

博士論文

Essays on Application of Game Theory

(ゲーム理論の応用に関する諸論文)

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Abstract

This dissertation consists of three chapters on application of game theory. They all concern strategic decisions and competitions among players under settings of parameters that reflect different scenarios in the real world. Each chapter considers a combination of economic, social, or political factors that influence decision-making and outcomes. Moreover, in all three chapters, theoretical models are developed to explain real-world phenomena or historical events. Each chapter discusses the concept of optimal or efficient strategies and decision-making based on the specific context and circumstances. Chapter 1 takes location selection perspective to examine optional location decision-making strategies for chains. Chapters 2 and 3 take historical and cross-cultural perspectives, examining cases in Qing China, Tokugawa Japan, etc., to explore the role of government and institutions in shaping outcomes, whether it is legal rights in Chapter 2 or decentralization under an authoritarian regime in Chapter 3. These chapters draw on data and historical evidence to support and illustrate their theoretical findings, and highlight how respective players' strength, policies, and actions impact the behavior of various actors within the systems being studied.

The first chapter, *A Location Selection Model in Discount Store and Fast-food Industry*, studies location selection in discount store chains and fast-food chains. The paper innovates from previous models by introducing the setting where one customer purchases for multiple times, and the setting where one firm controls multiple nodes in the network game. Specifically, it studies why discount store chains tend to gather in certain locations, while fast-food chains tend to disperse across a city, building restaurants not close to each other. The paper finds that the key variable that determines this different distribution pattern is ϵ , which is the ability that discount store chains and fast-food chains have in terms of continuing attracting customers. Specifically, the paper shows that it is optimal for discount store chains, which have strong ability in continuing attracting customers, to build stores next to each other, while it is optimal for fast-food chains, which have weak ability in continuing attracting customers, to avoid building stores next to each other. Moreover, the paper finds that for a chain with much weaker ability to continue attracting customers than its competitor, it is optimal for this chain to avoid building stores close to each other. The paper also brings the theoretical result to real-world application by examining real-world distribution and proposes a location selection framework, where the paper finds that if both firms prefer connected stores, the equilibrium would be a monopoly equilibrium, while if at least one firm prefers unconnected stores, the equilibrium would be a segregated equilibrium.

The second chapter, *Weak Central Government, Strong Legal Rights*, is coauthored with Rui Wang and Matthew Noellert. The paper examines the formation of legal institutions in Qing China and Tokugawa Japan with a focus on rice market and develops a model that studies legal rights formation. Specifically, the paper develops a subversive regime game model to explain legal rights formation that led to the divergence of development in Qing China and Edo Japan's rice market. The model illustrates that a state enforces legal rights when the capacity of noncooperation or rebellion to subvert the current regime in the foreseeable future is high, and the provision of legal protection mitigates the risk of losing power. Conversely, when the subversive capacity of conflict or rebellion is low and the state can suppress such conflict or rebellion at a lower cost, the state has incentive to protect rice market participants' rights. The equilibrium result shows that stronger and more powerful central governments like Qing China find it optimal to not offer legal protections, while weaker and less powerful central governments like Edo Japan can find it optimal to offer legal protections. The paper's analysis also suggests that a state's

strength matters the most in determining its attitude toward legal rights, which further influences the state's stability and longevity. The model contributes to understanding the motives for the Chinese and Japanese governments in establishing different legal institutions for rice markets and explains the impacts of different institutions on merchant behaviors, as well as the decline of Chinese rice markets and the boom of Japanese rice markets in the eighteenth century. Furthermore, it contributes to explaining legal rights formation across the world in history.

The third chapter, *The Price of Survival*, is coauthored with Rui Wang. The paper develops a signaling game model to analyze decentralization under an authoritarian regime. The model finds that: (1) Authoritarian states would not voluntarily decentralize, and decentralization takes place given strong external shocks that challenge ruling; (2) local governors who receive power from decentralization tend to become disobedient to the central government, and this easily causes civil war or even collapse of an empire; and (3) offering decentralization shows an authoritarian state's weakness so that local governments would start to not obey the central government's ruler. Thus, it was often the case that authoritarian states chose to not offer decentralization in spite of knowing its necessity. The paper assesses the theory using historical evidence from late nineteenth century China around the time of a political shift from centralization to decentralization and finds that domestic wars (Taiping Rebellion) played an important role in shaping late Qing China's decentralization. The model's implications also contribute to the discussion of the Qing empire's military failures in interstate competitions after mid-19th century as well as the self-strengthening movement in late Qing China. Furthermore, the model is applied to other authoritarian regimes such as Ming China, where the paper finds that the pattern of their decentralization follows the model precisely.

In conclusion, this dissertation explores strategic decision-making and competitions among players through the lens of game theory, offering insights into economic, social, and political factors that influence real-world scenarios. The three chapters delve into diverse perspectives, from location selection strategies in the discount store and fast-food chains to the role of government and institutions in legal rights formation (as demonstrated in Qing China and Tokugawa Japan) and the dynamics of decentralization under authoritarian regimes. The theoretical models developed in each chapter provide a framework for understanding optimal strategies and decision-making in specific contexts, backed by data and historical evidence. By examining chains' location preferences, legal rights in historical markets, and the implications of decentralization, this dissertation contributes to both the theoretical advancement of game theory and its practical application in interpreting and explaining real-world phenomena and historical events. Future research could extend the location selection choices, allowing more Hotelling-like dynamics for Chapter 1, and carrying empirical studies and calibrations for Chapter 2 and 3.

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Chapter 1

1. A Location Selection Model in Discount Store and Fast-food Industry

- A Location Selection Model Where One Player Controls Multiple Nodes

1.1 Introduction

This paper aims to answer the following research question: Why do large discount store chains, such as Walmart and Target, tend to concentrate in different locations from their rivals, while large fast-food chains, such as McDonald's and Burger King, tend to avoid their stores concentrated.

Figure 1 below shows the distribution of Target and Walmart, two chain discount stores rivaling each other, in Los Angeles. As we can see in the picture above, Target heavily concentrates on the northern part of the city, while Walmart heavily concentrates on the southeastern part of the city. We can find that not only the two brands are away from each other, but also shops of the same brand are very close to each other. Graff (1998), for example, shows that Walmart distributes around modest-sized communities far from competitors.

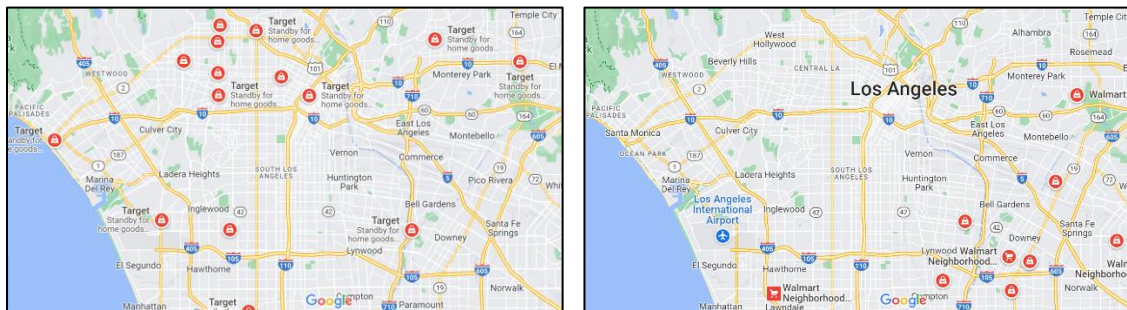


Figure 1 Distribution of Target and Walmart in Los Angeles

Such kind of distribution does not only show up in the United States. In Japan, similar situation exists. Ito Yokado and Don Quijote are two discount stores rivaling each other in Tokyo. As we can see in Figure 2 below, Ito Yokado stores largely distribute in the outskirts of Tokyo city, while Don Quijote stores heavily concentrate in the center of the city.

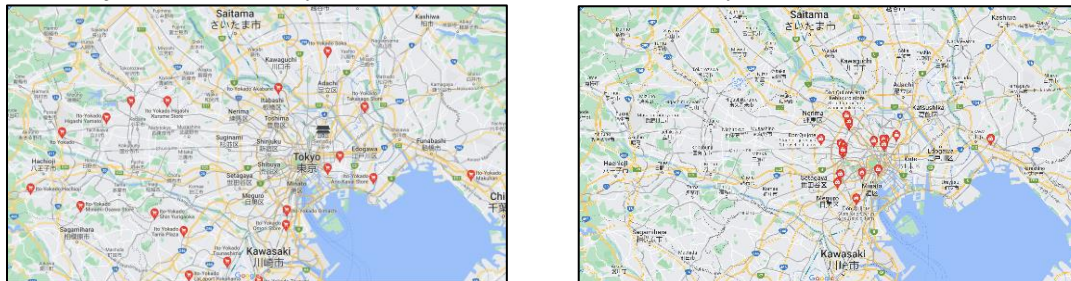


Figure 2 Distribution of Ito Yokado and Don Quijote in Tokyo

Similar to Target and Walmart, we can find that although the two brands are distributed far from each other, shops from the same brands are often very close to each other. Ito Yokado has 4 shops in Hachioji, while Don Quijote has as many as 5 shops near Shinjuku station.

The distribution of large fast-food chains, however, shows a different format. Figure 3 shows the distribution of McDonald's and Burger King in Los Angeles, where we can see that the two competitors have shops next to their rivals and have shops that disperse across the city. Niti (2007), for example, shows that McDonald's restaurants tend to avoid clustering, and often locate next to Burger King with QSR.

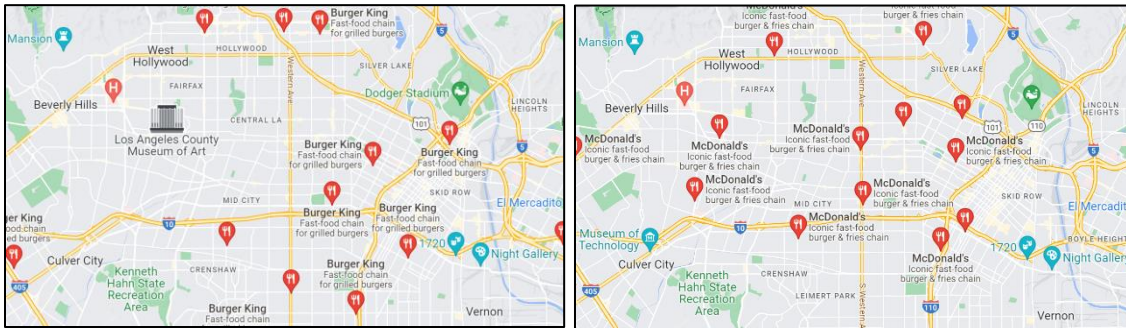


Figure 3 Distribution of Burger King and McDonald's in Los Angeles

Similar situation exists in Japan. Figure 4 shows the distribution of Matsuya and Sukiya, two beef bowls (GyuDon in Japanese), in Tokyo. We can see that the two brands' shops overlap with each other and are distributed all across the city.

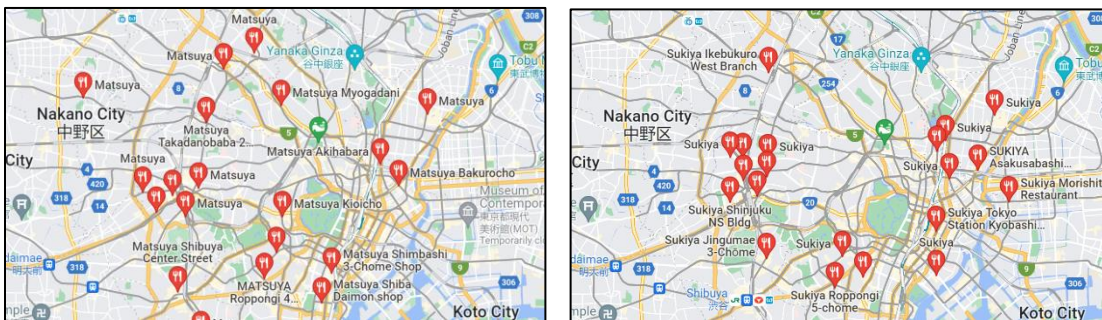


Figure 4 Distribution of Matsuya and Sukiya in Tokyo

From the above examples, we are able to see a clear difference in terms of the pattern of distribution between large discount stores and large chain restaurants. This paper would like to build a location selection model to study why such a different pattern of distribution exists.

Moreover, the study is innovative in that it involves the case where one firm controls multiple stores. When we regard firm as player and store as nodes, this model is one where one player controls multiple nodes in a network. While location selection and spatial competition model where one player controls one node has been largely studied in the past, the model where one player controls multiple nodes have seldom been studied in past literatures.

The classic Hotelling (1929) model told us that firms competing for unvaried density of customers on a straight line would choose to be in the extremes, meaning that companies would act to achieve maximum differentiation.

Building upon the Hotelling model, entry deterrence is also worthy of our attention. Schmalensee(1978) proved that the ready-to-eat breakfast cereal industry deters entry into the market and protects profit. He also argued that by doing divestiture on monopoly or oligopoly firms in the market, the competitive environment will become less hostile so that new entry can be easier. Also, Dixit (1977), Tullock (1965) and Smithies (1941) had specific discussions on monopolistic competition's optimality.

Salop (1979) varied the Hotelling framework by putting the analysis into a circle. Different from the original Hotelling model, it takes the location as given, and provides interesting discussions on the preserve of welfare properties at kinked solutions.

The nature of this one firm controlling multiple store settings also vividly reverberates with the discussion with the multistore paradox regarding the deterrence strategy and induction strategy. Peng and Tabuchi (2007) showed that as compared to price-then-variety and quantity-then-variety competition, location-then-variety competition with multistores yields a much richer set of equilibrium outcomes. Hirose and Matsumura (2015) showed that firms set up multiple stores unless the degree of payoff interdependence is low, where they analyzed the “strategic dominance” approach of setting up stores in narrow territories, with which the finding of this paper resonates well.

Building upon on the previous research, the author proposes a location selection model where one player controls multiple nodes, to uncover the distribution of discount store chains and fast-food chains.

1.2 The Model

We picture a town where there are two key locations, Location 1 and Location 2. In each location there are two nodes. These nodes may represent restaurants, convenient stores, electrical appliance stores, etc. Each location has an avenue that connects the two nodes. Let each avenue be a unit segment $[0,1]$, and customers are evenly and continuously distributed along the avenue. The network game setting follows Jackson (2014), and payoff settings gain ideas from Schmalensee (1978).

There are two firms in the game, who have the goal to maximize the profit they gain.

There are two stages in the game.

In stage 1, the two firms take turns to choose nodes. Specifically, firm 1 chooses a node first, and then firm 2 chooses another node. Then, firm 1 chooses another node, and then firm 2 chooses the remained one node.

In stage 2, the two firms simultaneously choose the price they charge, p_1 and p_2 . Firms charge the same price in both nodes they control.

The following figure shows the two possible resulted cases of the above location selection and price selection process (Figure 5). One may link this setting with reality by picturing a worker in segment AB (both A and B are restaurants) who is considering where to have his or her lunch. He or she would not travel all the way to location 2, but instead will have his lunch in location 1, and

only considers whether to go to restaurant A or B. The same applies for customers in location 2, where customers in segment CD would only go to restaurant C or D, instead of A or B.

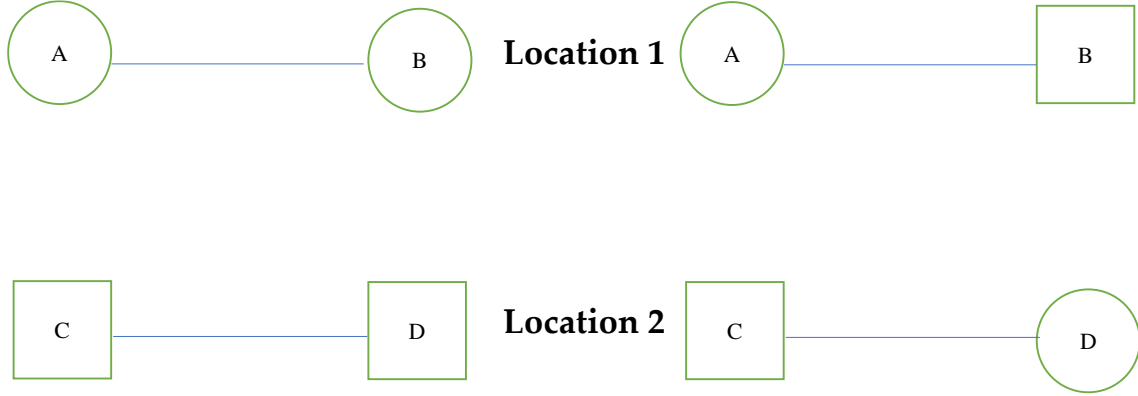


Figure 5 Two Cases

The action space of firm i ($i = 1, 2$) is thus the price it chooses, namely

$$A_i = [0, \infty)$$

Customers buy goods from shops for 2 times, and they maximize their utilities by choosing from which shop to purchase. Specifically, there is distance cost d and purchase price cost c associated. The purchased good provides utility u to the customer when the customer goes to the shop controlled by this player for the first time.

However, when customers go to the shop owned by the same player for the 2nd time, they experience decreasing marginal utility, as customers get bored on continuing purchasing the same product. If a customer goes to purchase the product at a shop controlled by the firm whose shop the customer has already been to for the first time, the utility that the customer receives is $\epsilon_i u$.

The profit that firm i gains from node k ($k = A, B, C, D$) it controls is denoted by $\Pi_{i,k}$, and the number of customers the node receives in the two times' customer purchases is denoted as n .

