c}{\partial p} < 0$ (for a fixed q).

We next study the (deterministic) pattern of change over time in the first moment of (X, Y, Z) using a differential equation approach. To solve, we again use MATLAB (command: ODE45). The results are qualitatively consistent with the stochastic approach.

2.3 Active Players

Finally, one needs to look at the Strategic Choice of λ in this. Here, the budget allocation may be assumed to be identically distributed, and hence we may look at only one seat and solve the allocation problem.

Recall that $E(\Delta X) = -(\lambda f + \gamma_1(O_n)(1-q))\frac{X}{N} + (\gamma_1(R_n)(1-q) + \lambda(1-f)(1-p))\frac{Y}{N}$

Therefore,

$$\begin{aligned}\frac{\partial E}{\partial \lambda} &= -f\frac{X}{N} + \left\{(1-q)\gamma_1'(R_n)\frac{\partial R_n}{\partial \lambda} + (1-f)(1-p)\right\}\frac{Y}{N} \\ &= -f\frac{X}{N} + \{(1-q)\gamma_1'(R_n) + (1-p))\}(1-f)\frac{Y}{N} \qquad (3)\end{aligned}$$

if f is large (close to 1) then choice of λ would be close to 0.

3 Assembly Model

We now have multiple seats, shared between the two parties according to majority in each constituency. Again we study the **single elecion, tenure and comparative statics** for *passive parties.* To study the tenure pattern, we look at the pattern of government change over a 50 year period with the stochastic approach.

In order to study the dynamics our proposed model in a robust way, we have carried out simulation exercise with three variants of the model. One that considers the uncertainty in the event probabilities only (**model 1**), the second considering the fluctuation through variance only (**model 2**) and a final model (**model 3**) that considers both.

3.1 The Modelling Strategy

Here we have proposed three basic models each of which originated from a typical contagion type model used in epidemiology. Contagion type of model of spread is used to come up with the dynamic change of voter's opinion that happens in a small time interval, say Δt. We then go on to use three type of modeling procedure to come up with the final models.

Basic idea is in a small time Δt, when numbers of people in the three different group change, $(X_n, Y_n, Z_n) \rightarrow (X_{n+1}, Y_{n+1}, Z_{n+1})$, since it is a small time interval and the total population has been taken to be fixed (when growth of population is not considered), exactly one of the X, Y, Z decreases causing exactly one of the other to increase. This event has been assumed to occur with probability as in the contagion (disease) type model with some parameter p (probability of switching to Z due to project failure), q (probability to stay on (not switch due to campaign)), f (probability of failure) , λ (rate of project arrival) as mentioned in section 2.

Thus in the first model what we call 'param only' model we take these parameters to be random and follow a Bernouli distribution (independent and different for different parameters) indicating that the event occurs when Bernouli distribution takes the value 1, otherwise does not occur. This model affects model very sharply with small changes in the parameter. We compare this in the context of the other two models given below.

In the second model, what we call 'var only' model, parameters remains non-random. But we introduce the randomness through the contagion system as indicated in section 2 and an exogeneous random vector. We calculate conditional expectation of the change in the system, i.e., $E(\Delta R_n \mid R_n)$ and the conditional variances and covariances which are the elements of the conditional covariance matrix, $Cov(\Delta R_n \mid R_n)$, where $R_n = (X_n, Y_n)'$ and $\Delta R_n = (\Delta X_n, \Delta Y_n)'$ since, $Z_n = n - X_n - Y_n$. Construction of the model is as follows:

$$R_{n+1} = R_n + E(\Delta R_n \mid R_n)\Delta t + (Cov(\Delta R_n \mid R_n))^{1/2}\xi_{n+1}\sqrt{\Delta t}$$

where Δt is the time to the step from n to $n+1$ and ξ_{n+1}s are independent and identically distributed random vector with mean zero and covariance matrix as identity matrix (we took it as two dimensional Normal distribution for simulation but it is not necessary). Notice that, this is a typical diffusion approximation scheme (Ref. Basak, Hu and Wei, spa 1997) matching first two (conditional) moments of ΔR_n and that of a diffusion process with randomness introduced through ξ_{n+1}. Difference between this and the 'param only' model is that in the 'param only' model one has

$$R_{n+1} = R_n + E(\Delta R_n \mid R_n)\Delta t$$

and since the conditional expection, $E(\Delta R_n \mid R_n)$ is a function of p, q, f, λ, the randomness in the model is introduced through them. This model affects very sharply due to small changes in the parameter as it is only a first order approximation (only the mean matched) and the randomness is discrete. 'Var only' model is much smoother as it is a second order approximation and the randomness is continuous (although it is not necessary for the theory).

