Governmental Control and Organizational Effectiveness
------ A simulation study of nonprofit organizations in China
Methods and Initial Results
MACS 302
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Methodology Overview

The purpose of this research is to simulate the development of nonprofit organizations and the control of the Chinese governments on these organizations. This simulation study adapts the organizational equation model proposed by Zimm (2005). An insight of this model is to observe that the population P will converge to the population capacity K if certain assumptions of the discrete logistic equation is satisfied. The logistic equation can be written in the following way:

$$P_{i,k+1} - P_{i,k} = r_i P_{i,k}(1 - \frac{\sum_{i=1}^{n} P_{i,k}}{K})$$

where $P_{i,k}$ is the population of the i^{th} species at the k^{th} cycle, r_i is the reproduction rate for the i^{th} species, and K is the population capacity of the environment where the n group lives.

It is important to make the following assumptions to design a simulation model for organizations, some of which are derived from the classic logistic equation:

1. The **growth rate** of the i^{th} organization at the $(k+1)^{th}$ cycle $P_{i,k+1} - P_{i,k}$ is a function of the **success** of an organization. The **success** of the i^{th} organization at the $(k+1)^{th}$ cycle can be defined by the revenue the i^{th} organization makes in the current cycle. We define the revenue as income $I_{i,k}$ minus cost $C_{i,k}$.
2. Demand is fixed, so that **price** is a function of production in the current environment (**price** decreases with increasing number of products). The concept of **capacity** in the logistic equation will be achieved when $I_{i,k} = C_{i,k}$ for an organization in the environment.
3. Since we assume there are **more than** 1 organization in the current environment, the growth rates of the organizations are **dependent** on the total number of products in the environment.
4. For practical reasons, we assume the **reproduction rate** for all the organizations are the same.

The following two assumptions are important for us to develop the constructs of government control.

5. The government can intervene the environment by providing funding to organizations within the environment. This additional resource is independent of organization population in each cycle $P_{i,k}$. We denote it as $sup_{i,k}$.
6. The government can intervene the environment by imposing three kinds of penalties onto organizations. We denote the cost of this penalty as $pen_{i,k}$:

   i) A penalty that prohibits organizations from emerging. Denote it as $pn^a_{i,k}$, which is a constant.

(**Emerging penalty**)

ii) A penalty that prohibits organizations from growing. Denote it as $pen^b_{i,k}$, which is a coefficient of $P_{i,k}$. (**Growing penalty**)

iii) A penalty that prohibits organizations from getting enough resources to challenge the government. Denote it as $pen^c_{i,k}$, which is a coefficient of $P^2_{i,k}$. (**Threat-preventing penalty**)

Research Hypotheses

1. Continued government **support** (as a kind of control) will help the organization to overcome resource deficiencies at the birth of the organization.
2. **Emerging penalty** will prohibits a significant number of small organizations from survival.
3. **Growing penalty** will deter the growth of some organizations in the environment.
4. **Threat-preventing penalty** will prevent the appearances of many organizations with large population that can challenge the government.

Model Construction

From the assumptions in the previous section, we can develop the simulation model.

Note there are n organizations in the environment. Denote the index of organizations is i, the index of cycles is k.

By assumption (1):

$$P_{i,k+1} = P_{i,k} + (I_{i,k} - C_{i,k}) \cdot r_i$$

where $I_{i,k} - C_{i,k}$ is defined as the **success** of the i^{th} organization at the k^{th} cycle.

By assumption (2):

Let W_k be the number of products within the environment, by a linear Marshallian price-demand line (Zimm, 2005), we would have,

$$\text{Price}_k = b + cW_k$$

where b, c are constants. b, c are a deterministic and unchanged values during the cycles. It is not difficult to observe that $c < 0$.

By assumption (3):

Let $a^*_{i,k}$ be the production coefficient of an organization, and assume the base production rate is the same across organizations,

$$W_k = \sum_{i=1}^{k} a^*_{i,k} P_{i,k}$$

if we have k organizations in the environment. $a^*_{i,k} = a + \epsilon_{i,k}$, where $\epsilon \sim N(0, \frac{a^2}{9})$.