We define,

$$\Pi_{i,k} = n(p_i - c)$$

Firm i 's utility is the sum of profit generated by all nodes which firm i controls. Namely,

$$\Pi_i = \sum_{k \text{ controlled by } i} \Pi_{i,k}$$

Equilibrium refers to a pure strategy Nash equilibrium: a profile of actions (p_1^*, p_2^*) , where $p_i^* \in P_i$ such that $\forall i, \forall p_i \in P_i$,

$$\Pi_i(p_i^*, p_{-i}^*) \geq \Pi_i(p_i, p_{-i})$$

1.3 Analysis

We start by analyzing the situation where players' nodes are pre-assigned, instead of the case where they take turns to select location. After understanding the dynamics of the situation where nodes are pre-assigned, we proceed to analyze the location selection in the following section using results derived.

1.3.1 Connected Nodes

First, let's consider the situation where firms hold connected nodes, meaning that the two firms hold nodes in two different locations respectively, where the two nodes that each firm holds are connected (left case in Figure 5).

Take one random customer between A and B.

The distance between A and B is 1, and we let the distance between A and the customer be x , so distance between the customer and B is $1 - x$ (Figure 6). Because the shops are identical and held by the same firm, the customer chooses the closer shop to purchase.

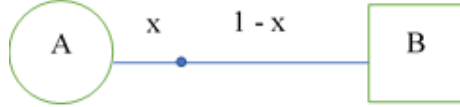


Figure 6 Customer distance

For a customer to purchase at A for the first time, he or she gets utility of $u - dx - p_1$. Because customers only purchase when this utility is non-negative, we have of $u - dx - p_1 \geq 0$. The number of customers that node A receives when customers purchase for the first time is thus $\frac{u-p_1}{d}$.

For a customer to purchase at A for the second time, he or she gets utility of $\epsilon_1 u - dx - p_1$. Because customers only purchase when this utility is non-negative, we have of $\epsilon_1 u - dx - p_1 \geq 0$. The number of customer that node A receives when customers purchase for the second time is thus $\frac{\epsilon_1 u - p_1}{d}$. If this number of customers is negative, we view this simply as a negative number of customers that decreases the total utility received by the player.

So the total number of customers that comes to node A is $\frac{u-p_1}{d} + \frac{\epsilon_1 u - p_1}{d}$, which is $\frac{(1+\epsilon_1)u - 2p_1}{d}$.

Because the profit of firm 1 is the sum of profit received in Node A and Node B and the two nodes are exactly the same,

$$\Pi_1(\text{Connected}) = \frac{2(p_1 - c)((1 + \epsilon_1)u - 2p_1)}{d}$$

To solve for the maximum utility, we take first order condition on p_1 , and have

$$p_1 = \frac{(1 + \epsilon_1)u + 2c}{4}$$

So the maximum profit that firm 1 gains when holding connected nodes is

$$\Pi_1(\text{Connected}) = \frac{\left(\frac{(1 + \epsilon_1)u}{2} - c\right)^2}{d} \quad (1)$$

1.3.2 Unconnected Nodes

Then, let's consider the situation when firms hold unconnected nodes, as illustrated by the right-side graph in Figure 5.

We once again focus on firm 1, as firm 2's action is vice versa equivalent.

For a customer to purchase at shop A for the first time, it should hold that,

$$u - dx - p_1 \geq u - d(1 - x) - p_2$$

which means that the person goes to shop A rather than shop B.

Solving which we have

$$x \leq \frac{1}{2} + \frac{p_2 - p_1}{2d}$$

For a customer to purchase at shop A for the second time when he or she has already purchased at A for the first time, it should hold that,

$$\epsilon_1 u - dx - p_1 \geq u - d(1 - x) - p_2 \quad (2)$$

which means that the person goes to shop A even it is his or her second time to purchase.

Solving which we have

$$x \leq \frac{1}{2} + \frac{(\epsilon_1 - 1)u + p_2 - p_1}{2d}$$

We denote the number of customers who purchased at shop A for the second time when he or she went to shop B for the first time by y (Figure 7). On the boundary it should hold that

$$\epsilon_2 u - d\left(\frac{1}{2} + \frac{p_1 - p_2}{2d} - y\right) - p_2 = u - d\left(\frac{1}{2} + \frac{p_2 - p_1}{2d} + y\right) - p_1$$

Solving which we have

$$y = \frac{(1 - \epsilon_2)u}{2d}$$

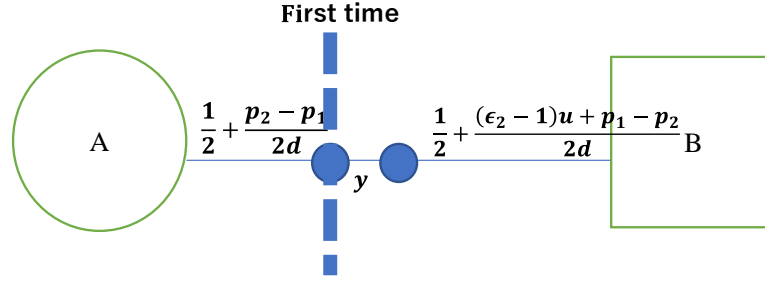


Figure 7 Illustration of y

Thus, the number of customers that purchased at shop A for the second time is the sum of x and y ,

$$\frac{1}{2} + \frac{(\epsilon_1 - 1)u + p_2 - p_1}{2d} + \frac{(1 - \epsilon_2)u}{2d}$$

Which is

$$\frac{1}{2} + \frac{(\epsilon_1 - \epsilon_2)u + p_2 - p_1}{2d}$$

Thus, summing customers number for the first and the second time

$$\Pi_1(\text{Unconnected}) = 2(p_1 - c) \left(1 + \frac{2p_2 - 2p_1 + (\epsilon_1 - \epsilon_2)u}{2d} \right)$$

(3)

Similarly, the utility of player 2 is

$$\Pi_2(\text{Unconnected}) = 2(p_2 - c) \left(1 + \frac{2p_1 - 2p_2 + (\epsilon_2 - \epsilon_1)u}{2d} \right)$$

(4)

Taking First Order Condition on p_1 and p_2 respectively, we have

$$p_1 = c + d + \frac{1}{6}(\epsilon_1 - \epsilon_2)u$$

$$p_2 = c + d + \frac{1}{6}(\epsilon_2 - \epsilon_1)u$$

Bringing p_1 into

$$\Pi_1(\text{Unconnected}) = 2(p_1 - c) \left(1 + \frac{2p_2 - 2p_1 + (\epsilon_1 - \epsilon_2)u}{2d} \right)$$

Gives

$$\Pi_1(\text{Unconnected}) = \frac{1}{18d}(\epsilon_1 - \epsilon_2)^2 u^2 + 2d + \frac{2}{3}(\epsilon_1 - \epsilon_2)u$$

(4)

1.3.3 Comparison of Profits

Now, we would like to understand whether the case where player 1 has connected nodes or the case where player 1 has unconnected nodes generates higher profit.

Let

$$\Pi_1(Diff) = \Pi_1(Connected) - \Pi_1(Unconnected)$$

So

$$\Pi_1(Diff) = \frac{\left(\frac{(1 + \epsilon_1)u}{2} - c\right)^2}{d} - \left(\frac{1}{18d}(\epsilon_1 - \epsilon_2)^2 u^2 + 2d + \frac{2}{3}(\epsilon_1 - \epsilon_2)u\right)$$

We first consider the simple case where $\epsilon_1 = \epsilon_2 = \epsilon$, namely when the two firms have exactly the same ability to continue attracting customers for the second time's purchase. We take u, c, d as given, and consider the edge value of ϵ that makes $\Pi_1(Diff) = 0$. We denote this edge value of ϵ as ϵ^* .

Now,

$$\Pi_1(Diff) = \frac{\left(\frac{(1 + \epsilon^*)u}{2} - c\right)^2}{d} - 2d$$

Solving $\frac{\left(\frac{(1 + \epsilon^*)u}{2} - c\right)^2}{d} - 2d = 0$, we have

$$\epsilon^* = \frac{2\sqrt{2d} + 2c}{u} - 1$$

(Notice that we drop the solution where $\frac{(1 + \epsilon^*)u}{2} - c < 0$, as this is economically meaningless)

Result 1. When $\epsilon_1 = \epsilon_2 = \epsilon$, $\Pi_1(Diff) > 0$ holds if and only if $\epsilon > \epsilon^*$

Proof:

We first prove the if part.

$\Pi_1(Diff)$ is a quadratic function that reaches 0 when $\epsilon = \epsilon^*$, and the function increases monotonically when $\epsilon > \epsilon^*$.

We then prove the only if part.

Suppose $\exists \epsilon^{**} \leq \epsilon^*$ s. t. $\Pi_1(Diff) > 0$.

Then,

$$\frac{\left(\frac{(1 + \epsilon^{**})u}{2} - c\right)^2}{d} - 2d > 0$$

We have $\epsilon^{**} > \frac{2\sqrt{2d} + 2c}{u} - 1$, thus we have a contradiction. (again, we drop the economically meaningless solution where $\frac{(1 + \epsilon^{**})u}{2} - c < 0$)

1.3.4 Discussion on the results

That is to say, connected nodes generate higher profit for the firm when the firm attracts repeaters well, while unconnected nodes generate higher utility for the firm when his or her shop fails to catch repeaters. With Result 1, we are able to understand the distribution of discount stores and fast-food chains.

Discount stores have high ϵ . Not only do they offer very cheap and affordable goods, but also they provide a large variety of goods. Whenever customers want to purchase things, discount stores are always the place that they would like to head for, so that these stores have strong ability to continue attracting customers, namely high ϵ . Thus, from result 1, we can see that it is optimal for these discount stores to build connected shops.

Fast-food chains, on the other hand, have low ϵ , because people prefer variety of foods. Eating the exact same brand's same beef bowl every day can be extremely boring. Thus, it is hard for these fast-food chains to continuously attract customers every time they purchase. From this, we can see that fast-food chains have low ϵ , and from result 1 we are able to see that it is optimal for them to build shops next to their opponents.

1.3.5 Extension – what if $\epsilon_1 \neq \epsilon_2$

Now we make a brief extension to consider the more general case. What if $\epsilon_1 \neq \epsilon_2$?

We take u, c, d, ϵ_2 as given, and consider the edge value of ϵ_1 that makes $\Pi_1(Diff) = 0$. We denote this edge value of ϵ_1 as ϵ_1^* .

We are able to get a closed form of ϵ_1^* (again, dropping the minus value which is economically not meaningful)

$$\epsilon_1^* = \frac{\frac{\epsilon_2 u^2}{9} + \frac{1}{2} - c - \frac{2ud}{3} + \sqrt{\left(\frac{\epsilon_2 u^2}{9} + \frac{1}{2} - c - \frac{2ud}{3}\right)^2 - \left(\frac{2u^2}{9} - 1\right)\left(\frac{u^2}{18}\epsilon_2 + 2d^2 - \frac{2}{3}\epsilon_2 ud - \frac{1}{4} + c - c^2\right)}{\frac{u^2}{9} - \frac{1}{2}}$$

When $\epsilon_1 < \epsilon_1^*$, $\Pi_1(Diff) < 0$, as the value we dropped above is negative. The quadratic function has value below 0 in $(0, \epsilon_1^*)$.

We take an example to better illustrate the situation.

Suppose

$$u = 205$$

$$c = 100$$

$$d = 1$$

$$\epsilon_2 = 0.9$$

ϵ_1 takes value from 0.01 to 0.9, and we have a graph of $\Pi_1(Diff)$ based on different values of ϵ_1 .

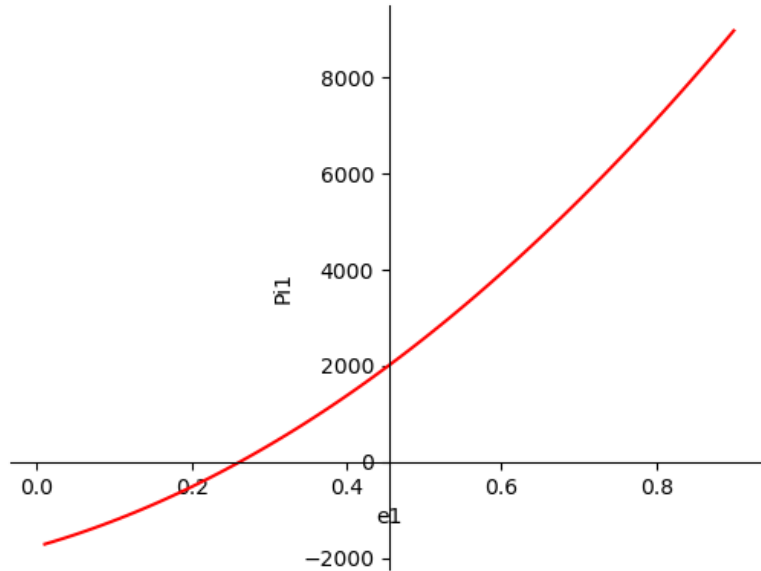


Figure 8 Epsilon_1 and Pi_Diff

From Figure 8, we are able to see that when $\epsilon_1 \ll \epsilon_2$, namely when firm 1 has much lower ability to continue attracting customers than firm 2, it has an optimal strategy to avoid building shops that are connected, namely close together.

1.4. Location Selection

Now let's endogenize location selection, namely that firms are now able to select the locations by themselves. Specifically, firms take turns to select the locations.

If $\epsilon_1 = \epsilon_2 = \epsilon$, we know that both firms prefer connected nodes when $\epsilon > \epsilon^*$, and both prefer unconnected nodes when $\epsilon < \epsilon^*$. Firms are indifferent when $\epsilon = \epsilon^*$.

If $\epsilon_1 \neq \epsilon_2$, it can happen such that firm 1 prefers unconnected nodes, while firm 2 prefers connected nodes, namely when $\epsilon_1 \ll \epsilon_2$ s.t. $\epsilon_1 < \epsilon_1^*$. If $\epsilon_1 > \epsilon_1^*$, firms both firms still prefer connected nodes. If $\epsilon_1 = \epsilon_1^*$, firm 2 prefers connected nodes, and firm 1 is indifferent.

Result 2. If both firms prefer connected nodes, the equilibrium results in monopoly equilibrium.

Proof:

Suppose firm 1 chooses a random node in the game, e.g., node A. When it comes to firm 2's turn, firm 2 would know that holding connected nodes would benefit her more.

Thus, firm 2 will choose a node freely in C or D, and firm 1 would choose node B, and then firm 2 would choose the remaining node.

The final equilibrium of selection result would be **(AB, CD)**, where both firms enjoy monopoly price. We call this a monopoly equilibrium.

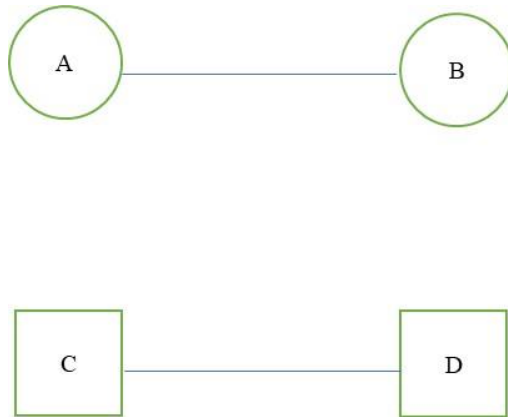


Figure 9 Monopoly Equilibrium

Result 3. If at least one firm prefers unconnected nodes, the equilibrium results in segregated equilibrium.

Proof:

First, we consider the case when both firms prefer unconnected nodes.

Suppose firm 1 chooses node A, then firm 2 has a best response to choose node B, as firm 2 prefers unconnected nodes.

The equilibrium would be (AC, BD) or (AD, BC), where both firms build unconnected shops. We call this a segregated equilibrium.

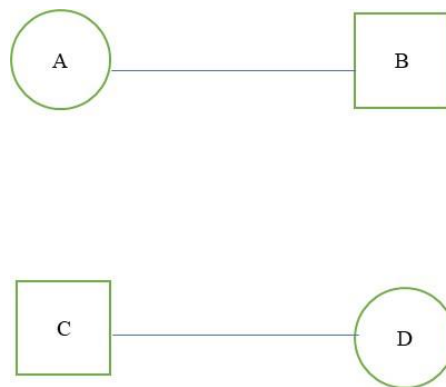


Figure 10 Segregated Equilibrium

Then we consider the case when only firm 2 prefers connected nodes, and firm 1 prefers unconnected nodes ($\epsilon_1 \ll \epsilon_2$).

Suppose firm 1 chooses first. It chooses a random node, say A. Firm 2 would definitely choose node C or D, as it prefers connected nodes. However, firm 1 would definitely choose the remaining node in C or D, leaving node B to firm 2. This results in segregated equilibrium.

What if firm 2 chooses first? Suppose firm 2 chooses node A, then firm 1 has a best response of choosing node B. Again, a segregated equilibrium is formed.

From result 3, we can see a very important conclusion: If one firm wants segregated shops, the eventual equilibrium will definitely be a segregated equilibrium.

1.5 Conclusion

This paper builds a spatial competition model where one player controls multiple nodes and analyzes its equilibrium and location selection dynamics. The two key takeaways are:

(1) The paper shows that it is optimal for discount stores to build stores concentrated on certain locations and far from their opponents, because they have strong ability to continue attracting customers, namely high ϵ . On the contrary, it is optimal for fast-food chains to build segregated shops not close to each other, because they have weak ability to continue attracting customers, namely low ϵ .

(2) The paper also finds that when chains have different ϵ , namely ϵ_1 and ϵ_2 , and $\epsilon_1 \ll \epsilon_2$, it is optimal for the weaker chain with ϵ_1 , which is weaker ability to continue attracting customers, to build segregated shops not close to each other.