Third model is the mixture of both. In fact, we call it 'var both' model. In this case, as in the second model,

$$R_{n+1} = R_n + E(\Delta R_n \mid R_n)\Delta t + (Cov(\Delta R_n \mid R_n))^{1/2}\xi_{n+1}\sqrt{\Delta t}.$$

However, since the conditional expectation, $E(\Delta R_n \mid R_n)$, and the conditional variance, $Cov(\Delta R_n \mid R_n)$, both are function of the parameters, p, q, f, λ, which are taken to be random here, randomness is coming in the model from two sources. One through randomness of the parameter and the other through ξ_{n+1}. This model affects sharply with parameter change much more than the second model but less than the first, whereas, at the same time it is much smoother than the first model but a little less than the second.

3.2 Detailed Results of the Assembly Model

The simulation is carried out for three alternative values for each of the parameters (λ, f, p and q) to get an idea about the importance of change in each. The results are illustrated qualitatively in the following tables.

Table 1: Average P_c for different values of the parameters (in %age format)

Model 1			
p	0.2	0.25	0.3
avg. P_c	31.33	31.15	30.52
q	0.7	0.8	0.9
avg. P_c	28.07	31.81	33.11
λ	0.1	0.2	0.3
avg. P_c	29.63	31.11	32.26
f	0.5	0.7	0.9
avg. P_c	0	0	93
Model 2			
p	0.2	0.25	0.3
avg. P_c	24.74	22	22.22
q	0.7	0.8	0.9
avg. P_c	21.33	23.07	24.56
λ	0.1	0.2	0.3
avg. P_c	22.63	22.19	24.15
f	0.5	0.7	0.9
avg. P_c	12.7	21.48	34.78
Model 3			
p	0.2	0.25	0.3
avg. P_c	20.26	21.56	19.81
q	0.7	0.8	0.9
avg. P_c	18.41	20.11	23.11
λ	0.1	0.2	0.3
avg. P_c	20.22	18.89	22.52
f	0.5	0.7	0.9
avg. P_c	10.96	18.96	31.7

We first look at the change in average value of P_c with one variable of the model at a time. In all the three variants of the model P_c changes very little with p or λ. There is also no monotonic pattern. With changes in q, there does exist an increasing pattern but the rate of change is small. The parameter that has the strongest effect on the value of P_c is f which has a strong positive effect in all three variants. So, unconditionally, f is seen to have the maximum effect on rate of change. For model 1, it suddenly jumps to 93% from 0 when value of f becomes 0.9. In the other cases also the probability of change is around 10% when f is 0.5 and becomes more than 30% for $f = 0.9$.

Table 2: Conditional effect of the parameters on P_c
Results are presented in the order of the models (1,2,3)

	λ	f	p	q
$P_c\|f$	(+,+,+)			
$P_c\|q$	(+,0,+)			
$P_c\|\lambda$		(0,+,0)		
$P_c\|q$		(0,+,+)		
$P_c\|\lambda$			(+,0,0)	
$P_c\|f$			(+,+,+)	
$P_c\|q$			(0,0,+)	
$P_c\|f$				(+,+,+)
$P_c\|\lambda$				(+,0,0)

The corresponding detailed results are presented in the three dimensional plots in figures at the end of the paper.

As there might be cross effects in conjunction with other parameters, we investigate this by fixing the other parameters at each level and study the effect of each parameter on P_c. Conditioal on other parameters, the failure rate, f, has the maximum impact in the expected direction on the probability of change. With a rising f, P_c also rises. We find that if we fix f or q (loyalty) then conditionally λ has the expected positive effect also.

Coming to the switching parameter p, again conditional results are quite definitive, P_c rises in p for fixed level of λ, f or q. Finally, the loyalty parameter q has the same effect for any level of f and λ. Other conditioning values turn out to be non-monotonic.