By assumption (4):

$$r_1 = r_2 = ... = r_n$$

By assumption (5), we would have the income of the i^{th} organization at the k^{th} cycle:

$$I_{i,k} = a^*_{i,k} P_{i,k}(b + cW_k) = a^*_{i,k} P_{i,k}(b + c \sum_{i=1}^{n} a^*_{i,k} P_{i,k})$$

By assumption (6), we would have the following situations,

$$C_{i,k} = pen^c_{i,k} P^2_{i,k} + (d + pen^b_{i,k}) P_{i,k} + pen^a_{i,k}$$

Finally comes the simulation model:

$$P_{i,k+1} = a^*_{i,k} c P_{i,k} \sum_{i=1}^{n} a^*_{i,k} P_{i,k} + (1 + a^*_{i,k} b - d - pen^b_{i,k}) P_{i,k} + (sup_{i,k} - pen^a_{i,k}) - pen^c_{i,k} P^2_{i,k}$$

Parameter Selection

It is important to choose reasonable parameters for the simulation model.
Observe that:

$$\text{Price}_k = b + cW_k > 0$$

we would have:

$$c > -\frac{b}{W_k} \sim -\frac{b}{aP_{max}}$$

Therefore, c would depend on the maximum choice of the value P. Since we are considering multiple groups in the environment, it is reasonable to set $P_{max} = 10000$. That makes:

$$c > -\frac{b}{10000a} \ (0.1)$$

For the value of d, the cost per population, it is just enough to get a reasonable estimate of d. $0 < d \leq ab$ (0.2), since the wage per worker should be smaller than the value they make at the start of the simulation.

Similarly, we would have a coarse range of possible values of the following variables:

$$0 \leq sup_{i,k} \leq \frac{P_{max}}{10} d \ (0.3)$$

$$0 \leq pen^a_{i,k} \leq \frac{P_{max}}{10} d \ (0.4)$$

$$0 \leq pen^b_{i,k} \leq d \ (0.5)$$

$$0 \leq pen^c_{i,k} < -c \ (0.6)$$

Now it comes to determine the value of our parameters. It is quite important to review the definitions of these parameters and connect them with the theoretical constructs.

Parameters	Value	Construct	Source & Reasons
a	1	Base value of production rate per population	Zimm (2005)
$a^*_{i,k}$	$1 + N(0, \frac{a^2}{9})$	Real production rate per population	Randomization
b	3	Initial price at the start of simulation	Zimm (2005)
c	-0.0003	the slope of price against number of products	deduced from formula (0.1)
d	1	Wage per population	Zimm (2005) and formula (0.2)
$sup_{i,k}$	0	Funding from government in k^{th} cycle	formula (0.3)
$pen^a_{i,k}$	0	1^{st} governmental penalty in k^{th} cycle	formula (0.4)
$pen^b_{i,k}$	0	2^{nd} governmental penalty in k^{th} cycle	formula (0.5)
$pen^c_{i,k}$	0	3^{rd} governmental penalty in k^{th} cycle	formula (0.6)
r	1	Reproduction rate for organizations	Zimm (2005)

Data Collection and Model Validation

The validation dataset is generated from my interviews scripts and qualitative data from my field research from $2014-2016$ in Shanghai, China. The validation set consists of detailed development history of 12 nonprofits that have been operated for various length of time. During the two-year time, the researcher discuss with the organizations' management team about the difficulties of developing the organization, with an emphasis on how governmental behavior has an impact on the success and failure of organizational activities. One thing to note is that the values generated from this dataset are fuzzy scores intended to establish the differences between the observations rather than providing an accurate estimation of orgainizational behavior for the organizations. Ragin (1987) has contributed to advanced techniques to analyze these fuzzy variables.

There are also things to note that the simulation model derived by Zimm (2005) and this paper is a theoretical model and is used to examine theoretical hypotheses rather than generating predictions. Nonetheless, the four parameters $sup_{i,k}$, $pen^a_{i,k}$, $pen^b_{i,k}$, $pen^c_{i,k}$ will be calibrated based on the qualitative data to generate coarse predictions of the development of nonprofits in China. These parameters will be determined by various factors but mainly official documents. The calibration is possible because the governments tend to have different attitudes towards nonprofits in different times.