Appendix

Python Code

```
u=205
```

```
c=100
```

```
d=1
```

```
e1=0.1
```

```
e2=0.9
```

```
e1 = np.linspace(0.01,0.9,100)
```

```
Uti=((1+e1)*u/2-c)*((1+e1)*u/2-c)/d-1/18*(e1-e2)*(e1-e2)*u*u/d-2*d-  
2/3*u*(e1-e2)
```

```
fig = plt.figure()
```

```
ax = fig.add_subplot(1, 1, 1)
```

```
ax.spines['left'].set_position('center')
```

```
ax.spines['bottom'].set_position('zero')
```

```
ax.spines['right'].set_color('none')
```

```
ax.spines['top'].set_color('none')
```

```
ax.xaxis.set_ticks_position('bottom')
```

```
ax.yaxis.set_ticks_position('left')
```

```
plt.plot(e1,Uti, 'r')
```

```
plt.xlabel("e1")
```

```
plt.ylabel("Pi1")
```

```
plt.show()
```

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Chapter 2

2. Weak Central Government, Strong Legal Rights

- **An Information Game Model on the Origins of Divergent Legal Institutions in Eighteenth-Century Chinese and Japanese Rice Markets¹**

2.1 Introduction

Most economists agree that legal institutions are associated with economic development (Acemoglu and Johnson, 2005a; Hodgson, 2015; North, 2005; Rodrik et al., 2004), and can also help explain the great divergence (Rosenthal and Wong, 2011; North and Thomas, 1973). However, given a similar level of development, why did some countries offer strong legal institutions while others did not?

Both the establishment and continued operation of institutions require costs (Chang, 2011). As stationary bandits, to use Olson's memorable phrase, ruling governments are treated as self-interested maximizers (Olson, 1993). Thus, when a central government creates an institution, we can expect that it will align with the government's interest. In historical contexts, informal institutions from social communities structured individual economic rights (Greif, 2006).² This is because even if the state has the capacity to establish formal institutions and understand the contribution of institutions to prosperity, such establishment is still not necessary unless institutional change can bring enough benefits to the central government (Aoki, 2007; Barzel, 2002). Therefore, only when governments are confronted with strong incentives, namely economic or political profits in the foreseeable future, do they create new institutions, including legal institutions. (Johnson and Koyama, 2017; Levi, 1988; Moselle and Polak, 2001; Salter and Hall, 2015). However, what are the strong incentives?

To answer the above questions, we introduce the predatory state theory to help us understand state institution-building. According to the predatory vision of the state (Vahabi, 2020), protection afforded by a predatory state is driven by promotion of predation. Governments offered protection under the following three circumstances: (1) Under a multiple-predatory system, central government's efforts to prevent decrease of income caused by capital flight or peoples' exit; (2) To maximize the long-term state's revenue; (3) To maintain long-term political stability. Although this theory provides explanations for the establishment of formal institutions, it still needs to be considered within specific historical contexts. First, in many states, especially non-Western states, there is no interstate competition (multiple-predatory system) (Qian and Sng, 2021). Second, huge numbers of non-Western states tended to keep taxes low, and some states even experienced decreasing revenue (Ohno, 1996; Pamuk, 2012; Sng and Moriguchi, 2014). Given these historical contexts, in most cases outside of early modern Europe, formal institutions

¹ This chapter is co-authored with Rui Wang and Matthew Noellert from Hitotsubashi University

² In some historical contexts, because of political instability or lack of enforcement, the state was unable to establish formal institutions even it wanted to do so. See Cai et al. (2020).

(including legal institutions) tended to depend on governments' concerns for political stability or longevity more than maximizing state revenue.³

Destructive power is another important factor affecting political stability. Destructive power is determined by the internal power structure, and in turn, destructive power can also shape power structure.⁴ In following with the studies of Bush and Mayer (1974), Umbeck (1981), Knight (1992), and Vahabi (2004, 2009, 2010), our assumption is that potential or real inside destructive power (conflict and rebellion), rather than other factors, play a key role in the establishment of legal institutions, especially in historical contexts lacking interstate competition. While many economic historians have analyzed the emergence of formal or informal institutions (e.g., Acemoglu et al., 2005b; Alston et al., 2012; Dye and Croix, 2020; Hodgson, 2017; Hoffman, 2015; North and Weingast, 1989; Piano and Salter, 2021; Rajan and Zingales, 2003) most of the literature solely focuses on Europe or neo-Europe cases. Few scholars have explored the emergency of formal institutions in pre-modern non-Western states.

We take destructive power as the starting point for analyzing the emergency of legal institutions in pre-modern Chinese and Japanese rice markets. Specifically, we focus on rice markets in Suzhou and Osaka, which were two of the largest rice markets at the time, and whether or not states offered legal rights for rice market participants. In this paper, legal rights refer primarily to the right of participants in the rice market to trade freely and to dispose of goods freely. Most importantly, when the above-mentioned rights are violated, the legal system can and does offer protection to the owners of goods.⁵ The rice market is special in that rice was one of the most important commodities in pre-modern China and Japan and was closely tied to national security and national interest, so it can serve as a good index of the nation's general level of stability.

This article examines the emergence of legal institutions in Qing China and Tokugawa Japan during the eighteenth century. Our study contributes to the literature on the foundations of institutions of non-Western states through a comparison of how the Qing and Tokugawa central governments established different legal institutions for the rice market in response to different levels of domestic threats to their longevity. It also adds to the literatures on the relationship between formal legal systems and informal social organizations, including Greif's and Tabellini's (2017) model to emphasize personal relations such as clans in imperial China, which could have contributed to weaker legal institutions. In our study, a weak legal system drives merchants to invest more in informal protections for individual rights and collectivism. Conversely, a strong legal system leads to the exact opposite scenario. We attribute the different performances of Chinese and Japanese rice market to (at least partially) different institutions and different merchant behaviors. Our study also sheds light on state-building in economic history and political science. Many works on state-building borrow heavily from the early modern European experience, which emphasizes that interstate wars led to the enhancement of state capacity (e.g., Dincecco, 2011;

³ All governments are interested in maintaining the continuity of power, the difference is the methods used to achieve it. For example, while western governments rarely created new institutions driven by social welfare, Qing government, such as government in Emperor Yong Zheng's era, treat social welfare as a means of consolidating power.

⁴ For example, in nondemocratic countries, disenfranchised poor can overthrow the regime through revolution. The threat of revolution pushes governments to democratize. See Acemoglu and Robinson (2001).

⁵ It should be noted that while economic rights such as property rights are recognized and enforced partially by the government (Barzel, 1997), actual property rights can still exist in the absence of enforcement of state authority (Eggertsson, 1990). But in this article, we only focus on legal rights, which are formal institutions afforded by the government.

Hoffman, 2015; Queralt, 2019). However, the different internal structures of European states also led to different paths to state-building during this period (Karaman and Pamuk, 2013). Furthermore, in some non-Western countries, the intrinsic political structure (especially the central-local relationship) rather than extrinsic war is an important determinant of state capacity, including legal capacity (Ma and Rubin, 2019). Many game theoretical literatures on repressive regime also more heavily focused on the two-layer interactions between the top government and individual disobediences, rather than bringing in the perspective of central-local relationship. Karlins used an n-person assurance game to identify that raising individuals above the tipping points is significant for revolutions (Karlins, 1993). Kiss found that different information transmission method influences effectiveness of mobilization. (Kiss, 2017) In this paper, our findings can further enrich the understanding of state-building by offering a central-local relationship perspective in examining the cases of 18th century China and Japan through a three-layer model.

We argue that the capacity of real or potential inside power threats (conflict and rebellion) to subvert the regime and the cost of state suppression of conflict or rebellion played important roles in determining how China and Japan adopted different levels of protection for rice market participants.⁶ According to our subversive regime game model, a state enforces legal rights when the capacity of noncooperation or rebellion to subvert the current regime in the foreseeable future is high and the provision of legal protection mitigates the risk of losing power. Conversely, when the subversive capacity of conflict or rebellion is low and the state can suppress them at a lower cost, the state had no incentive to protect rice market participants' rights. The model helps us understand the motives for the Chinese and Japanese governments in establishing different legal institutions for rice markets and explains the impacts of different institutions on merchant behaviors, as well as the decline of Chinese rice markets and the boom of Japanese rice markets in the eighteenth century.

Our article proceeds as follows. Section 2 will overview the historical background of pre-modern rice markets in China and Japan. Section 3 will explain the reasons for the different legal institutions in Chinese and Japanese rice markets through our model. Section 4 will present further historical evidence to illustrate our model's predictions. Section 5 marks the conclusion.

2.2 Historical Backgrounds

In this section, we compare the structure of rice markets in Qing China and Tokugawa Japan, in particular the political environment, market development, trade participants, and the legal system, to motivate our theoretical model.⁷

Beginning in 1644, the Manchus spent the next hundred years gradually expanding their control from Northeast Asia to China proper, Taiwan by 1681, and present-day Xinjiang and Tibet by the mid-18th century (Meng, 2006; Hostetler, 2001; Millward, 1998; Perdue, 2005). As the surrounding territories were successively incorporated into the Qing empire in the 18th century,

⁶ We do not deny that other factors such as culture, ideology, elite conflict, etc. also influenced institution-building in Qing China and Tokugawa Japan. In this study, we only emphasize the impact of domestic power threats (conflict and rebellion) on the establishment of legal institutions in rice markets, which is a factor that has been often overlooked.

⁷ For a more comprehensive comparison of pre-modern China and Japan, see also Sng and Moriguchi (2014).

the frequency and scale of warfare declined significantly (Li, 2019; Ma, 2012). In Japan around the same time, after establishing the *Bakufu* (Shogunate) in 1603, the Tokugawa Shogunate eliminated the Toyotomi regime at the Battle of Osaka in 1615 and suppressed domestic Christianity in 1637, gaining control over the archipelago including the three main islands (Honshu, Kyushu, Shikoku) by the mid-17th century. As an island nation, Japan was isolated by the sea from territorial competition, and there were no major wars in Tokugawa Japan until the mid-19th century, except for two wars with the Ainu people in Hokkaido (Walker, 2006). From around 1650 to 1850, therefore, both Qing China and Tokugawa Japan enjoyed a long period of political stability.

Political stability led to the development of domestic economies and the distribution of goods, among which rice was the most important commodity in both countries. In China, by the mid-19th century, the value of commodity grains accounted for nearly 40% of the value of total commodities, and nearly 50 million people depended on commodity grains for their livelihood (Wu C., 1983; Wu H., 1985).⁸ In Tokugawa Japan, which was also an agrarian nation, rice was the main traded item in the market as the regime stabilized and commodity circulation expanded in the 17th century. (Hayashi, 2000) By the 19th century, in Osaka, the largest commodity market, the value of commodity rice accounted for 38% of the total value of commodities (Shinbo and Saito, 1989)

In both China and Japan, Water transport was a major component of rice transportation. Japanese rice shipments made use of maritime transport. In China, land transport was mainly restricted to short distances, while long-distance transport relied heavily on inland waterways or maritime transport. Since the development of long-distance trade, some markets such as Suzhou and Hankou in China and Osaka and Edo in Japan with convenient transportation developed into important central markets to collect and distribute rice. The rice market in Suzhou accounted for 20% of China's total rice trade, while the Osaka market accounted for 20%-40% of Japan's total rice trade by volume (Deng, 2009; Miyamoto, 1988). Facilitated by long-distance trade, the rice markets in both China and Japan were highly integrated by the 18th century (Bassino, 2007; Shiue and Keller, 2007).

In Qing China, while participants in local rice trade were primarily merchants and farmers, merchants rather than farmers dominated the long-distance rice trade. However, *Yaren* played an important intermediary role in both the local market and long-distance trade. The *Yaren* (broker) or *Guanya* (government-licensed market broker) first originated in the Tang Dynasty as an intermediary for the government to manage the market (Qiu, 2008). In the early Qing, *Yaren* acted as brokers under the management of local government officials. The local government mandated *Yaren* to participate in market transactions by offering commercial functions such as regulating price and quality or exchanging information to assist sellers and buyers, for which they received commissions (Mann, 1987; Yan and Li, 2013). In addition to the commercial function, the *Yaren* system was also a conduit for transferring market information to the state, while their official sanction to manage the market and collect taxes created a power asymmetry between *Yaren* and other participants in rice trade (Yamane, 1995).⁹ More notably, beyond the 18th

⁸ It is worth noting that rice was grown in central and southern China and throughout Japan, and wheat was traded mainly in the northern China. In this paper, the national market in Qing China refers to the rice market, not wheat market.

⁹ *Yaren*, under supervision of Chinese local government, supervised the merchants to prevent tax evasion, and submitted collected taxes to the government. In addition to collecting taxes, *Yaren* were also responsible

century, local governments not only oversaw the rice market through the *Yaren* system but also derived significant income from it.¹⁰ Consequently, the *Yaren* was associated with the local government and operated in the grain market on its behalf, and we will refer this concept of local government authorized broker as *Lgb* in our following discussion.

In Tokugawa Japan, Daimyos (local lords) conducted most of the rice trade. During the Edo era, 80% of the commodity rice comprised the *Ryoushumai* (tax-rice) of Daimyos (Miyamoto, 1988). Under the shogunate system, a Daimyo retained autonomous administrative, economic, and even military powers within his domain after swearing allegiance to the shogun (Miyamoto, 1978). This allowed a Daimyo to break up the intermediary organizations¹¹ in his domain by force, to collect rice directly from the farmers, to establish a uniform transportation route to the rice market by setting up docks and warehouses, hiring ships and professional traders, and to obtain more currency to meet final expenditures with lower transportation costs (Miyamoto, 1988).¹² In Osaka, the largest rice market in Japan, merchants purchased *Kome kitte* (rice securities that could be exchanged for rice) issued by Daimyos through bidding. These rice securities had limited redemption periods, and holders could trade them during the exchange period or exchange them for rice directly from Kurayashiki (Daimyo's warehouse where rice was stored) where these securities were issued, and then supplied rice to the demand side (Takatsuki, 2012).¹³ Furthermore, Daimyos used the proceeds from the sale of rice as collateral to borrow money from merchants (Mori, 1970). In a nutshell, income from the sale of rice and borrowing against the proceeds of rice sales is a major component of Daimyos' income, and the stability of the rice market has a significant impact on Daimyos' fiscal system.

The development of rice markets brought more commercial disputes. While the Tokugawa Shogunate removed commercial disputes from the judicial system for a time in the early 18th century¹⁴, the disruption of commercial transactions forced the shogunate to permit commercial litigation again (Ohira, 2013). Whereas in China, there were provisions for commercial disputes in the Qing legal code and county magistrates also handled a vast number of commercial disputes

for registering information on both sides of the transaction, which was used by the government to maintain social order (Such as a clue to investigate crimes). At the same time, *Yaren* were also required to check the trafficking of prohibited goods (e.g. iron, lead, copper, etc.). See Yan and Li (2013).

¹⁰ According to Liu (2003), local governments increased revenue by issuing licenses to *Yaren* and charging fees, and *Yaren* also tended to gift money to local governments to secure their backing.

¹¹ These intermediary organizations are mainly consisted of *goushou* (tycoon), who have better ability to transport commodities and obtain market information, maintained some military power to ensure the security of commodity transportation. In the early Edo period, Daimyos had to rely on these tycoons to transport rice for sale because they had difficulty in obtaining market information and had no ability to transport goods. See, Miyamoto (1988).

¹² In addition to regular expenses, the alternate attendance system (*Sankin Kotai*) costs Daimyos much. The system required the Daimyo to alternate between living in Edo for a year and living in their own domain for a year. The annual processions of Daimyo to Edo were expensive. Furthermore, the cost of maintaining mansions in Edo and the consumption of goods or services by Daimyos and their retainers were also very high.

¹³ As the issue of *Kome kitte* did not coincide with the market entry of rice, prices could fluctuate depending on the weather and other factors. To avoid this risk, in the late 17th and early 18th centuries, rice futures market was gradually developed. See, Takatsuki (2012).

¹⁴ One important reason was the Shogunate's desire to cut down administrative expenses and leave the civil litigation to the social communities. However, at the economic center of Osaka at that time, commercial disputes were often accepted by the shogunate. See Takatsuki (2012).

(Huang, 1996; Fan, 2007). In both cases, disputes related to the rice market were an important part of commercial litigation.

In Qing China, the local government managing *Lgb* gave *Lgb* large degree of freedom. Not only were *Lgbs* able to administer the rice market on behalf of the local government, but also they were able to participate and trade in the rice market themselves. Since *Lgbs* were both participants and administrators of the rice market, in the absence of constraints on *Lgb*'s behaviors, there was a risk that merchants and farmers might be exposed to embezzlement of goods by *Lgb*. In fact, the embezzlement of merchants and farmers by *Lgb* was very much prevalent. *Lgb* could establish associations to take control of intermediary business or regulate the trade in order to satisfy their interest despite the losses of merchants or farmers (Negishi, 1932; Chen, 1992). Although there were indeed some official legal codes designed to limit the ability of *Lgb* from embezzling goods, most of the time, the government did not effectively enforce these legal provisions either. While rice merchants and farmers had the option to pursue legal action when their goods were embezzled, since the *Yaren* system operated under the authority of local governments and constituted a significant source of fiscal revenue, local magistrates generally favored resolving legal disputes through persuasive negotiation, encouraging both parties to reach a mutual settlement rather than relying solely on legal codes to uphold the rights of owners and quell competing claims.¹⁵ Therefore when disputes arose between *Lgb* and rice merchants or farmers, *Lgbs* were not only seldom substantially punished but sometimes they were even sheltered by the magistrates.¹⁶ This resulted in the historical fact that it was often the rice merchants and farmers rather than *Lgb* who suffered losses in the commercial disputes (Chen, 2017; Deng, 2019; Fan, 1996). This can be illustrated by a case in the early 19th century. In Suzhou, some rice merchants made recourse to a magistrate's ruling after their goods were embezzled by local *Yaren*. While the magistrate declared that *Yaren* should not embezzle the rice merchant's goods in the future, he did not require the *Yaren* to compensate the merchants' losses.¹⁷ In fact, illegal claims by the *Lgb* against the rice merchant were common in historical records until the mid-19th century (Wang and Tang, 1998). As the formal legal system did not offer protection for merchants' rights, Qing dynasty commercial books required merchants to be wary of the embezzlement of *Yaren* and suggested trading with familiar *Yaren*.¹⁸ These historical observations indicate that the Qing government offered weak legal protections.