As a conditioning factor, f has the maximum impact on the results as all the parameters λ, p and q raises P_c in all the three variants of the model for each fixed level of f. The second most important conditioning factor is q. The effect of λ, f and q on P_c, conditionally on p, is non-monotonic. This implies that switch parameter plays the role of a strategy shifter. The optimal behaviour of the political parties in terms of controlling the value of λ (project arrival rate) will be different for different levels of p.

Looking at the distribution of the length of tenure (see figure at the end of the paper) in all three variants of the model, it can be easily seen that the average length increases as we introduce more variation in the model (from model 1 to 2 to 3). This corroborates the finding in Table 1 that the rate of change is higher in model 1 than in model 2 and 3.

3.3 Strategic Players

We now move on to the **strategic part**, but now the choice of both λ as well as campaign budget allocation among different seats needs to be studied.

So the objective would be to $MaxE(\Delta X)$ etc. over λ and over simultaneous choice of $\{R_{ni}, O_{ni}\}$, i = seats and n = time.

We know that $\sum_{seats} R_{ni} = R_n = R_{n-1} + \lambda(1-f)$, so it depends on λ again. $\sum_{seats} O_{ni} = O_n = 1$.

So a stochastic optimal control problem to be formulated.

For budget allocation we have, $\frac{\partial E}{\partial R_{ni}} = \gamma_1'(R_{ni})(1-q)\frac{Y_i}{N_i} = \gamma_1'(R_{ni})(1-q)y_i$ (say). Therefore, the marginal condition will imply $\gamma_1'(R_{ni})(1-q)\frac{Y_i}{N_i} = \gamma_1'(R_{nj})(1-q)\frac{Y_j}{N_j} = \tau$ (say). Thus, $y_i > y_j \Rightarrow \gamma_1'(R_{ni}) < \gamma_1'(R_{nj}) \Rightarrow R_{ni} > R_{nj}$, as γ_1 is assumed to be increasing and concave.

Then, for choice of λ,

$$
\begin{aligned}
\sum_i \frac{\partial E(X_i)}{\partial \lambda} &= \sum_i \left[-fX_i + (1-f)y_i\left\{(1-q)\gamma_i'(R_{ni}) + (1-p)\right\}\right] \\
&= -f\sum_i x_i + (1-f)(1-q)\sum_i y_i\gamma_1'(R_{ni}) + (1-f)(1-p)\sum_i y_i \\
&= -f\sum_i x_i + (1-f)(1-p)\sum_i y_i + (1-f)K\tau \\
&= K\left[f\bar{x} + (1-f)(1-p)\bar{y} + (1-f)\tau\right] \qquad (4)
\end{aligned}
$$

If X is small in a particular seat and τ is large (i.e. q small, less loyalty), then ruling party may choose a large λ.

3.4 Empirical Issues

1. As we have assumed $dt = 0.0167 = 1$ month in calendar time, then one needs to carefully calibrate the population size also (1 lac or 1 million preferred) so that we can have $\lambda = 0.1$ / 0.2 / 0.3 realistically.

2. We would like to estimate the relevant parameters of the model for a given democracy and make estimates and forecasts (calibration exercise). So to estimate λ and f from actual data (MOU vs. project actually happening)

3. Also, comparing the estimates and forecasts for two democratic systems would be an interesting issue.

4 Possible Extensions

- We propose to generalize the model to accomodate a multi-party system.

- We started with the 3-dimensional model (X, Y, Z). One then needs to go on to the 5-dimensional model (X_m, X_s, Z, Y_s, Y_m), distinguishing between members and supporters.

- **Possible asymmetry in campaigning:** We can consider that the campaigning effects are asymmetric across consituencies. Then the budget allocation may also be asymmetric. To study the optimisation problem in this situation.

- **Asymmetric perception of failure rate:** Information does not reach all equally well. If perceived "fail" is low for some people, does it help longer tenures?
  Suggested solution: introduce a stochastic "f". Higher variance (more information asymmetry, feature of LDCs) ⇒ longer tenure?