Theoretical Simulation Results

In this part I am going to simulate the organizational effectiveness based on the simulation model we have deduced. It is important to make assumptions about the organizations in the environment before we proceed. Some of these have already be discussed in previous sections.

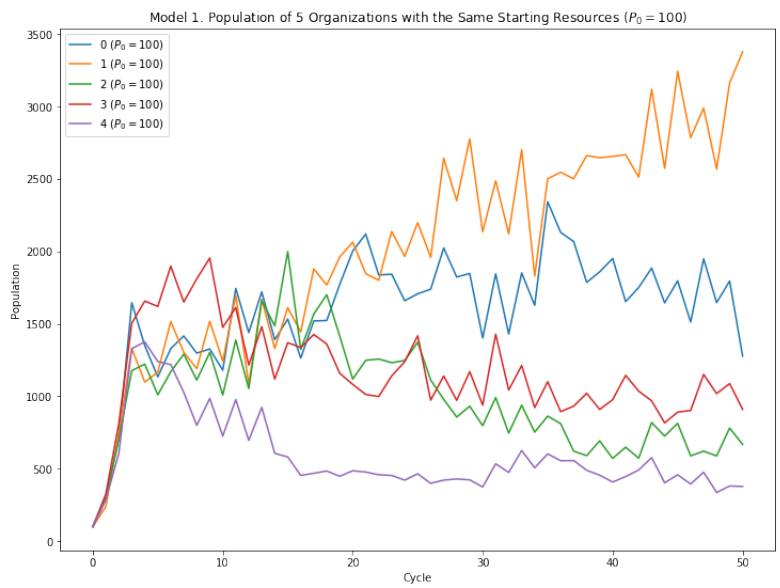
1) Suppose there are 5 organizations in the environment.

2) Suppose the maximum population capacity $P_{max} = 10000$. All organizations have the same reproduction rate $r = 1$.
3) Suppose there the base production rate a and the cost per population is the same across organizations, but the real production rate a^* is a random variable that is normally distributed.
4) Suppose the simulation process go through 50 cycles.
5) If an organization reaches a population of 0, then we define it as **dead.** Dead organizations will no longer make productions.

Effects of the Parameters

In this part I am going to present and discuss the effects of some of the parameters in the simulation model. It is important to check if the parameters fulfill their purposes and if there are things unexpected generated by the model. Based on our research hypotheses, the effects of government support and three kinds of penalty are tested.

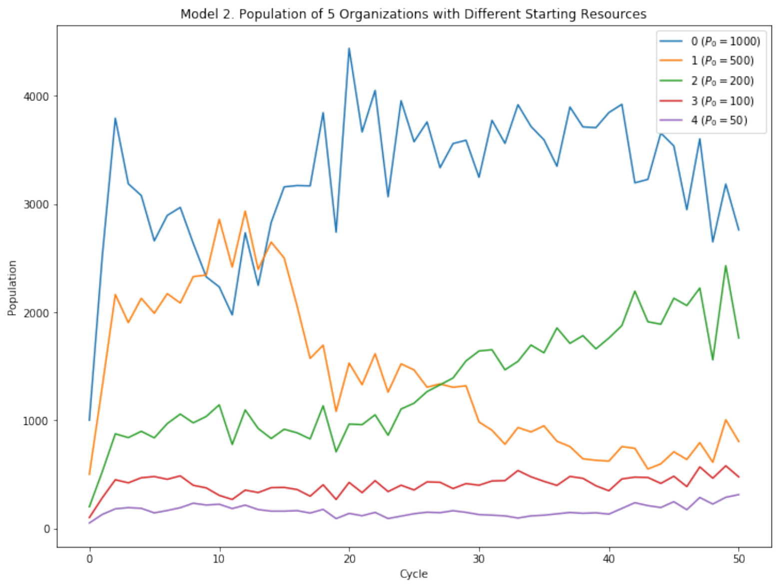
Model 1: Organizations with the same initial resources $P_{i,0} = 10$. (Fair Game)
Hypothesis 1: With same starting resources and no interventions, the success of each organization is completely due to chance.