¹⁵ Shiga refers this form of ruling as "situation, reason and law", which rarely relied on or cited any specific codes and also lacked enforcement. For more on Qing civil adjudication, see Shiga (1984).

¹⁶ During Qing Dynasty, local governments with limited funds and civil litigation were not a major part of magistrates' assessment; Therefore local magistrates were reluctant to devote excessive administrative resources to civil litigation. See Ch'u (1962).

¹⁷ Because only a small number of Qing dynasty litigation files currently exist, it is difficult for us to gain a comprehensive understanding of the litigation related to *Yaren*'s embezzlement. However, case studies have demonstrated that it is quite common that the rights of merchants and farmers were difficult to be protected in commercial disputes with *Yaren*. For example, among the 17 surviving lawsuits between *Yaren* and merchants in the local archives of Ba County (now Chongqing), few of them resulted in the protection of merchants' interests, and even if merchants won, merchants often had difficulty in getting their all goods back. For more details, see Zhou (2021).

¹⁸ For example, in a commercial book, the *Yaren* is described as follows “牙主真誠，則客商陰受其福；牙主欺詐，則客商受累無窮。邇來牙行欺偽者多，誠實者少 (If the *Yaren* is honest, then the business of merchants will be naturally smooth, and if the *Yaren* is deceitful, then the business of merchants will be dragged down. However, there are many fraudulent *Yaren* but few honest *Yaren*).” See, Bian (2020).

In contrast, by the end of the eighteenth century, the Tokugawa shogunate institutionalized protections for rice market participants' rights. After 1730, the Tokugawa shogunate recognized the legality of several rice markets, such as the Osaka Doujima rice market, and accepted commercial disputes related to rice trading. In Osaka, Daimyos issued rice securities more than the rice storage capacity in order to obtain more currency, which caused the problem of *kuu mai kitte* ("empty" rice securities that could not be exchanged for rice). This problem became more serious in the mid-18th century. In 1761 the Shogunate banned the issuance of non-exchangeable rice securities to protect the rights of rice buyers. Around 1800, in several legal cases about non-exchangeable rice securities, merchants resorted to lawsuits to protect their rights, and magistrate's rulings showed that the Shogunate offered legal rights to rice holders (Takatsuki, 2012).¹⁹ The legal rights were not limited to Osaka rice market. While the forms of rice trading varied across Japan at the time, rice market participants' rights were respected by the government (Nakabayashi et al., 2020).

Before western intrusion, both Japan and China enjoyed a long period of political stability and brought about the development of rice markets. While disputes related to rice market participants' rights were important parts of commercial litigation in both countries, in Qing China the enforcement for legal protections was weak.²⁰ In other words, the formal legal system did not offer real protections for rice market participants' rights. In contrast, the Tokugawa shogunate established a credible commitment to the legal system which offered legal rights to rice market participants.²¹ In the following section we will turn to our model that place these historical observations in one consistent and coherent framework of analysis.

2.3 The Model

In this section, we model the relationship between a central government (Qing China and Edo Japan's central government), a mid-level agent (Chinese local government/Daimyo) and a lower-level participant in a market (merchant/farmer). The central government needs the mid-level agent to help ensure stability of the market so that it can receive the profits of holding power²², and the mid-level agent needs the lower-level participant to run the market but can also benefit from exploiting the lower-level participant through embezzlement.

In our model, the players face three key constraints:

- (1) The central government sets a level of legal protection, subject to the constraint

¹⁹ It is also noted that the magistrate protects the rights of rice securities holders not only in commercial disputes between rice merchants and Daimyos, but also in commercial disputes within rice merchants. See Takatsuki (2012).

²⁰ There were provisions for commercial disputes in the Qing legal code, but these provisions placed more emphasis on maintaining the stability of the market or society rather than on protecting the rights of asset owners. In many legal cases, the local magistrates would sacrifice individual rights in order to maintain the ruling order. See, Zhou (2021).

²¹ There is no evidence to suggest that the Qing government was weaker in its enforcement than the Tokugawa government. Sometimes, the bureaucracy could efficiently put the Emperor's wishes into practice. For example, in 1768, after the Qianlong emperor ordered the arrest of witchcraft practitioners, provincial officials arrested large numbers of suspected practitioners in a short time, and the widespread arrests did not end until the witchcraft was disproven (Kuhn, 1990).

²² Although this model can also explain profits from taxation or economic growth, in this paper we focus on the profits from holding power given historical contexts.

that a low level of legal protection discourages the lower-level participant from trading and deteriorates the market, and a high level of legal protection discourages mid-level agent from exploiting the lower-level participant.

(2) The mid-level agent chooses its action about whether to cooperate with the central government or not, subject to the constraint that not cooperating with the central government has associated costs.

(3) The lower-level participant chooses whether to fight against the mid-level agent's exploitation, subject to the constraint of fighting costs. If it chooses to fight, the top central government would also be affected.²³

2.3.1 Setup

The model includes three players: A central government (R), who has the choice to determine the level of legal protection. A mid-level agent (M), who has the choice to decide whether to cooperate with the central government or not. A lower-level participant (P), who has the choice of whether to fight against the mid-level agent's exploitation.

When the mid-level agent decides not to cooperate with the central government, various problems can occur. If the mid-level agent has strong military power, he may rebel and overthrow the central government. If the mid-level agent has weak military power, he may use more indirect methods such as disobeying or distorting laws set by the central government. In either case, these approaches harm the central government's interest and can eventually result in overthrowing the central government or the central government losing control of the market. To simplify the model, we set the mid-level agent's action into a binary choice: $\gamma = 0$, meaning not cooperating with the central government, and $\gamma = 1$, meaning cooperating with the central government. Similarly, when the lower-level participant decides to fight embezzlement, although his target is the mid-level agent, the overall market stability enjoyed by the central government would be negatively influenced (e.g. through food riots), and we set the lower-level participant's action also into a binary choice: $\delta = 0$, meaning fighting embezzlement, and $\delta = 1$, meaning not fighting embezzlement.

The game is a one-shot game in the following steps:

Step 1: The Central government Learns Its Type

Nature determines the central government's type θ of continuing to hold effective control over the market when facing noncooperation by the mid-level agent, and $1 - \theta$ of not. $\theta \in [0,1]$ is determined by various factors in history, such as a nation's political economy, power, military strength, approval rating, etc. For simplicity we assume it follows a uniform distribution. Stronger central government's power, stronger central government military strength, and strong approval by citizens would all lead to higher θ , because the central government would be less likely to be overthrown by a rebellion so that it loses control of the rice market. We assume that the central government is able to perfectly observe his type as private information, reflecting the historical fact that only the central government knows how much strength it really holds in the market. The mid-level agent, on the other hand, cannot directly know θ , and can only guess θ , with a guess of the central government's θ which we label as θ_{guess} . In the real history, the mid-level agent would guess a central government's θ by observing the central government's political strength,

²³ As the rice market proceeds in an agent manner, the top-level central government cannot directly exploit the lower-level participants, so we are only considering the mid-level agent exploiting lower-level participants here.

economic strength, military strength, approval rating, etc. From these historical contexts, the mid-level agent would be able to know the support of θ , but the specific value of the true θ is unknown. The central government will 100% effectively control the market if the mid-level agent cooperates with the central government.²⁴

Step 2: Central government Chooses the Level of Legal Protection

Given its type θ , the central government chooses its level of legal protection $a \in [0,1]$ it would like to offer. When $a = 1$, the central government offers the strongest level of legal protection and guarantees of participants' rights, and when $a = 0$, the central government does not offer legal protection of any kind at all.

Step 3: The Mid-level Agent Acts

Then, the mid-level agent, based on its guess of the central government types θ_{guess} and the central government's level of legal protection a , decides to cooperate or not, namely γ .

Step 4: The Lower-level Participant Acts

Based on the central government's level of legal protection a , the lower-level participant decides whether to fight against embezzlement of their goods. Notice here we are not assuming that the lower-level participant, through fighting, can completely eliminate the mid-level agent's embezzlement profit. Instead, it can only partly fight off embezzlement, given its relative strength z . It is more natural to assume that the lower-level participant, through ways such as forming business cooperation or bribery, can only partly decrease the amount being embezzled, since the two are different so large in terms of the strength of power. Moreover, not only does the fighting action affects mid-level agent's payoff, but also from the larger picture, such fighting negatively affects the central government's payoff. Such a setting is closer to the historical fact that many food riots can also negatively influence central government's stable control of the market in history.

2.3.2 Structural Variables

In this section, we introduce structural variables to be discussed in this paper. For clarity and easy of understanding, all variables' explanations are based on the scenario of the rice market, while in section 4, extensions of the variables beyond the context of rice market will also be discussed.

Cost of friction (f): When the mid-level agent decides not to cooperate with the central government, both the central government and the mid-level agent suffers from the cost of friction f . This f can be measured by the central government's military scale and the respective nation's geographical scale. A large military owned by the central government gives higher pressure to the disobedient mid-level agent, thus being a cost for the mid-level agent. Simultaneously however, a large military requires higher maintaining costs, including more army provisions and more military spending, thus being a cost for the central government too. Similarly, when a nation has large territory, it is harder for the disobedient mid-level agent to overthrow the central

²⁴ Note that this is not to say that the lower-level participant's fighting action does not influence the central government. When the lower-level participant fights, the central government receives a negative payoff. The reason that we are not assuming that the mid-level agent's fighting action can overthrow the central government's control of the market is because his main fighting target is still the mid-level agent, rather than the central government, and the strength of power between the central government and the lower-level participant differs by too much.

government, but simultaneously it costs the central government more military spending, as it has a large territory to protect. Qing China, for example, compared with Edo Japan, has a higher f , due to its larger military scale and larger territory.

Cost of exposure (k): When the mid-level agent decides to not cooperate with the central government, he exposes himself to a risk of k . This k can be measured by the relative power of the mid-level agent compared with the military scale of the central government. When the mid-level agent has higher relative power, he faces lower cost of exposure, as it is more likely that he can overthrow the central government. Edo Japan's Daimyos, for example, would have a higher k compared with local governors in Qing China.

Success reward (X): The mid-level agent can enjoy the benefit from toppling the current central government's control on the rice market. This reward can be in the form of taxation – that all taxes that used to be collected in the rice market by the central government can now be collected by mid-level agent himself instead. X in Qing China, for example, would be higher than X in Edo Japan, due to the larger territory and population in Qing China.

Cost of fighting embezzlement (c): c is the cost it takes for the lower-level participant to fight embezzlement by the mid-level agent. Specifically, c is high when it takes a huge cost for the lower-level participant to fight against the mid-level agent's embezzlement, and c is low when it takes minimum cost for the lower-level participant to fight against the mid-level agent's embezzlement. For example, in the case of Qing China, we can measure c by the cost of building clubhouses (*huiguan*) in the nation²⁵ as a percentage of the lower-level participant's income in the rice market. We suppose $c \in [0,1]$, where 1 means extremely high cost and 0 means no cost at all.

Embezzlement willingness and ability measure (e): The willingness and ability held by the mid-level agent to embezzle goods owned by the lower-level participants. We suppose $e \in (0,1)$, where 1 means total embezzlement and 0 means zero embezzlement.

Lower-level participant's strength (z): A measurement on the strength of the lower-level participant where $z \in [0,1]$. $z = 1$ means that the lower-level participant is extremely strong and can completely eliminate embezzlement, and $z = 0$ means that the lower-level participant is extremely weak so that he cannot decrease any embezzlement at all.

Stability reward (ψ): ψ is the reward the central government can enjoy when the market is stable by holding the position of power and reaping a reward ψ from maintaining its ruling position. It is similar to the traditional holding office reward in revolutionary game literatures, such as (Ginkel,1999). The reward can be whittled away through an offer of legal protections, uncooperative action by the mid-level agent, or fighting action by the lower-level participant.

2.3.3 Endogenous Variable

The only endogenous variable, and the key variable in this paper, is the level of legal protection (a).

Legal protection (a): We suppose the level of legal protection follows $a \in [0,1]$, where $a = 0$ means not offering legal protection at any kind, and $a = 1$ means offering the strongest level of protection. Historically, an example of $a = 0$ can be the Maghreb merchants, who traded long

²⁵ In this paper, we use the number of clubhouses (*huiguan*) to measure the extent of fighting action by the lower-level participant. Further discussions of *huiguan* are given in section 4.

distances in the Mediterranean reduced their trading costs by hiring agents in the trading region in the 11th century. However, this came with the risk that the agents might embezzle the merchants' goods. The Maghreb merchants established an informal group known as the Merchants' Union since at the time the formal legal system was unable to adequately defend the commodities of the merchants. Within the Union, the merchants protected their interests by imposing multilateral penalties to prohibit bad reputations from engaging in future trade, and the agents were willing to sacrifice their immediate interests (embezzling the merchants' goods) for the long-term interest. An example of $a = 1$ can be the case of the 18th century of England when Lord Mansfield was the Lord Chief Justice of England. He established a set of very clear general principles which effectively protected the rights of merchants through a series of commercial litigations judgement – judgements since then have systematic principles to follow, rather than being determined arbitrarily. Individual merchants could fully protect their rights from infringement through legal means, without the need for any assistance from private institutions.

2.3.4 Players' Payoffs

In this section we study the payoffs of the three players.

Central Government's Payoffs

If the mid-level agent cooperates with the central government and the lower-level participant does not fight, the central government maintains control of the market, offering a legal protection level of a . The central government's payoff is $U_R = \psi - a$.

If the mid-level agent cooperates with the central government but the lower-level participant fights, the central government maintains control of the market, but needs to lose a cost dealing with the lower-level participants' fighting. The stronger the lower-level participant, the larger the cost is. We define the central government's payoff as $U_R = \psi - a - z$.

If the mid-level agent does not cooperate with the central government, and the lower-level participant does not fight, but the central government is able to hold control of the market successfully, the central government receives a frictional cost f . The payoff is $U_R = \psi - f$. Here a is not included in the payoff because when the mid-level agent does not cooperate with the central government, he is essentially refusing the central government's offer of legal right, so the two sides have not reached an agreement, and the central government does not lose the offer payoff a , since no such legal right protection is successfully established. Similarly, a is not included in the following payoffs due to this reason.

If the mid-level agent does not cooperate with the central government, and the lower-level participant fights, but the central government is able to hold control of the market successfully, the central government receives a frictional cost f , and also the fighting cost z . The payoff is $U_R = \psi - f - z$.

If the mid-level agent does not cooperate with the central government, and this causes the central government to lose control of the market, the central government's payoff is $U_R = -f$ if the lower-level agent does not fight, and $U_R = -f - z$ if the lower-level agent fights.

Notice that in our case, we have assumed that only the mid-level agent's uncooperative actions can cause the central government to lose control of the market. This is because historically, the lower-level participants' fighting strengths are limited in the rice market. Bribery or business coalition might be able to work when P wants to protect his profit from being embezzled but can

hardly rewrite the whole system of the market. Even the largest food riots in China have not successfully alter the system of the rice market.

Thus,

$$U_R = \begin{cases} \psi - a & \text{if } \gamma = 1 \text{ and } \delta = 1 \\ \psi - a - z & \text{if } \gamma = 1 \text{ and } \delta = 0 \\ \psi - f & \text{if } \gamma = 0 \text{ and } \delta = 1 \text{ and ruler holds control} \\ \psi - f - z & \text{if } \gamma = 0 \text{ and } \delta = 0 \text{ and ruler holds control} \\ -f & \text{if } \gamma = 0 \text{ and } \delta = 1 \text{ but ruler loses control} \\ -f - z & \text{if } \gamma = 0 \text{ and } \delta = 0 \text{ but ruler loses control} \end{cases}$$

Mid-level Agent's Payoffs

When the mid-level agent cooperates with the central government and the lower-level agent does not fight, he benefits from legal protection due to increased amount of trade, but also loses certain benefits of embezzlement. Thus, M receives $U_M = a + (1 - a)e$.²⁶ If instead the lower-level participant fights, M further loses $z(1 - a)e$, and receives $U_M = a + (1 - z)(1 - a)e$.

When the mid-level agent decides to not cooperate with the central government, but was punished so that the mid-level agent loses chances to continue embezzling, he suffers the frictional and exposure cost, and has $U_M = -f - k$. Here because he has lost the chance to continue embezzling, no terms regarding the embezzlement e are included in his payoff.

When the mid-level agent decides to not cooperate with the central government, and such action successfully causes the central government to lose control of the market (e.g. was not successfully punished), the mid-level agent gains the success reward X . Thus, $U_M = X - f - k$. Notice that the $(1 - a)e$ embezzlement gain is not explicitly included in the utility function because gaining X means new rules in the market are going to be designed by the mid-level agent, so the original embezzlement measurement does not work again.

So, we have,

$$U_M = \begin{cases} a + (1 - a)e & \text{if } \gamma = 1 \text{ and } \delta = 1 \\ a + (1 - z)(1 - a)e & \text{if } \gamma = 1 \text{ and } \delta = 0 \\ -f - k & \text{if } \gamma = 0 \text{ but ruler holds control} \\ X - f - k & \text{if } \gamma = 0 \text{ and ruler loses control} \end{cases}$$

Lower-level Participants' Payoffs

If the lower-level participant decides to fight, he could pay the cost of fighting as well as a lower cost of embezzlement dependent on his strength, and if he decides not to fight, he will face the full cost of embezzlement. We are not assuming that the lower-level participant can easily fight against the mid-level agent to completely eliminate embezzlement – it is more reasonable historically to assume that lower-level participants have used tactics like bribery or coalition to mitigate the mid-level agent's embezzlement. Note that we are dealing with the case where the

²⁶ Here we have simplified the model by assuming M fully enjoys the legal protection benefit (a), to avoid including too many parameters. Adding in a proportional variable to define M only enjoy part of the legal protection benefit is also possible but should not change the result significantly.

lower-level participant stays in the market for certain, because historically, they are merchants that have to trade their goods for a living.