- **Population growth:** If all groups grow equally, then no change in proportions and results unchanged.
  If Z grows faster than X or Y, then may assume Z has net growth, X & Y stationary. Also the reverse case. Results to be studied.
  X, Y grows at rate α_1 and Z grow at rate α_2. Then cases to be considered are
  (i) $\alpha_1 = \alpha_2$
  (ii) $\alpha_1 > \alpha_2$
  (iii) $\alpha_1 < \alpha_2$.

- **Episodic event:** War or Natural Calamity. Should have both short term and long term impact. May be modelled by "delay" equations.

5 Concluding Remarks

When outcomes of developmental projects undertaken are uncertain, ruling parties in a democracy often face a difficult choice. Taking up projects that fail result in bad publicity and hence a dent in the vote bank. But on the other hand a successful project leads to more votes as well as more money in the funds. In the context of a two party model of democracy with neutrals and supporters, we set up a dynamic stochastic model to explore this situation.

Using numerical methods, we show that the rate of failure of projects play a crucial role in changing the probability of a reelection. We also explore the role of other factors like rate of project arrival, party loyalty and changeover probability. We have studied the unconditional and conditional (fixing the value of other parameters at different levels) effect of all the parameters on the probability of change. The results throw up some interesting patterns on joint effects that are quite intriguing and calls for further research.

The results indicate that in a strategic setting, in some situations, the ruling party would be better off by ensuring a low rate of project arrival to increase their chances of reelection. This has interesting implications for addressing the development vs. political stability conundrum.

The model that we have considered here relies on three alternative formulations of the uncertainty inherent in the situation under study. The results are accordingly more or less sensitive to changes in the value of the parameters. A comparative study of this has also been made.

In the sequel we have pointed out some possible future directions of research in this area. there are many interesting alternatives to be explored both theoretically or numerically as well as empirically using available databases or primary data specifically collected for this purpose.