Observation 1: The simulation results confirmed our hypothesis. Besides, it shows that the growth rate of each organization in the first 5 cycles is quite similar. This indicates that randomized production rates has limited impact on the growth of organizations when there are sufficient resources in the environment in the current cycle.

Model 2: Organizations with different initial resources $P_{1,0} \neq P_{2,0} \neq P_{3,0} \neq P_{4,0} \neq P_{5,0}$. (Unfair Game)

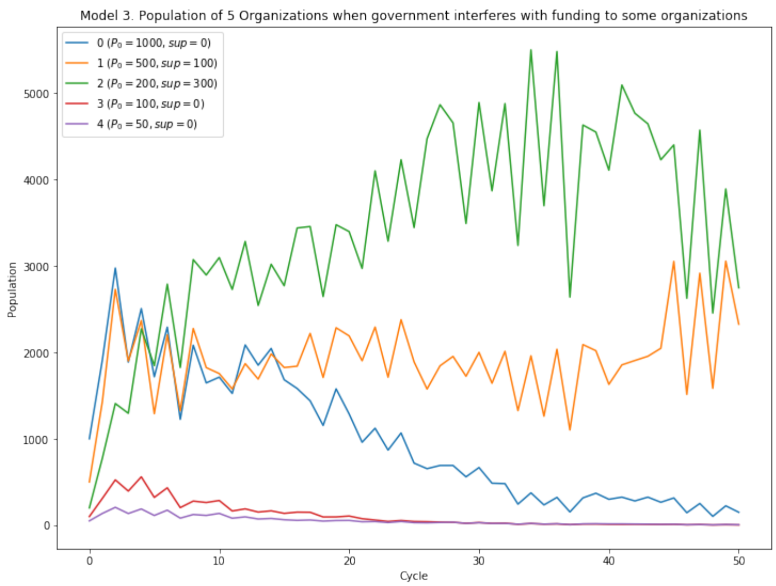
Hypothesis 2: Organizations with more initial resources are likely to succeed in the environment after the equilibrium is reached, since the greater starting population, the greater rates of growth.



Observation 2: Our hypothesis is confirmed. It is clear to observe the population growth rates for different organizations are very different in the first 5 cycles, and the population starts to fluctuate once the total population reaches the capacity K. Organizations will more initial resources is likely to dominate the current environment in terms of population. However, randomization also makes it possible that some organizations with less initial resources may performace better than those will more initial resources after the total population is near the capacity K. (In model 2, equilibrium is reached at the 5^{th} cycle, and group 3 surpasses group 2 at around the 28^{th} cycle).

Model 3: Organizations with different initial resources and some organizations receive support from the government each cycle.

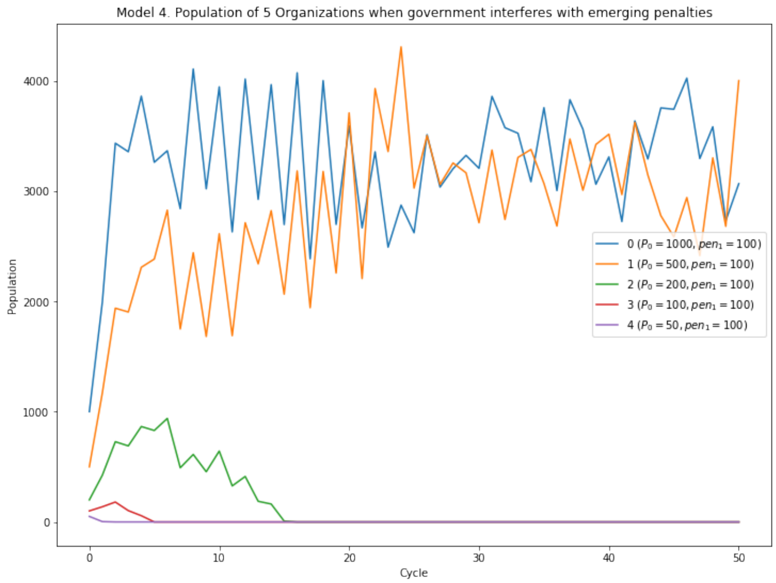
Hypothesis 3: Organizations with continued support from the government will have an advantage in population growth, despite initial resource weakness.