This gives the utility of $U_P = \begin{cases} a - c - (1 - z)(1 - a)e & \text{When fighting} \\ a - (1 - a)e & \text{When not fighting} \end{cases}$

Summarizing the payoffs above, we have the following game tree.

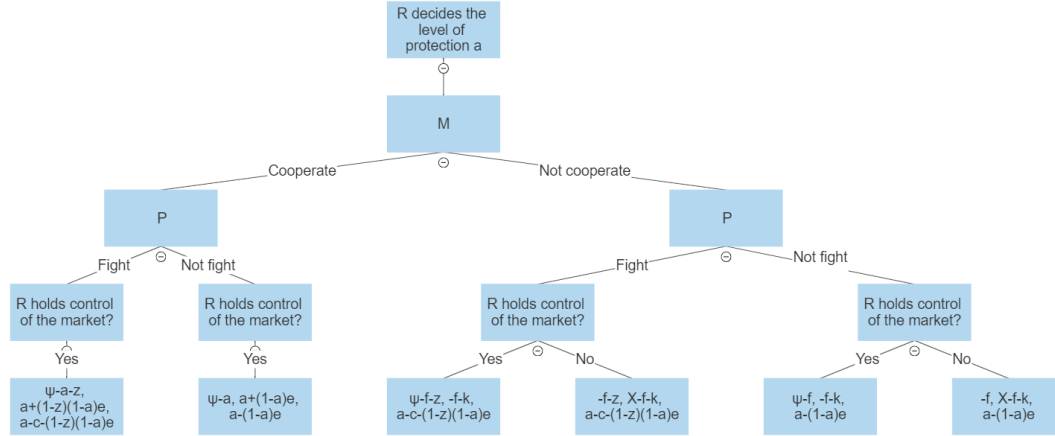


Figure 11 Game Tree

2.3.5 Results and Perfect Bayesian Nash Equilibria

In this section we give results and perfect Bayesian Nash Equilibria of the model. For specific proof, please refer to appendix 1.

Results are below:

Result 1 Lower-level participants fight against embezzlement when the legal protection level is low.

Result 2 A high level of legal protection makes the mid-level agent have the best response to cooperate.

Result 3 When the frictional cost f and exposure cost k is higher, the central government is more likely to not offer any legal protection.

Result 4 A Strong central government (with high θ , f , k) is more likely to hold power in the rice market than a weak central government, even without offering legal protections.

We first define strategy profile σ as the strategy profiles of the three players: $\sigma = (\sigma_R, \sigma_M, \sigma_P)$.

R's strategy profile σ_R is a mapping $[0,1] \rightarrow [0,1]$, and $\sigma_R(\theta) = a$.

M's strategy profile σ_M is a mapping $[0,1] \rightarrow \{0,1\}$, and $\sigma_M(a) = \gamma$.

P's strategy profile σ_P is a mapping $[0,1] \times \{0,1\} \rightarrow \{0,1\}$, and $\sigma_P(a, \gamma) = \delta$.

We then define belief μ as the belief of M on θ :

$$\mu(a) \in \Delta([0,1])$$

We are omitting the belief of P as P's payoff does not depend on the belief of θ and only depends on the value of a .

We define Perfect Bayesian Nash Equilibria (hereafter abbreviated as PBNE) as:

A pair of strategy profile σ and belief μ is a PBNE if,

- (1) at each information set ρ , each player maximizes his or her conditional expected payoff given μ
- (2) at each information set ρ , μ_ρ is calculated by Bayes' rule whenever it is reached, and μ_ρ takes any value if ρ is unreached.

Perfect Bayesian Nash Equilibria are:

- (1) Suppose $c \geq ez$,

The strategy profile $(\sigma(\sigma_R, \sigma_M, \sigma_P), \mu)$ is a PBNE where:

$$\begin{aligned}\sigma_R(t) &= 0, t \sim [0,1] \\ \sigma_M(0) &= 1, \sigma_M(l) = 0, l \sim (0,1] \\ \sigma_P &= 1 \\ \mu(0) &\text{ takes any value s.t. } \mu(0) \geq 1 - \frac{f+k+e}{X}\end{aligned}$$

- (2) Suppose $c \geq ez$,

The strategy profile $(\sigma(\sigma_R, \sigma_M, \sigma_P), \mu)$ is a PBNE where:

$$\begin{aligned}\sigma_R(t) &\in [\max(1 - \frac{c}{ez}, 0), \frac{(1-\theta)X-f-k-e}{1-e}], t \sim [0, 1 - \frac{f+k+e}{X}] \\ \sigma_R(t) &= 0, t \sim (1 - \frac{f+k+e}{X}, 1] \\ \sigma_M &= 0 \\ \sigma_P &= 1 \\ \mu(s) &\text{ takes any value s.t. } \mu(s) \leq 1 - \frac{f+k+e}{X}, s \in [\max(1 - \frac{c}{ez}, 0), \frac{(1-\theta)X-f-k-e}{1-e}]\end{aligned}$$

- (3) Suppose $c \leq ez$,

The strategy profile $(\sigma(\sigma_R, \sigma_M, \sigma_P), \mu)$ is a PBNE where:

$$\begin{aligned}\sigma_R(t) &= 0, t \sim [0,1] \\ \sigma_M(0) &= 1, \sigma_M(l) = 0, l \sim (0,1] \\ \sigma_P &= 0 \\ \mu(0) &\text{ takes any value s.t. } \mu(0) \geq 1 - \frac{f+k+e(1-z)}{X}\end{aligned}$$

- (4) Suppose $c \leq ez$,

The strategy profile $(\sigma(\sigma_R, \sigma_M, \sigma_P), \mu)$ is a PBNE where:

$$\begin{aligned}\sigma_R(t) &\text{ takes any value s.t. } 0 \leq \sigma_R(t) \leq 1 - \frac{c}{ez} \ \& \ 0 \leq \sigma_R(t) \leq \frac{(1-\theta_{guess})X-f-k-e+ze}{1-e+ze}, t \sim [0, 1 - \frac{f+k+e(1-z)}{X}] \\ \sigma_R(t) &= 0, t \sim (1 - \frac{f+k+e(1-z)}{X}, 1] \\ \sigma_M &= 0 \\ \sigma_P &= 0 \\ \mu(s) &\text{ takes any value s.t. } \mu(s) \leq 1 - \frac{f+k+e}{X}, s \in [0, 1 - \frac{c}{ez}] \ \& \ s \in [0, \frac{(1-\theta_{guess})X-f-k-e+ze}{1-e+ze}]\end{aligned}$$

2.4 Empirical Evidence

Our model predicts that strong central governments (equivalent to central government with higher θ , k and f in the model) are more likely to not offer legal protections (Result 3 & 4) than weak central governments (equivalent to central government with weak θ , k and f in the model). Moreover, a high level of legal protection leads to more participation and cooperation of the mid-level agent in the market (Result 1 & 2).²⁷

In this section, we turn to historical empirical evidence to support our model. We first discuss the strengths and weaknesses of Qing China and Tokugawa Japan with respect to Result 3 observed in section 2, and then support Results 1 and 2 through the historical records of rice merchant behavior and the rice markets performance.

2.4.1 Governments: Strong or weak

Based on Weberian definition of the state - holding a monopoly on the legitimate use of force in its territory (Linz and Stepan, 1996) - we measure the strength of the government by the degree of monopoly over force and the scale of domestic threat power. A government who has a complete monopoly on force and faced lower domestic threat power is considered a strong central government, while in contrast, a government who does not have a complete monopoly on force and faced higher domestic threat power is considered a weak central government.

In pre-modern China and Japan, a central government's monopoly on force was primarily reflected in its control of the military. In Qing China, the military was highly centralized and consumed nearly 60% of the Qing government's annual expenditure. At its peak in the mid-18th century the size of the Qing military reached 800,000 men, making it the largest military force in the world (Chen, 1992; Luo, 1984, Ding, 2003; Elliott, 2000). The Qing government had absolute control over the world's largest army, and no one could move it without his permission, corresponding to a high friction cost (f) in the model.²⁸

Compared to the Qing, the Tokugawa Shogunate's military power was much smaller. In Tokugawa Japan, Edo Bakufu had control over 30,000 troops in its dominions, which was about 5% of the total military in Japan (Koike, 2017). Although Edo Bakufu's military power was stronger than any other single Daimyo, some powerful Daimyos could also rival it, such as the lord of Kaga, who was able to mobilize an army of 20,000 soldiers. Therefore, it was difficult for Edo Bakufu to defeat a combination of powerful Daimyos with his own army alone, signifying a low friction cost (f) in the model. Moreover, the Daimyos, holding strong military power, would also face lower cost of exposure (k), because it would need fewer efforts recruiting armies, and its ability of punishing rebellions would also be weaker compared with its Qing China counterpart.²⁹

²⁷ The model also predicts that, even without offering strong legal institutions, strong central governments will still remain in power longer and more likely than weak central governments (Result 4). For details, see Appendix 2.

²⁸ According to Qing legal code, local commanders had to apply to their superiors before moving their troops, who then reported the matter to the central government, which in turn reported to the emperor. Only after receiving the Emperor's approval could a local commander move his troops. If a local commander moved his troops without the emperor's permission, he would be punished by caning or even exile.

²⁹ For example. When the shogunate suppressed the Shimabara rebellion (1637), its dispatched troops were repeatedly defeated by the rebel force, and eventually shogunate had to rely on the military power of

The geographical differences between China and Japan also affected the suppression capacity. China under the Qing Dynasty (1644-1911) controlled a landmass of 13.4 million square kilometers, which was more than 30 times the size of Tokugawa Japan. The distance from Beijing to Suzhou was over 1,000 kilometers, whereas the distance from Edo to Osaka was only 520 kilometers. The vast hinterland of Qing China was thousands of kilometers from the sea, while in Japan no region was more than 120 km away from the sea, which offered a cheaper transport system (Tan, 1982; Kikuchi, 2011). The larger territory and higher cost of transportation made overthrowing the regime more costly in China than in Japan, which is why rebellions in Qing China were confined to a certain region and hardly threatened the central government. Such a difference in geographic scale also contributed to a higher friction cost (f) in Qing China compared with Edo Japan.

In the rice market, both the Qing central government and the Tokugawa Shogunate faced potential or real threats to power. These power threats came mainly from the low-level and mid-level rice market participants. Figure 12 shows that number of food riots in China and Japan peaked in the mid-to-late eighteenth century and then declined, with Japan's number of food riots per million population more than two times than that of China. The comparatively active food riots in Japan demonstrated Edo Bakufu's lower θ compared with θ of Qing Emperor's.³⁰ Furthermore, although number of food riots fell over time in both regimes, food riots almost completely disappear in China after 1770, while in Japan they continued at an average rate of 3 or 4 per year.³¹ It is also worth noting that food riots in Qing China were mostly small-scale, short-term, and even the large food riots were limited to a few hundred people and to a single county or city (Wong, 1982). In contrast, in Tokugawa Japan, food riots were large-scale and long-term, with thousands or even tens of thousands of participants in large food riots, and thus more destructive. For example, in 1787, the food riots paralyzed the Edo government (Fukaya, 1979). This significant difference in the number and scale of food riots between Qing China and Edo Japan further implies a lower θ in Edo Japan compared with Qing China.

Daimyos to suppress the rebellion. And some of Daimyos involved in the suppression were able to mobilize tens of thousands of troops in a short period time. For more details, see Kanda (2005)

³⁰ Between 1781 and 1789, food output in Japan decreased as the climate deteriorated due to volcanic eruptions, leading to a massive famine (Temmei famine). This famine contributed greatly to the increase in food riots nationwide. For more details about Temmei famine, see Kikuchi (1997).

³¹ After the mid-18th century, the Qing government increased the penalties for those involved in food riots. This may have contributed to a significant reduction in food riots during the Qing dynasty (Fan and Luo 2011).

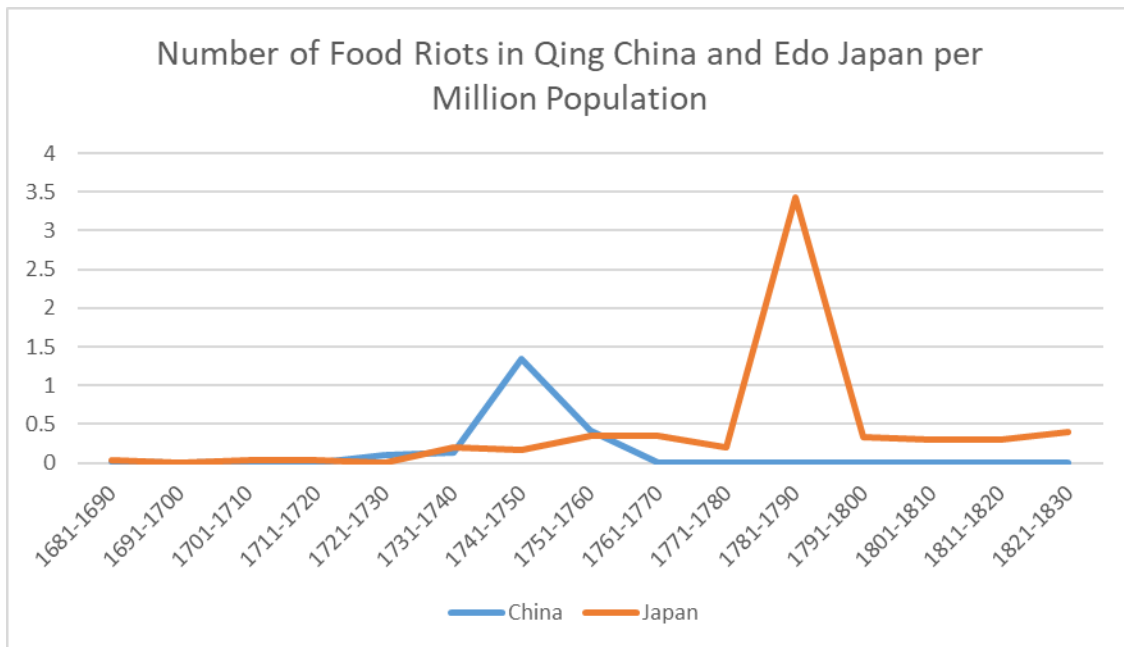


Figure 12 Number of Food riots in Qing China and Edo Japan per Million Population ³² Source: Cao (2001), Fukao et al (2017). Harada (1982), Horichi (2011) and Kitou (2000)

Table 1 records scattered series of *Kokudaka* revenues in Japan, which increased from the mid-17th century to mid-19th century, in contrast to the Shogunate's *Kokudaka* which peaked in the mid-18th century and then declined.³³ Bakufu's share of all *kokudaka* also declined from 17 percent in the early eighteenth century to under 14 percent in the early nineteenth century. As noted in section 2, Daimyos were major participants in the rice market and heavily relied on rice trading to meet financial expenditures, with some Daimyos deriving nearly 90% of their currency income from trading rice (Kusumoto, 1989; Takatsuki, 2011). Since *Kokudaka* can represent the economic and military strength of Daimyos, the total Daimyos' *Kokudaka* was also five to six times larger than Bakufu's (Katsu, 1968; Kikuchi, 1986), which enabled Daimyos to become a potential power threat against Bakufu in the rice market, corresponding to a lower θ in the model.

In contrast, in China the local government did not pose much of a threat to the Qing central government. In terms of the rice market. While Chinese local governments did exert control over the rice market through Lgb's management, their economic and political influence ultimately originated from the Qing central government. Consequently, local governments were more susceptible to central government regulation and oversight. Even the power of governors in early and mid-Qing China was much weaker than that of the central government (Guy, 2010). The Qing government prevented local officials from establishing close ties with other local powers (e.g., clans) by frequently transferring local officials (a magistrates' term of office in a locality was often one to three years) and by disallowing officials from serving as magistrates in their

³² Population data in Qing China and Edo Japan are comparatively limited so we carried linear interpolation.

³³ In Edo era, *Kokudaka* refers to total government revenues, expressed in terms of *koku* of rice, where 1 *koku* is roughly 180 liters volume. In this system, the output of crops other than rice and seafood was converted into the output of rice of the same economic value as those products.

hometowns. Furthermore, local governments in China had few powers to mobilize their armies, and most of their taxes had to be transferred to the central government (Ch'u, 1962). Unlike Daimyos, local governments in China lacked military and financial capability to be independent of the central government. (Zhou, 2021). This shows that in the case of Qing China, we can see fewer actions challenging the status quo of the rice market, and thus we can witness a more stable and higher θ compared with the Edo Japan case mentioned above. In short, Qing government had absolute dominance and control of both the local government and the *Yaren* system it used to manage the rice market,³⁴ corresponding to a higher θ in the model.

From the discussions above, we are able to see that by the eighteenth century, the Qing central government monopolized the use of force by controlling the nation's military power, faced lower number and scale of food riots (higher θ in the model), and had dominance over mid-level agents (higher θ in the model), making it a strong central government (higher f and higher k in the model). In contrast, Daimyos in Edo Japan maintained control of their own army, and thus the Bakufu could not monopolize the use of force. Bakufu also faced more powerful food riots (lower θ in the model), and faced significant danger of being replaced by some Daimyos either militarily or commercially in the rice market (lower θ in the model), signifying the Shogunate a weak central government (lower f and lower k in the model).

Our model's result matches the historical reality in which a strong central government like the Qing central government offered weak legal institutions, while a weak central government like the Edo Bakufu offered strong legal institutions. The logic here is simple: Stability of the rice market significantly influences the income of all Daimyos. Any Daimyo who embezzled merchants would not only face merchants boycotting the rice sold by that Daimyo, but also would lead to merchants' loss of confidence in the whole rice trade process and the whole rice market in Japan. This would lead to a more destabilized rice market, so that the income of all Daimyos would decrease. Naturally, decrease in Daimyo's income would increase Daimyos' tendency towards rebellion. The cost of providing legal protection for participants in the rice market was relatively small compared to the cost of suppressing a rebellion. Therefore, Edo Bakufu chose to create stable rice markets to meet the interests of both the Daimyos and the masses. On the contrary, the Qing Empire faced fewer food riots and lower risk of rebellion, and it was less costly for the Qing government to suppress sporadic food riots than providing long-term legal protections for rice market participants. As North points out - while stronger states are more able to ensure property rights, an overly powerful state may threaten the security of private ownership in the absence of constraints (North, 1994). Edo Bakufu offered legal rights to rice market participants, whereas the Qing central government preferred to suppress rebellion by military power rather than offering legal rights to mitigate the risk of power threats.