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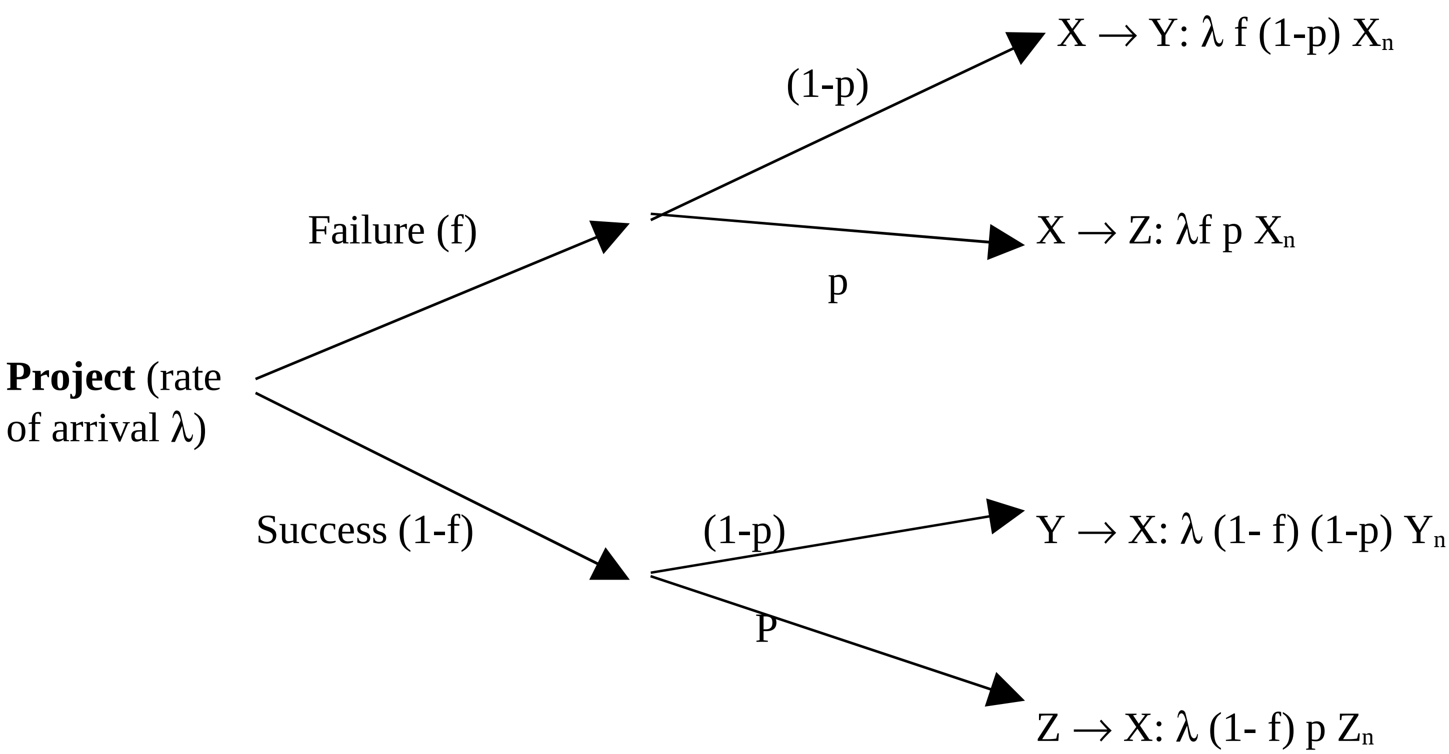