Observation 3: It is quick impressive to see that continued government support has helped some organizations to overcome initial resource deficiencies. The two organizations with governmental funding is able to surpass the organization with the most initial resources at the 15^{th} cycle.

Model 4: Organizations with different initial resources and emerging penalty is enforced.

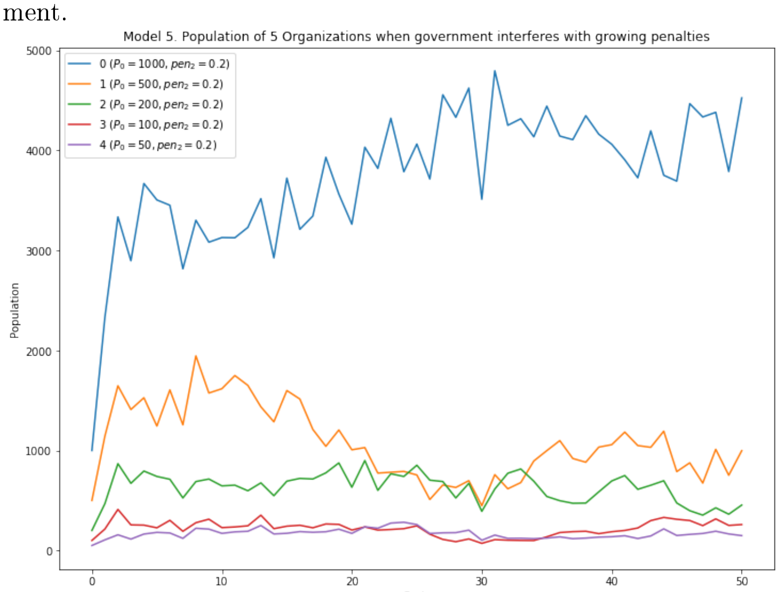
Hypothesis 4: Emerging penalty will keep organizations with small initial resources from survival but will not affect organizations with enough initial resources.



Observation 4: Our hypothesis is confirmed.

Model 5: Organizations with different initial resources and growing penalty is enforced.

Hypothesis 5: Growing penalty will decrease the growing rates of organizations in the environment.

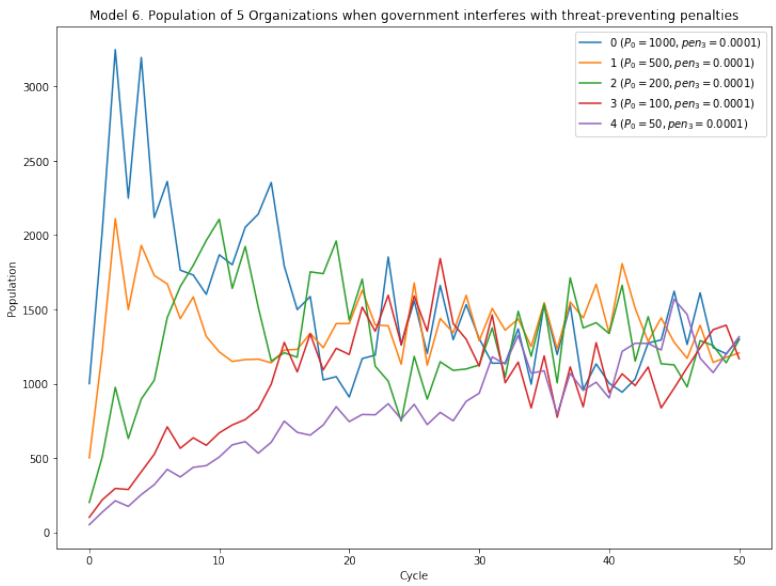


Observation 5: Growing penalty has a limited impact on big organizations but a significant im-

pact on small organizations. In other words, the effects of initial difficiencies are enlarged since the overall growth rate (in the environment) has been decreased.