³⁴ Precisely because *Yaren* were subordinate to the Qing government, their existence was also highly dependent on government decisions. For example, in 1763, top bureaucrats had discussed the abolishment of the *Yaren* system. See, Lv (1991).

Table 1 The change of <i>kokudaka</i> in Tokugawa Japan			
Japan Combined		Edo Shogunate Region	
Year	Koku	Year	Koku
1644-1651	23,617,595	1702	4,005,623
1697-1702	25,910,642	1730	4,481,056
1716-1736	26,432,946	1757	4,482,900
1831-1834	30,558,918	1838	4,192,042
		1863	4,075,743

Table 1 The change of Kokudaka in Tokugawa Japan

Source: Kikuchi (1986), Murakami (1973) and (1982)

2.4.2 Merchants: Succumb or Fight

After the 17th century, *Huiguan* (clubhouse) emerged and grew throughout China, becoming the main informal institution in which merchants invested (Ho, 2017). Clubhouses would take a certain amount of members' business income to fund its operations, and in return, it would offer protections for members' economic interests (Qiu, 1990). However, as clubhouse was not recognized by legal system, it preferred to resolve commercial disputes through informal means such as negotiation. In the rice market, clubhouse was an important means for merchants to fight against *Lgb*. For example, in the early eighteenth century, rice merchants from the Dongting region established clubhouses to counter the long-standing embezzlement of *Lgb*. The clubhouse gradually replaced the formal legal system to effectively resolve disputes between merchants and *Yaren* (Fan, 1996). As Figure 13 illustrates, in Suzhou, the largest rice market at that time, number of rice clubhouses with a huge increase in 18th century.³⁵ Furthermore, Figure 14 also shows that, before mid-nineteenth century, a number of rice clubhouses were established nationwide, not merely in Suzhou. In Yellow River and Huaihe region, the volume of rice trade decreased significantly, while in Suzhou, the decrease was less significant due to the existence of clubhouses. In the absence of legal rights, Qing rice merchants were shaped as having more regionalism and collectivism. The Dongting merchants, for example, was a regional-based business group.

How did these clubhouses emerge and grow so rapidly in a short period of time? Result 2 in our model provides an explanation. When legal protections were not offered, such as the case in Qing China, mid-level agent (local government, represented by *Lgb*)'s willingness of carrying embezzlement was high, our model shows that market participants would become more likely to invest in their own ways of right protections. The establishment of these clubhouses provided merchants with ability to cooperate and generate synergies to fight against *Lgb*'s embezzlement.³⁶

³⁵ Merchants secure the interests of individual or group traders through joint petitions, and some merchants sell grain directly through clubhouse to avoid embezzlement by *Lgb*.

³⁶ People also choose to rely on the formal legal system to protect their rights when legal codes can offer protections for property. For example, because Qing legal codes were more protective of common property rather than individual property, this may account for the increase in clan-controlled common property (Greif and Tabellini 2017).

An exact opposite situation happens in Edo Japan. In Tokugawa Japan, merchants preferred to invest in business model rather than informal institutions.³⁷ Some large merchants ensured continued profitability and expansion through improving employment system, and some merchant family speculated by keeping abreast of rice prices (Takatsuki, 2011; Yasuoka, 1998). Effective legal rights also led to the emergence of individual investors, of whom the most famous one was Honma Munehisa, who was an active investor in rice market during 18th century. Born in Sakata, a city in east of Honshu, Honma first got success in local rice market, after which he moved on to speculate in the rice markets of Osaka and Edo, where he also achieved great success with his skillful investments because of his excellent investment skills he was hired as an economic adviser by shogun in his late years (Satou, 1972). It shall also be noticed that being a speculator in the rice market of Osaka and Edo, Honma Munehisa had cut off ties with his family, meaning that he achieved his success entirely as an individual investor rather than backing by family or community, which was unimaginable in a rice market without well legal protections for rice market participants' rights.

Honma's case could hardly happen in the rice market of Qing China. During Qing dynasty, successful merchants were known as *red-top* merchants, and the *red-top* was the hat of officials. As the words imply, in Qing China, successful merchants relied heavily on political power rather than superior investment skills. As property emanated from political power, which force merchants to seek custody under political power such as establishing private relationship with local magistrate or top bureaucrats (Fan, 2007).³⁸ Like the establishment of clubhouse, keeping private relationship with officials was an also important part of the investment in informal protections for merchants.³⁹

³⁷ It should be noted that in some commodity transactions without legal protections for individual rights, Japanese merchants also preferred to invest in informal protections for their rights. For example, Mitsuda (2021) shows that the *Hino Dai Toudan* of Omi merchants was similar to the clubhouse and would intervene to defend the interests of its members when they were involved in commercial disputes.

³⁸ Even in today's China, merchants still need to maintain good private relationships with the government in order to secure their property rights more effectively, but they also face the risk of expropriation by the central government. See, Shum (2021).

³⁹ Merchants maintained private relationships mainly through gifting money to officials. Although the exact amount was elusive, according to the research of Chang (1962), in the early nineteenth century, foreign trade merchants donated around 500,000 taels of silver per year to officials or the government, essentially half of the legal tariff amount.

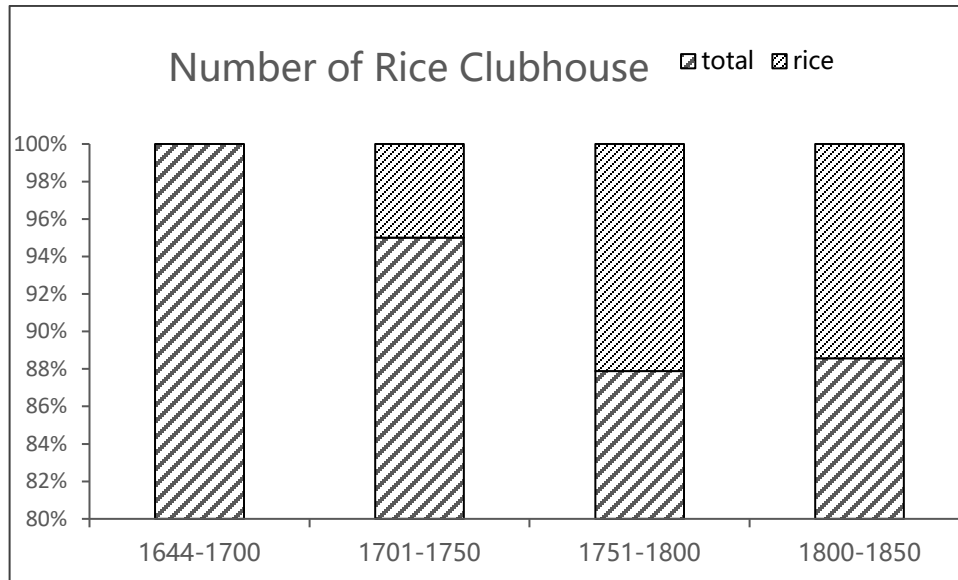


Figure 13 Rice Clubhouse in Suzhou. Source: Wang and Tang (2019)

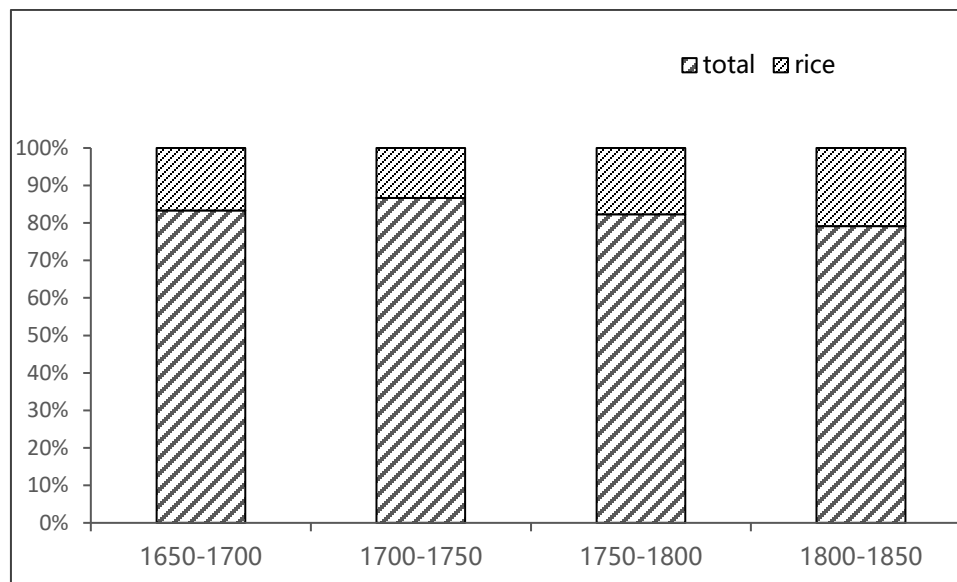


Figure 14 Rice Clubhouse foundations during the Qing dynasty. Source: Peng (1995)

2.4.3 Rice Market: Growth or Decline

While the rice markets in both Qing China and Tokugawa Japan developed in the 18th century, the rice market in Suzhou declined significantly from the late 18th century. According to Figure 15, the rice trade in Suzhou peaked in the mid-18th century and tailed from then on. By the early 19th century, the volume of rice trade in Suzhou was only half of what it had been at its peak. Rice trade in Huaihe and Huanghe area also decreased significantly, where rice trade in Huanghe region in year 1820 being only 1/7 of its trade amount in year 1770, showing a 6/7 decrease within 50 years.

By contrast, as shown in Figure 16, in Osaka, the volume of rice trade increased steadily from the early 18th century and peaked in the early 19th century. Furthermore, the volume of rice trade in the early 19th century was more than two times the volume of rice trade in the early 18th century.

Not only in Suzhou, but also throughout China, the trade in rice declined from its peak in the mid-18th century to a full-scale decline in the early 19th century (Cheung, 2008; Deng, 2009). In Japan, however, rice markets developed further after the mid-eighteenth century, with the continuous development of regional rice markets and even the emergency of trading rice futures in some markets (Hayashi, 2000). In terms of rice market integration, according to Figure 7, Yao's and Zheng's (2016) research shows that since the late eighteenth century, rice markets were more integrated in Japan than in China at national levels, rice market in west Japan were also more integrated than in the most developed in Yangtze delta, and results are still robust even accounting for weather shocks, public storage and political events.

While many factors impact the differences in rice markets performance between China and Japan, our study has only scratched the surface of this rich research program, and more research is necessary in the future. However, our model offered a theoretical explanation from institutional perspective for this difference. In contrast to centralized Qing China, during the Edo era, the Daimyos enjoyed a high degree of autonomy, making the Tokugawa Bakufu in Japan more decentralized. Many scholars (e.g., Arze et al., 2016; Faguet, 2014; Xu, 2011) have argued that decentralization was more conducive to the provision of public services and even economic development. Moreover, the decentralized Tokugawa Bakufu was more effective in implementing policies that offered legal protections for the rice market participants. Because Daimyos dominated Japan's rice trade, since the 18th century, Daimyos' financial system became increasingly dependent on rice markets (Ito, 2014). Legal protections supported the stable rice market (as shown in the likelihood of cooperation in the model), which in turn enabled Daimyos to obtain currency in a sustainable manner. In the end, Daimyos preferred to engage in rice market transactions for long-term benefits rather than for short-term benefits through embezzlement, decreasing e in the model and further enhances market's stability. The number of Daimyos participating in the Osaka rice market by the early 19th century was nearly four times the number of Daimyo in the 18th century. By contrast, in Qing China, because the weakness of formal legal protection, merchants had to invest in informal institutions to protect their own rights. As discussed in the famous research of Field (2007), in the absence of clear property rights, urban dwellers were forced to stay at home in order to assert their assets, which in turn affected their participation in the labor market. In Qing China, rice merchants faced a similar problem, as they had to invest more in protecting their rights. Such a high investment cost limited their participation in the rice market and thus partially resulted in the decline of the rice market.⁴⁰

⁴⁰ As we have stressed, this is a theoretical explanation, and more empirical research is necessary in the future.

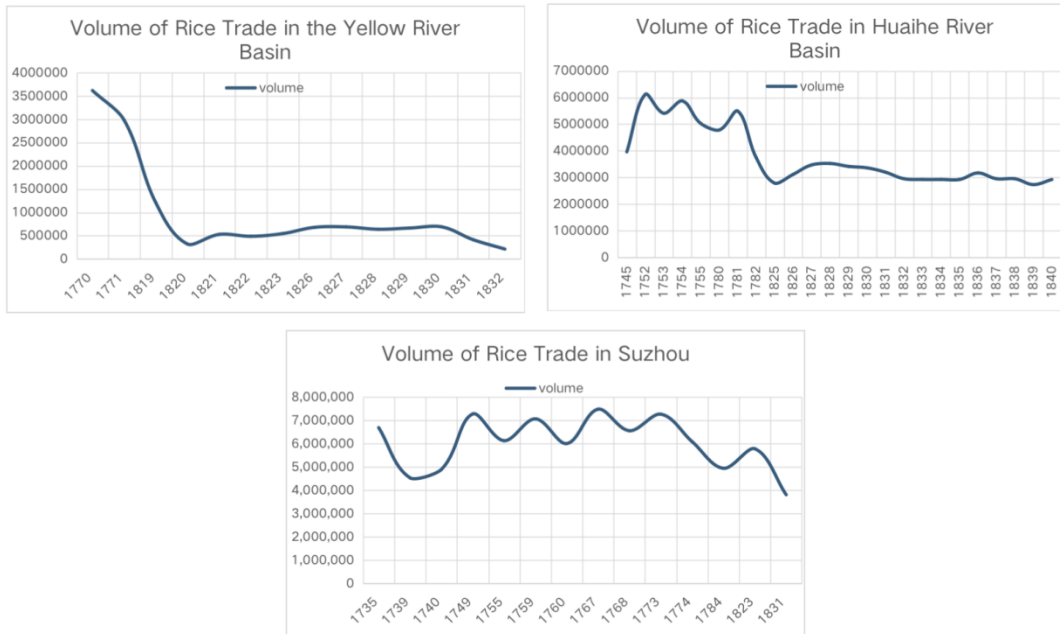


Figure 15 Volume of rice trade in China. Source: Liao (2007), Deng (1994)

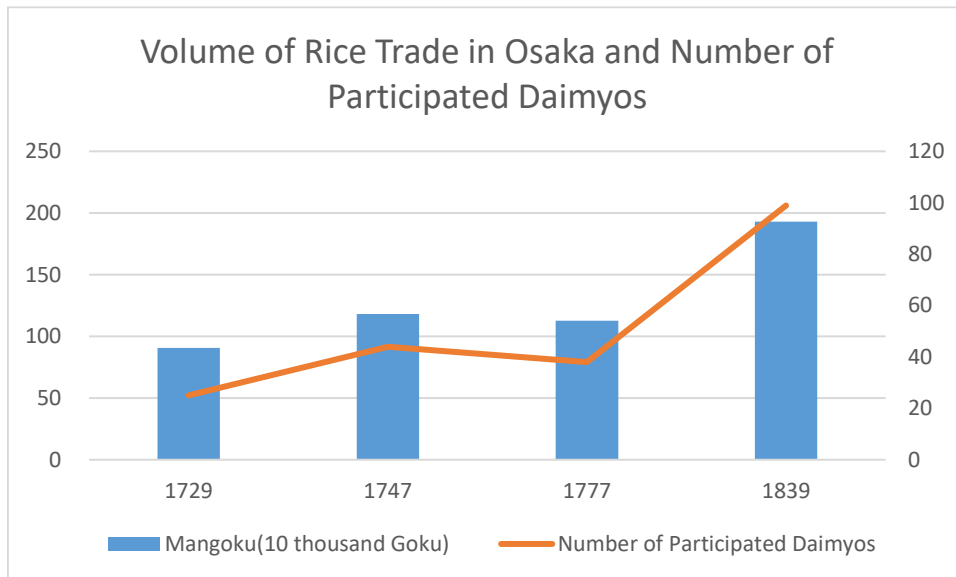


Figure 16 Volume of rice trade in Osaka. Source: Miyamoto (1988)

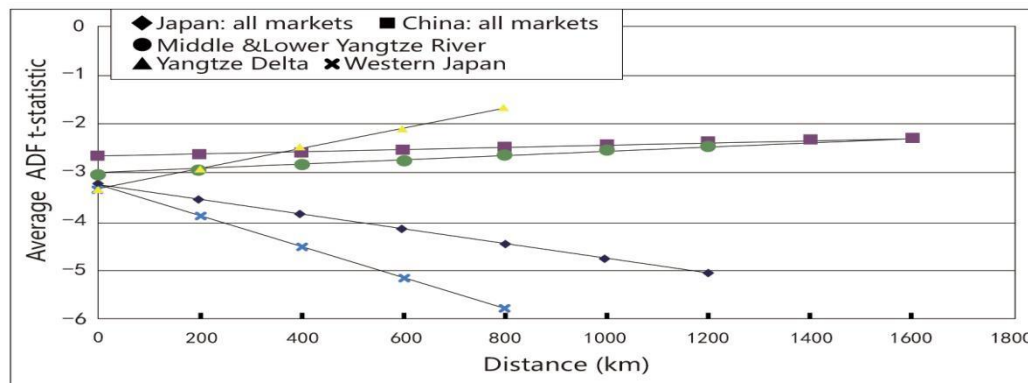


Figure 17 Cointegration for Japanese and Chinese Rice Market. Source: Yao and Zheng (2016)⁴¹

2.4.4 Equilibria: Qing China and Edo Japan

In this section, we look at the historical materials that matches Qing China and Tokugawa Japan with the Perfect Bayesian Nash Equilibria in section 3.5. The historical materials show that the situation in Qing China matches equilibrium (3), and the situation in Tokugawa Japan matches equilibrium (2).⁴²

Qing China: The situation in Qing China matches equilibrium (3).