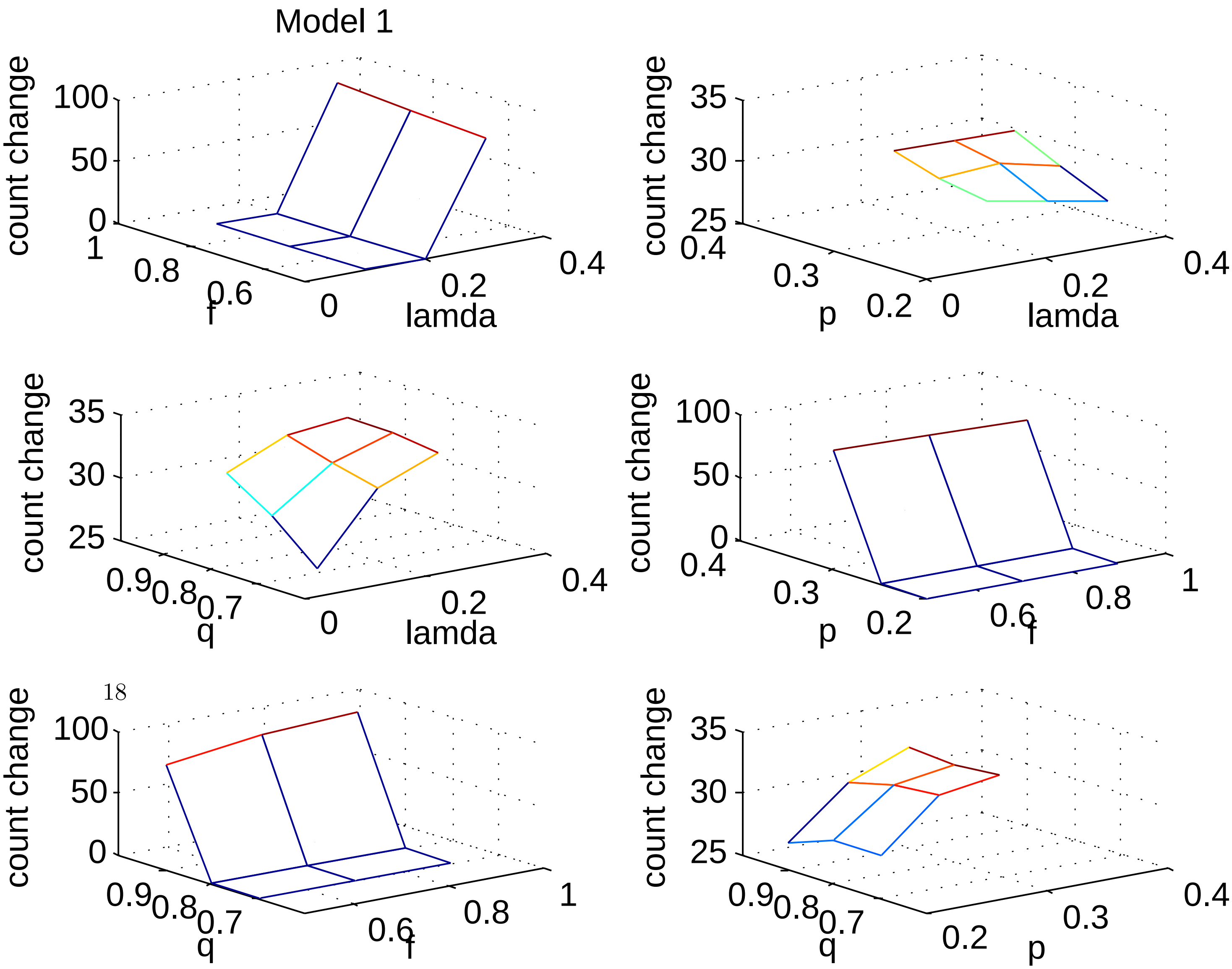
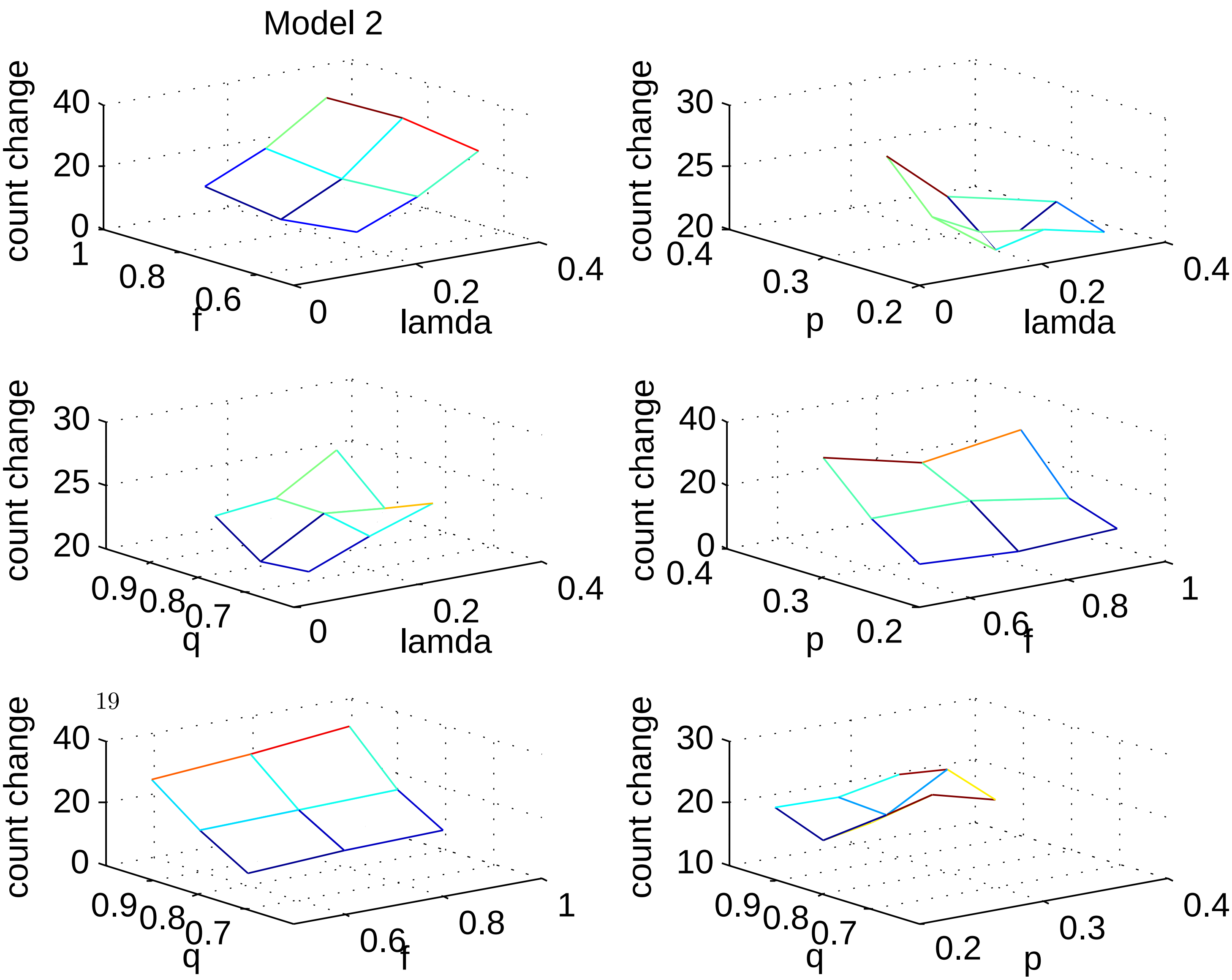
Project Tree Diagram