Model 6: Organizations with different initial resources and threat-preventing penalty is enforced.

Hypothesis 6: Threat-preventing penalty will decrease the growth rate of large organizations and thus control the organizational sizes of all organizations in the environment.



Observation 6: The hypothesis is confirmed. Notice that the population of each organization starts to converge starting from the 10^{th} cycle, and even the organization with the least starting resources is able to catch up with other organizations after the 30^{th} cycle.

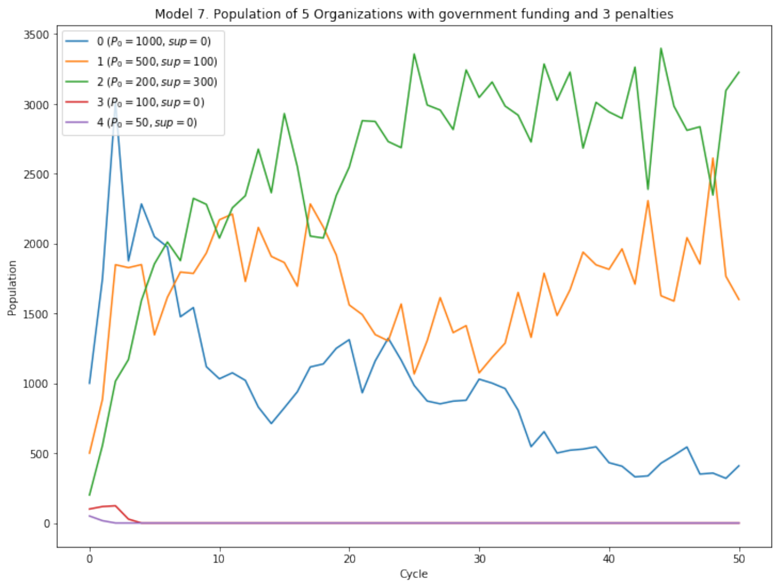
Initial Results Summary:

Now we are able to make a formal version of our model. The funding and penalties from the government has multiple effects on the growth of organizations in the environment.

Parameters	Government Purpose	Examples
$sup_{i,k}$	Help small organizations overcome resource scarcity	Incubation projects
$pen^a_{i,k}$	Eliminate small (grassroots) organizations	Set bars for registration
$pen^b_{i,k}$	Stabilize relative organization population	Operation Fees
$pen^c_{i,k}$	Prevent large organizations	Governmental Intervention

Combine the models proposed above and construct our initial model (suppose there are 5 organizations in our model).

$sup_{i,k} = [0, 100, 300, 0, 0]$
$pen^a_{i,k} = [100, 100, 100, 100, 100]$
$pen^b_{i,k} = [0.2, 0.2, 0.2, 0.2, 0.2]$
$pen^c_{i,k} = [0.0001, 0.0001, 0.0001, 0.0001, 0.0001]$
The simulation model shows the following result:



Organizations with governmental support will likely to succeed in the environment where all the three penalties are enforced, while organizations without government support, even if they have the most initial resources, will likely to fail in the long run. This embodies the idea that the Chinese government has strong control over the nonprofits and all organizations without strong connections to the government are likely to fail.

Next Step

The next step of our simulation model is calibrate the coefficients of three penalties based on the official documents, regulations, and researcher's qualitative data (The penalties are global). The support from the government is also calibrated based on the interview scripts researchers collected while discussing with the management team. A final product will be a simulation model that is filled with dynamic coefficient of penalties and support across different time era. The final model will be used to show the impact of Chinese's governments restrictive policies on the growth of non-profits in China.

References:

Ragin, C. (1987). *The comparative method: Moving beyond qualitative and quantitative methods.*

Berkeley: University of California.

Zimm, A. D. (2005). Derivation of a logistic equation for organizations, and its expansion into a competitive organizations simulation. *Computational & Mathematical Organization Theory, 11*(1), 37-57.