As we have introduced in the previous sections, the embezzlement actions of Yaren (local government brokers, or *lgb*), were quite prevalent. *Lgb* could establish associations to take control of intermediary business, regulating trade in order to satisfy their interest despite the losses of merchants or farmers, signifying a high e (embezzlement willingness and ability) in Qing China (Negishi, 1932; Chen, 1992).

Facing *lgb*'s embezzlement, merchants in Qing China defended their interests by establishing clubhouses, which consisted of groups of merchants in the same industry or in the same region. They formed rules and regulations to maintain the functioning of the clubhouse, which in turn defended the interests of the members in case of disputes between them and others. For example, the Dongting merchants set up the *Dongting Clubhouse*, whose funds mainly came from the donations of the members, and the members elected 15 people as the directors to maintain the operation of the clubhouse, and the statute of the clubhouse also clearly expressed that the members enjoy the right of protection of the clubhouse, but also bear the responsibility of maintaining the clubhouse and the obligation to pay the funds. This is also the reason why in the 18th century, in Suzhou, when the rice merchants of the Dongting and the *Yaren* had disputes, the *Dongting Clubhouse*, rather than individual merchants, would step forward and appeal to protect the rights and interests of the members. (Fan, 1996; Tang, 1993) These clubhouses like the *Dongting clubhouse* increased the merchants' strength (z in the model) by bringing the individual

⁴¹ An augmented Dickey-Fuller test (ADF) tests the null hypothesis that a unit root is present in a time series sample, when the ADF is used in the test, is a negative number. The more negative it is, the stronger the rejection of null hypothesis.

⁴² In Appendix 2, we provide historical examples of equilibrium (1) and equilibrium (4).

merchants' power together. Moreover, for each individual merchant, a clubhouse was cheap to fund since there are many contributors to this clubhouse, signifying a low c in the model.

The local government in Qing China also witnessed in the strength of the central government. As we have discussed in section 4.1, a strong central government of Qing China made the local government to refrain from taking actions against the central government, signifying that the local government had the witnessed that the central government was strong enough, signifying the strong support $\theta \geq 1 - \frac{f+k+e(1-z)}{x}$ in the model.

Bringing the discussion, we see that a low c , high z , high e and high θ in Qing China matches the parameters in equilibrium (3). The equilibrium infers that Qing China's central government would not offer any legal protections, the local government would not act against the central government, and the merchants would fight against the lgb 's embezzlement, all of which completely matches the historical facts.

Edo Japan: The situation in Edo Japan matches equilibrium (2).

In 1730, the Shogunate established the *komekatanengyouji*(米方年行司) in Osaka to manage the rice market and receive lawsuits from rice merchants, thus bringing the rice market under the control of the Shogunate and preventing irregularities in the rice market through judicial means, so that the rice merchants could rely on the formal institutions of the state to protect their rights. For example, in 1791, when 54 rice merchants appealed to the Shogunate for the timely delivery of rice by the Chikugo Daimyo, the Shogunate intervened in the dispute and required that the Chikugo Daimyo deliver all of the rice in warehouse to the merchants, and reimburse the merchants for any shortfalls in the form of cash afterwards, thus settling the dispute within 20 days. (Takatsuki, 2012). The establishment of *komekatanengyouji* illustrates the legal protection a offered by the Shogunate, and reimbursed merchants did not need to fight against the embezzlement, because they were protected by the Shogunate.

Daimyos, on the other hand, lost the embezzlement income they could have enjoyed, and naturally tended to not cooperate with the Shogunate. As we have discussed in section 4.1 and 4.2 about Daimyo's relative power compared with the Shogunate, the relative power of Daimyo to Shogunate is much stronger compared to the case in Qing China, illustrating the support regarding $\theta \leq 1 - \frac{1-\frac{c}{ez}+\frac{c}{z}+f+k}{x}$. In the short term, Daimyo could also enjoy the stability of the rice market brought by the legal institutions, but as we have seen in the long term, Edo Bakufu was overthrown by armies of Choshu and Satsuma, namely the Satcho Alliance, showing Daimyo's uncooperativeness.

Brining the discussion together, historical facts concerning the legal protection offered by Tokugawa Shogunate, Japanese merchants' enjoyment of the legal protection, and Daimyo's uncooperative action in the long term all correspond well with the model result.

2.5 Conclusion

This paper examines the reasons why the pre-modern Chinese and Japanese governments provided different levels of legal protection for rice markets. According to our model, under the Japanese shogunate system, Daimyos had a high capacity for subversion against the shogunate regime by launching rebellions. The Tokugawa Shogunate had an incentive to provide strong legal institutions for the rice market to ensure that the Daimyos had a stable financial income and

thus mitigate the risk of rebellion, as Daimyos' financial income was highly dependent on the sale of rice. In contrast, under the absolutism of the Qing government, neither the local government nor the merchants had the ability to subvert the regime, and the government had no incentive to offer legal protections for the rice market.

Our model also offers insight into the different business behaviors of Chinese and Japanese merchants. With ample legal protections, Japanese rice merchants participated in smaller units of market transactions and had a stronger individualism than Chinese rice merchants. These factors contributed to the prosperity of Edo Japan's rice market, e.g., the Osaka rice market, and rice trade. In the absence of legal protection, Chinese rice merchants tended to form territorial groups and participate in the market in larger trading units, being more collectivist. Such lower legal rights contributed to the deterioration in Qing China's amount of rice trade, as seen in the stagnation in Suzhou rice market.

In this regard, our paper sheds new light on studies of the rice trade by examining the significance of legal protections. We argue that the difference in levels of legal protection being offered by the two nations' central governments was by no means a random event. Instead, it was determined by the two nations' level of centralization and further foreshadowed the two nations' different paths of development in the late 19th century. Additionally, because our study focuses on only two parameters in a pre-modern time period, extending our approach to study other parts of the world and different time periods, e.g., contemporary, may offer more insights about how power shaped not only legal institutions but also other political structures or political events.⁴³

⁴³ Moreover, bringing signaling into the game setting to study whether a weak central government has incentive to disguise itself as a strong central government could be an interesting extension worthy of exploration.

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Appendix 1 Prove of the Results and Equilibria Results

Remember that $U_P = \begin{cases} a - c - (1 - z)(1 - a)e & \text{When fighting} \\ a - (1 - a)e & \text{When not fighting} \end{cases}$

The lower-level participant will choose to fight or invest in their own ways of rights protections when $a - c - (1 - z)(1 - a)e \geq a - (1 - a)e$, simplifying which we have,

$$a \leq 1 - \frac{c}{ez} \quad (5)$$

So, we know that when $a \leq 1 - \frac{c}{ez}$, meaning that when the legal protection level a is low, the lower-level participant fights against the embezzlement.

We take this as result 1 below.

Result 1. Lower-level participants fight against embezzlement when the legal protection level is low.

We then study that given a certain legal right level a provided, how will the mid-level agent act.

The mid-level agent would be cooperative with the central government only if they considered the utility of being cooperative higher than the utility of being uncooperative.

Let's first consider the case when the lower-level participant fights, namely when

$$a \leq 1 - \frac{c}{ez}$$

For the mid-level agent to not cooperate with the central government, it must be that the utility of being uncooperative is higher than or equal to the utility of being cooperative, meaning that

$$\theta \times (-f - k) + (1 - \theta)(X - f - k) \geq a + (1 - z)(1 - a)e$$

Solving this we have,

$$a \leq \frac{(1 - \theta)X - f - k - e + ze}{1 - e + ze} \text{ s. t. } a \leq 1 - \frac{c}{ez}$$

However, remember that the mid-level agent cannot see the central government's true type before the mid-level agent takes action and can only have a guess, so we replace θ with θ_{guess} , and we replace this inequality as:

$$a \leq \frac{(1 - \theta_{guess})X - f - k - e + ze}{1 - e + ze} \text{ s. t. } a \leq 1 - \frac{c}{ez} \quad (6)$$

The above inequality shows that when the cost of friction f and exposure k is high, the mid-level agent is more likely to become cooperative, because a higher f and k cause the inequality above less likely to hold. Also when the guessed θ_{guess} is high, the mid-level agent is more likely to become cooperative. When higher protection is offered, e.g. a is higher, the inequality is less likely to hold so that the mid-level agent is more likely to cooperate with the central government.

Then let's consider the case when the lower-level participant does not fight, namely when

$$a \geq 1 - \frac{c}{ez}$$

Then for the mid-level agent to not cooperate with the central government, it must be that the utility of being uncooperative is higher than or equal to the utility of being cooperative, meaning that

$$\theta \times (-f - k) + (1 - \theta)(X - f - k) \geq a + (1 - a)e$$

We have (again replacing θ with θ_{guess}),

$$a \leq \frac{(1 - \theta_{guess})X - f - k - e}{1 - e} \text{ s. t. } a \geq 1 - \frac{c}{ez} \quad (7)$$

Similarly, we are able to have observations about dynamics of f , k , and θ_{guess} as the previous case. When the cost of friction f and exposure k is high, the mid-level agent is more likely to become cooperative, because a higher f and k cause the inequality above less likely to hold. Also when the guessed θ_{guess} is high, the mid-level agent is more likely to become cooperative. When higher protection is offered, e.g. a is higher, the inequality is less likely to hold so that the mid-level agent is more likely to cooperate with the central government.

So, to summarize, when (1) $a \leq 1 - \frac{c}{ez}$ and $a \leq \frac{(1 - \theta_{guess})X - f - k - e + ze}{1 - e + ze}$ or (2) $a \geq 1 - \frac{c}{ez}$ and $a \leq \frac{(1 - \theta_{guess})X - f - k - e}{1 - e}$, the mid-level agent has a best response to not cooperate. When (3) $a \leq 1 - \frac{c}{ez}$ and $a \geq \frac{(1 - \theta_{guess})X - f - k - e + ze}{1 - e + ze}$ or (4) $a \geq 1 - \frac{c}{ez}$ and $a \geq \frac{(1 - \theta_{guess})X - f - k - e}{1 - e}$, the mid-level agent has a best response to cooperate.

Looking at (3) and (4) above, we see that for the mid-level agent to have a best response to cooperate, it must be that $a \geq \frac{(1 - \theta_{guess})X - f - k - e + ze}{1 - e + ze}$ or $a \geq \frac{(1 - \theta_{guess})X - f - k - e}{1 - e}$, meaning that a should be high enough. Thus, the level of legal protection a must be high enough so that the mid-level agent can have the best response to cooperate. We take this as Result 2.

Result 2. A high level of legal protection makes the mid-level agent have the best response to cooperate.

Now we have understood the influence of a on M and P's actions. Let's proceed to the equilibrium studies.

We label the probability of the mid-level agent to become uncooperative to be β .

Let's first consider the case that lower-level participant does not fight, which means when

$$a \geq 1 - \frac{c}{ez}$$

Then the expected utility from the government offering a would be,

$$U_R(a) = (1 - \beta)(\psi - a) + \beta[\theta(\psi - f) + (1 - \theta) \times (-f)]$$

Simplifying it gives,

$$U_R(a) = \beta(\theta\psi - f - \psi + a) + \psi - a \quad (8)$$

When $\beta = 0$, $U_R(a) = \psi - a$. When $\beta = 1$, $U_R(a) = \theta\psi - f$.

So, if the mid-level agent cooperates, the central government has a best response to choose $a = 0$.

Let's see if this is also the best response for the mid-level agent vice versa. By examining the best response results we have derived in Result 2, we can see:

If $0 \geq 1 - \frac{c}{ez}$ holds, and $0 \geq \frac{(1-\theta_{guess})X-f-k-e}{1-e}$, then the mid-level agent also has a best response to cooperate with the central government.

So, every player is choosing his best response. We have an equilibrium ($a = 0$, cooperate, not fight) s.t. $0 \geq 1 - \frac{c}{ez}$ & $0 \geq \frac{(1-\theta_{guess})X-f-k-e}{1-e}$

If the mid-level agent does not cooperate, the central government is indifferent in choosing whichever $a \geq 1 - \frac{c}{ez}$, because his utility is the same $\theta\psi - f$. So if $1 - \frac{c}{ez} \leq \frac{(1-\theta_{guess})X-f-k-e}{1-e}$, for any $a \geq 1 - \frac{c}{ez}$ and $a \leq \frac{(1-\theta_{guess})X-f-k-e}{1-e}$, the mid-level agent chooses to not cooperate. Also because a can only take value between 0 and 1, we replace $1 - \frac{c}{ez}$ with $\max(1 - \frac{c}{ez}, 0)$. So, we have equilibria ($a \in [\max(1 - \frac{c}{ez}, 0), \frac{(1-\theta_{guess})X-f-k-e}{1-e}]$, not cooperate, not fight) s.t. $1 - \frac{c}{ez} \leq \frac{(1-\theta_{guess})X-f-k-e}{1-e}$

Then, let's consider the case that lower-level participant fights, which means when $a \leq 1 - \frac{c}{ez}$

$$U_R(a) = (1 - \beta)(\psi - a - z) + \beta[\theta(\psi - f - z) + (1 - \theta) \times (-f - z)]$$

s.t. $a \in [0, 1 - \frac{c}{ez}]$

Simplifying it gives,

$$U_R(a) = \beta(\theta\psi - f - \psi + a) + \psi - a - z \quad (9)$$

When $\beta = 0$, $U_R(a) = \psi - a - z$. When $\beta = 1$, $U_R(a) = \theta\psi - f - z$.

So, if the mid-level agent cooperates, the central government has a best response to choose $a = 0$.

Let's see if this is also the best response for the mid-level agent vice versa. By examining the best response results we have derived in Result 2, we can see:

If $0 \leq 1 - \frac{c}{ez}$ holds, and $0 \geq \frac{(1-\theta_{guess})X-f-k-e+ze}{1-e+ze}$, then the mid-level agent also has a best response to cooperate with the central government. So we have an equilibrium ($a = 0$, cooperate, fight) s.t. $0 \leq 1 - \frac{c}{ez}$ & $0 \geq \frac{(1-\theta_{guess})X-f-k-e+ze}{1-e+ze}$.

If the mid-level agent does not cooperate, the central government is indifferent in choosing whichever $a \leq 1 - \frac{c}{ez}$, because its utility is the same. For any $a \leq 1 - \frac{c}{ez}$ and $a \leq \frac{(1-\theta_{guess})X-f-k-e+ze}{1-e+ze}$, the mid-level agent chooses to not cooperate. So we have equilibria (a , not cooperate, fight) where $a \leq 1 - \frac{c}{ez}$ and $a \leq \frac{(1-\theta_{guess})X-f-k-e}{1-e}$.

We first define strategy profile σ as the strategy profiles of the three players: $\sigma = (\sigma_R, \sigma_M, \sigma_P)$.

R's strategy profile σ_R is a mapping $[0,1] \rightarrow [0,1]$, and $\sigma_R(\theta) = a$.

M's strategy profile σ_M is a mapping $[0,1] \rightarrow \{0,1\}$, and $\sigma_M(a) = \gamma$.

P's strategy profile σ_P is a mapping $[0,1] \times \{0,1\} \rightarrow \{0,1\}$, and $\sigma_P(a, \gamma) = \delta$.

We then define belief μ as the belief of M on θ :

$$\mu(a) \in \Delta([0,1])$$

We are omitting the belief of P as P's payoff does not depend on the belief of θ and only depends on the value of a .

We define Perfect Bayesian Nash Equilibria (hereafter abbreviated as PBNE) as:

A pair of strategy profile σ and belief μ is a PBNE if,

- (3) at each information set ρ , each player maximizes his or her conditional expected payoff given μ
- (4) at each information set ρ , μ_ρ is calculated by Bayes' rule whenever it is reached, and μ_ρ takes any value if ρ is unreached.

Perfect Bayesian Nash Equilibria are:

- (5) Suppose $c \geq ez$,

The strategy profile $(\sigma(\sigma_R, \sigma_M, \sigma_P), \mu)$ is a PBNE where:

$$\sigma_R(t) = 0, t \sim [0,1]$$

$$\sigma_M(0) = 1, \sigma_M(l) = 0, l \sim (0,1]$$

$$\sigma_P = 1$$

$$\mu(0) \text{ takes any value s.t. } \mu(0) \geq 1 - \frac{f+k+e}{X}$$

- (6) Suppose $c \geq ez$,

The strategy profile $(\sigma(\sigma_R, \sigma_M, \sigma_P), \mu)$ is a PBNE where:

$$\sigma_R(t) \in [\max(1 - \frac{c}{ez}, 0), \frac{(1-\theta)X-f-k-e}{1-e}], t \sim [0, 1 - \frac{f+k+e}{X}]$$

$$\sigma_R(t) = 0, t \sim (1 - \frac{f+k+e}{X}, 1]$$

$$\sigma_M = 0$$

$$\sigma_P = 1$$

$$\mu(s) \text{ takes any value s.t. } \mu(s) \leq 1 - \frac{f+k+e}{X}, s \in [\max(1 - \frac{c}{ez}, 0), \frac{(1-\theta)X-f-k-e}{1-e}]$$

- (7) Suppose $c \leq ez$,

The strategy profile $(\sigma(\sigma_R, \sigma_M, \sigma_P), \mu)$ is a PBNE where:

$$\sigma_R(t) = 0, t \sim [0,1]$$

$$\sigma_M(0) = 1, \sigma_M(l) = 0, l \sim (0,1]$$

$$\sigma_P = 0$$

$$\mu(0) \text{ takes any value s.t. } \mu(0) \geq 1 - \frac{f+k+e(1-z)}{X}$$

(8) Suppose $c \leq ez$,

The strategy profile $(\sigma(\sigma_R, \sigma_M, \sigma_P), \mu)$ is a PBNE where:

$$\sigma_R(t) \text{ takes any value s.t. } 0 \leq \sigma_R(t) \leq 1 - \frac{c}{ez} \ \& \ 0 \leq \sigma_R(t) \leq \frac{(1-\theta_{guess})X-f-k-e+ze}{1-e+ze}, t \sim [0, 1 - \frac{f+k+e(1-z)}{X}]$$

$$\sigma_R(t) = 0, t \sim (1 - \frac{f+k+e(1-z)}{X}, 1]$$

$$\sigma_M = 0$$

$$\sigma_P = 0$$

$$\mu(s) \text{ takes any value s.t. } \mu(s) \leq 1 - \frac{f+k+e}{X}, s \in [0, 1 - \frac{c}{ez}] \ \& \ s \in [0, \frac{(1-\theta_{guess})X-f-k-e+ze}{1-e+ze}]$$

Looking at (1) and (3), in these two equilibria, central governments offer $a = 0$ when $\theta \geq 1 - \frac{f+k+e}{X}$ or $\theta \geq 1 - \frac{f+k+e(1-z)}{X}$. This shows that a higher f and k makes the inequality more likely to hold, in which the central government will offer $a = 0$.