17


Model 1
count change
100
50
0
1
0.8
0.6
f
0
0.2
0.4
lamda
count change
35
30
25
0.4
0.3
p
0.2
0
0.2
0.4
lamda
count change
35
30
25
0.9
0.8
0.7
q
0
0.2
0.4
lamda
count change
100
50
0
0.4
0.3
p
0.2
0.6
0.8
1
f
count change
100
50
0
0.9
0.8
0.7
q
0.6
0.8
1
f
count change
35
30
25
0.9
0.8
0.7
q
0.2
0.3
0.4
p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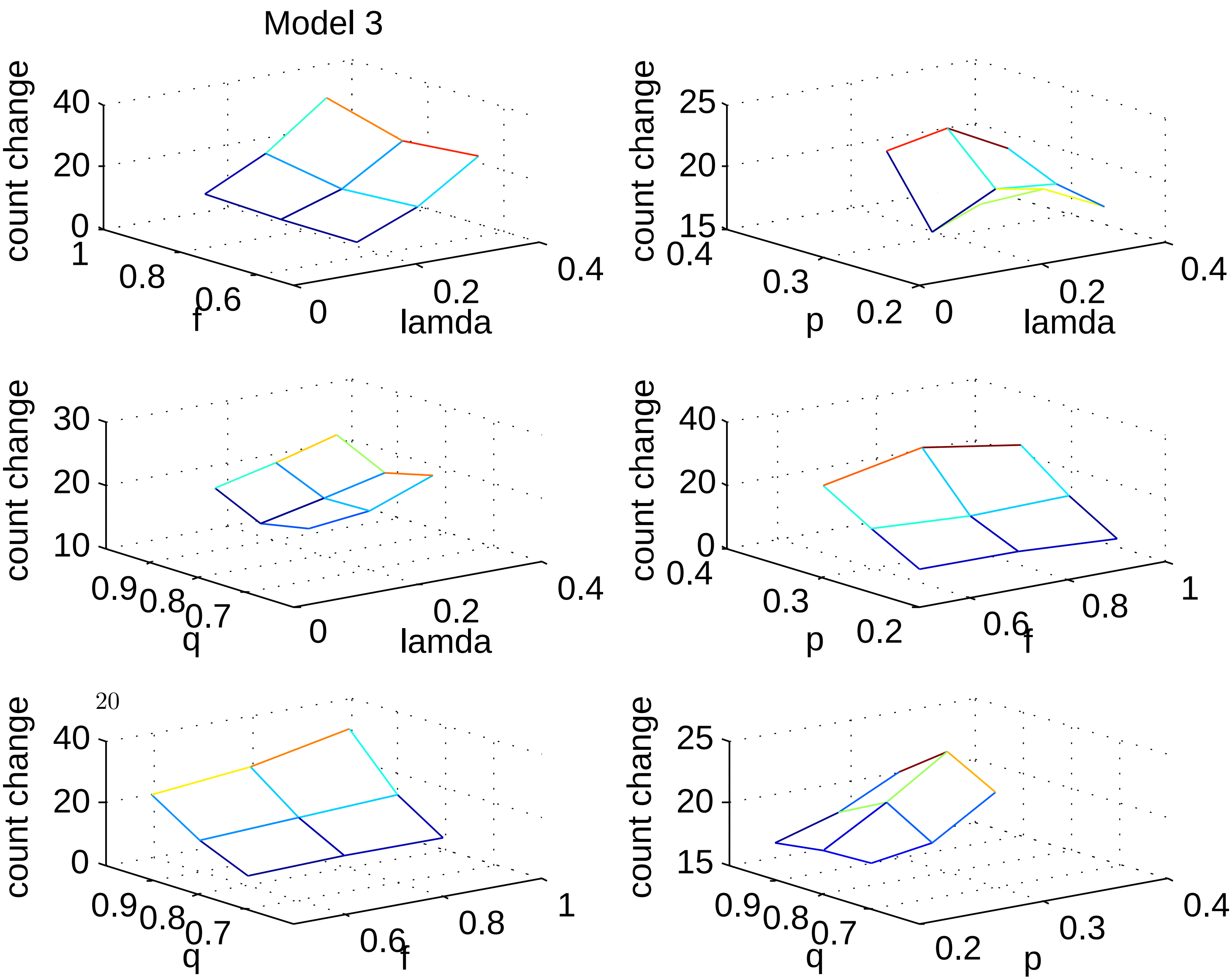
lamda
f
p
q
19


Model 3
count change
f
lamda
p
q
0.9
0.8
0.7
0.6
0.4
0.3
0.2
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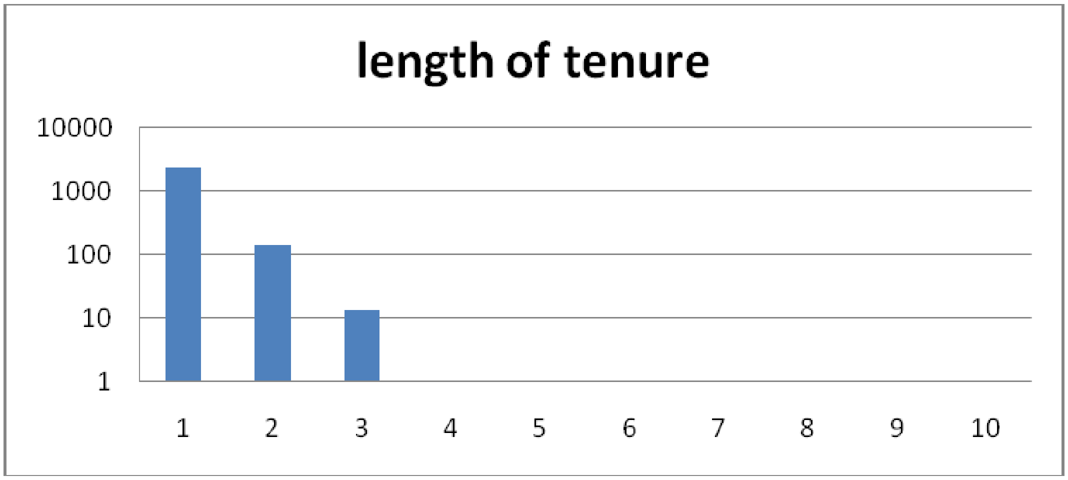
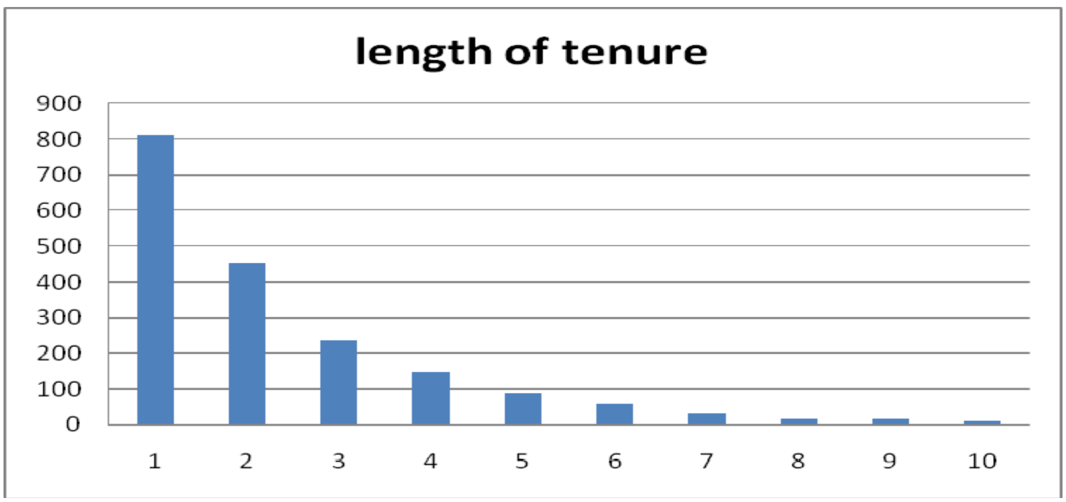
40
20
30
10
25
15

Model 1



Model 2



Model 3