Historically, nations with stronger central power tend to have higher f and k , so this gives us result 3 below.

Result 3. When the frictional cost f and exposure cost k is higher, the central government is more likely to not offer any legal protection.

Then we examine equilibria (1) and (3) from a different perspective. The result of the equilibrium shows to us that mid-level governments tend to cooperate with the central government even if the central government does not offer legal rights at all. This matches countless historical results.

On the other hand, let's examine equilibria (2) and (4). These two equilibria take place when $\theta \leq 1 - \frac{1-\frac{c}{ez}+\frac{c}{z}+f+k}{X}$ or $\theta \leq 1 - \frac{f+k+(1-z)e}{X}$, showing that if the central government is weak enough, it is the mid-level government's best response to choose to not cooperate with the central government despite the central government offers a moderate level of legal right protections.

Summarizing the above findings, we have result 4 below.

Result 4. A Strong central government (with high θ , f , k) is more likely to hold power in the rice market than a weak central government, even without offering legal protections.

Appendix 2 Central Governments: To Survive, or not to Survive

Although our model focuses on the central government-player relationship in rice markets, we can also extend our modeling insights to explain how the strong central governments low-legal rights equilibrium enabled them to have a longer holding-power than weak central governments with high legal rights. Our framework also casts light on other types of central governments (Monopoly of military power but higher domestic threat power or non-monopoly of military power but lower domestic threat power) which match equilibrium (1) and equilibrium (4).

We firstly apply our model's equilibrium result to analyze *why* it was the Qing Emperor rather than the Edo shogun who ruled longer. The Nash equilibrium result in our model shows that a weak central government, though offering legal protections, will still end up in the long-term equilibrium where the mid-level agent does not cooperate with or rebel against the central government, because the mid-level agent's act of rebelling strongly dominates the act of not rebelling. Comparing to Qing emperor, with weaker military power, narrower territory, and higher threat power, even with strong legal institutions, the Shogun might not escape from the fate of being overthrown sooner.

Since the establishment of shogunate system in 1603, despite the shogun's efforts to weaken the power of Daimyos by various means, Daimyos still had a high level of autonomy. Meaning that a Daimyo could develop the economy, politics and even the military within his domain. In Edo era, both the shogun's and Daimyos' armies consisted of samurai and conscripted peasants (Fujiwara, 1987). In the absence of military innovations such as weapons or military organization, the shogun might still be able to enjoy its temporary stability. But once new military technologies emerge, the Daimyos quickly realized that these new technologies decreased shogunate's possibility to survive a rebellion (θ in the model), and the temporary stability inevitably collapses toward the long-term equilibrium of Daimyos' rebellions. Thus, it is not surprising that some powerful Daimyos (Dai-Damyos) who traded heavily in rice market became gravediggers of the Edo shogunate.⁴⁴

For example, the lords of Choshu and Satsuma were prototypical cases of both a major participant in rice market and the main force in the overthrow of the shogun. Although the lords of Choshu and Satsuma benefited significantly from trading in rice market,⁴⁵ in the mid-19th century, the Daimyos immediately undertook military reform with the introduction of western military technology. By equipping the army with new weapons, building new navy and reforming military organizations, Choshu and Satsuma boosted the quality and quantity of the army in a short time. By 1861, Satsuma was able to mobilize 50,000 soldiers with over 4,000 new rifles, two warships and some artillery units (Haraguchi, 2001). This change in military power immediately broke the balance between the shogun and the Daimyos. Hence, from 1864 to 1866 the Shogun fought two wars against the Choshu but defeated, so that the shogun's authority was further weakened. In 1868, in the Battle of Toba-Fushimi, the Shogunate's forces were again defeated by the allied

⁴⁴ For example, the *kokudaka* of Kagahan, Satsumahan, and Choushuhan were 1.2 million *koku*, 728,000 *koku*, and 360,000 *koku* respectively, and the combined *kokudaka* of these three Daimyos were close to half of the Shogunate's *kokudaka*. It is also noteworthy that even a Daimyo who belong to a branch of the Tokugawa family, such as Mitohan, was involved in the overthrow of the Tokugawa Shogunate at the end of the Shogunate.

⁴⁵ In the early 19th century, the amount of rice sold in the Osaka rice market alone by Choshu and Satsuma amounted to 120,000-140,000 *koku* per year, which accounted for around 7% of the entire volume of rice trade in Osaka (Miyamoto, 1988).

forces of Choshu and Satsuma, and the Shogunate system eventually came to an end (Banno, 2012).⁴⁶

Turning back to Qing China, where the emperor's monopoly on military power played a key role in perpetuating the status quo of holding power. In 1681, through eliminating domestic feudal lords, the emperor gained a monopoly on military power. With strong military power, the central government could easily reach equilibrium (3) in the model, where he did not need to cater other player's interest. In this context, even the introduction of new military technology after the Opium War in 1840 did not significantly decreased the government's probability of survival (θ in the model). However, since the Taiping rebellion, eight banners and green standard army were defeated by the Taiping army, which forced emperor to rely on local governmental military power such as the *Xiang Army* and *Huai Army*. Hence the emperor's monopoly on military power was broken and initiating the process of local militarization (Kuhn, 1970). As the emperor's control over military power weakened, the Qing empire became increasingly decentralized. For example, during the Boxer Rebellion, governments of southeastern provinces refused to follow the central government's orders to declare war on the Eight-Nation Alliance. By the early 20th century, although the Qing government tried to build a modernized army to maintain military superiority to local military power, new army relied heavily on the financial support of individual provinces, which weakened new army's allegiance to the emperor. Some new armies even became private military force for certain generals and would easily rebel against Qing government when their interests were not met.⁴⁷ This clearly matches equilibrium (2) in the model, where a weak central government will face rebellions whatever catering he offers. Eventually, as the emperor's military power weakened and local military power increased, in 1911 a new army in Wuhan broke out in a revolution against the central government and was supported by new armies from many provinces, eventually overthrowing the Qing emperor (Fung, 1980).

In the previous discussions, we have introduced the case of Qing China, which has strong military and low food riots, and the case of Edo Japan, which has the exact opposite – weak military and high food riots. Naturally, one may wonder what would happen if a state has both strong military and high food riots. We present the case of *Sui* Empire in China, to demonstrate that the case of strong military and high food riots match equilibrium (4) in our model.

In 581, the *Sui* Empire was established as a successor to the *Beizhou* Dynasty. After the conquests of the fragmented regimes such as *Xiliang*, in 588, the *Sui* Empire launched an attack on the *Chen* Dynasty, which had occupied the southern China, and completely conquered the *Chen* Dynasty in 590, thus ended the long period of division that had existed for almost 300 years and reunified China (Gao, 2006; Wang, 2008). 2008). The army of the *Sui* Empire consisted of 16 armies (16 *Wei*), 12 of which were responsible for foreign conquests and territorial defense, and four of which were permanently stationed in the capital (Bai, 2007). As a highly centralized empire, the *Sui* empire has all armies under the direct command of the emperor, who would appoint wartime

⁴⁶ The difference in weapons affected the fighting ability of the shogunate and Daimyos' armies. For example, at the Battle of Toba-Fushimi, the Shogunate army was armed with only 94 cannons, despite being three times as the size of the allied army, which was armed with 583 cannons.

⁴⁷ A typical case was Yuan Shikai. In 1901, He established *Beiyang* army and promoted a large number of commanders who were loyal only to him, making it difficult for the central government to mobilize the *Beiyang* army. In 1911, although Yuan Shikai had been previously demoted, central government had to reinstate him to command *Beiyang* army against revolutionary army. Ironically, Yuan Shikai did not suppress the revolutionary army, but forced the Qing emperor to abdicate after reaching an agreement with the revolutionaries in his favor (Tang 2004).

commanders to fight against the rival army during wartime. But after the war was over, the armies would immediately return to their original stations, and the emperor would take back the command (Fu, 1993). In the north, with its military power, the *Sui* Empire defeated the nomadic Turkic Khaganate and eliminated *Tuyuhun*, thus bringing the Mongolian plateau and Central Asia into the imperial sphere of influence (Fan, 1978). In the south, the *Sui* empire maintained a permanent military presence in the *Nanzhong* region (Yunnan and Guizhou provinces) to suppress the local ethnic groups and conquered the northern part of Vietnam by force (Fang, 1992; Fu, 1993). Thus, by the beginning of the 7th century, the *Sui* Dynasty had become a vast empire stretching from the Mongolian plateau in the north to the south of the Indo-China peninsulas.

While the reunification of the China provided a stable political environment for economic development, the *Sui* Empire was a more centralized economic system in which much of the agricultural output was expropriated by the government, and merchants and peasants were subjected to exploitation by officials who made it difficult to protect their rights (ZGJJ, 1982). In the early 7th century, both the *Sui* Empire's war against Goguryeo (one of three kingdoms of Korea) and mega projects (e.g. Grand Canal, Great Wall) incurred a substantial financial and manpower deficit and further increased the burden on *Sui* citizens. In 611, outbreak of Wang Bo revolt took place in Shandong. Although it was quickly suppressed, it was followed by a series of revolts in various regions, involving tens or even hundreds of thousands of people, such as the *Ajiu* army in Shandong, which was as large as 100,000 people. Although the *Sui* Empire suppressed the revolts many times, some of the rebels were also able to defeat the *Sui* army, such as the *Wagang* army which defeated the *Sui* army in 616 and 617 and established a regime (Fan, 1978). Eventually, the *Sui* Empire was unable to suppress the revolts, and finally fell in 618, where emperor Yang Guang was killed by the local government leader Yuwen Huaji. The lack of legal protections, high level of exploitation, the local government's rebel and high level of food riots all match our equilibrium result precisely.

Having discussed about equilibrium (2), (3) and (4), we would like to briefly touch upon the land and labor market's legal protection situations in Edo Japan, which matches equilibrium (1) in the model. In the Edo era, the Tokugawa Bakufu did not offer strong legal protection for participants in the land and labor markets. In the land market at that time, a debtor could still require a creditor to return the mortgaged land as long as the principal was repaid, even if the repayment was overdue for a number of years (Shirakawabe, 1994). In the labor market, information about the residents of a locality would be logged into the Nimbetsuaratamecho (人別改帳, Resident Registration Form), and only the individuals whose information was on the Nimbetsuaratamecho could be protected by the law. On the contrary, when a resident had no corresponding information in the Nimbetsuaratamecho, he or she would not be protected by the law, and it is very difficult for individuals to transfer their information from the resident registration form in one area to the resident registration form in another area, thus greatly impeding the free movement of labors. (Saito and Sato, 2012). The logic here is that the Daimyos were not direct participants in the labor and land markets compared to the rice market, corresponding a smaller e in the model and making the inequality $c > ez$ more likely to hold. Edo Bakufu then faced less risk of rebellion concerning the labor and land markets. Therefore, Edo Bakufu preferred to maintain the labor and land markets at a lower cost rather than investing in higher costs to offer stronger legal protections for participants.

Chapter 3

3. The Price of Survival

- **A Signaling Game Model on the Origins and Outcomes of Decentralization in Authoritarian States, taking 1850-1894 Qing China as an example⁴⁸**

3.1 Introduction

Why do states decentralize? Numerous developing and developed countries have implemented decentralization to date. (Garman et al., 2001; Hooghe et al., 2010). Many scholars have argued that decentralization can improve public services, make government more effective, reduce corruption, and even boost economic growth (e.g., Arze et al., 2016; Dillinger, 1994; Enikolopov and Zhuravskaya, 2007; Fisman and Gatti, 2000; Faguet, 2014; Qiao et al., 2008). However, the question of why states decentralize has been referred to as the “black hole” of the decentralization debate without a satisfactory answer (Faguet and Pöschl, 2015). Although decentralization may undermine the central government’s or ruler’s hold on power (Hariri, 2012; Landry, 2008; Treisman, 2006), many states including empires throughout history relied on decentralized institutional arrangement (Atasoy, 20016; Sanderson, 1995). It is thus critical to understand why states choose to devolve their power and resources to others who are beyond their control.

Our study is motivated by the decentralization in the history of the late Qing China. In conventional wisdom the Qing Empire was seen as a typically centralized state, in which the local government lacked the economic or military power to counterbalance the central government. However, the fact that the central government of the Qing empire devolved its fiscal and military power to the provincial governors after 1850s shall not be neglected. Following the decentralization, the Qing Empire not only succeeded in suppressing the largest domestic rebellion (the Taiping rebellion), but also engaged in state building and entered a new era of prosperity (Rowe, 2009). Against this backdrop, in the spirit of work that emphasizes presence of selfish rulers and officials with their own agenda (Brennan and Buchanan, 1980; Olson, 1993), we build a model to analyze the incentives and actions of these policymakers. We use the model to explain 1) why the Qing central government adopted a decentralization policy after the mid-nineteenth century; 2) why limited state building occurred in the late Qing Dynasty; and 3) why, despite triumphs over domestic rebellions, after the mid-nineteenth century the Qing empire's international conflicts were harder to defeat than to win and suffered a humiliating defeat in the First Sino-Japanese War. Moreover, jumping out of the Qing China case and looking from a greater picture, the model is able to explain 1) why authoritarian states decentralize; 2) why decentralization causes local disobedience and collapse of empires; and 3) why it could be hard for authoritarian states to offer decentralization in spite of knowing its necessity.

The impact of decentralization on policymakers' action in our model depends on two factors-the ruler’s type being strong or weak, and the capacity of war to overthrow current regimes. We emphasize that the capacity of war overthrowing the regime shaped the Qing China's institutional response to the wars that it faced before and after the 19th century. When the capacity of war overthrowing the current regime is low, our model implies that rulers are reluctant to weaken their

⁴⁸ This chapter is co-authored with Rui Wang from Hitotsubashi University

rule by decentralizing power even when they face the possibility of defeat. Conversely, when the capacity of war overthrowing the current regime is high and decentralization mitigates the risk of losing power, the ruler has higher incentives to decentralize. The incomplete information regarding the ruler's type also lead weak rulers to mimic the actions of a strong ruler. Moreover, the paper finds that although a strong ruler never offers decentralization, a weak ruler has a natural tendency to pretend itself as a strong ruler by not offering any decentralization of power, until the time when his weakness is revealed.

Decentralization shifts the fiscal and military functions of the central government to the provincial government. Under the decentralized regime in the late Qing China, governors with higher power have higher discretion, and are more likely to be able to choose to not follow the central ruler's order. Thus, a natural tendency for the local governors to increase their relative power occurred. We demonstrate in our model that governors are more likely to be able to choose to not cooperate with the central ruler, when they have increased their relative power, e.g. when investment has been made in improving fiscal and military capabilities, rather than in improving citizens' living standards.

Our main contribution is to advance understanding of the debate on the origins of decentralization. In line with the seminal work of Tiebout (1956), Musgrave (1959), Oates (1972; 1999) viewing government as a benevolent agent, the case for decentralization is simply made by arguing that the central devolve power to the local yields greater public sector efficiency and better positioned to recognize local preferences and needs. Alternative theoretical arguments emphasize that public officials are motivated more by self-interest than by benevolence or consideration of efficiency, and that decentralization is thus a mechanism to achieve policy ends (Weingast, 1995) or a means for central elites to remain in power (Sabatini, 2003). However, these seminal works have far focused on democratic rather than non-democratic countries.⁴⁹ While scholars have recently considered the formation of decentralization in non-democratic states (e.g., Ahmad and Brosio, 2006; Gandhi, 2008; Hess, 2013), they focused largely on the post-1950 countries case and lacked an examination of decentralization under non-democratic countries (e.g. autocratic regimes) in other periods. This paper contributes to this literature by offering a new perspective of War-decentralization and the case of China in 19th century. Although there are varieties of decentralization (Bardhan, 2002; Bo, 2020; Bo et al, 2021; Jin et al, 2005; Litvack et al., 1998; Qian and Roland, 1998;), in our baseline model, we equate decentralization with fiscal and military decentralization.⁵⁰

This paper joins a large literature on the "war made states" in economic history (e. g., Besley and Persson, 2010; Scheve and Stasavage, 2012; Tilly, 1990;). Past scholarships emphasize the role of interstate war in state-building. In Western Europe, frequent interstate conflicts led to the enhancement of state capacity (e. g., Dincecco, 2011; Hoffman, 2015; Karaman and Pamuk, 2013; Queralt, 2019). However, the Western case does not tell the whole story about war and state capacity. First, in many non-Western countries, internal rather than external conflict plays an

⁴⁹ A number of theoretical and empirical studies have identified that in democracies, decentralization is benefit for political parties and incumbent politicians, which trigger them to design and practice decentralization between national and local governments (Enikolopov and Zhuravskaya, 2007; O' Neill, 2005; Riker, 1964).

⁵⁰ In this paper, we follow Faguet (2015) in defining decentralization as the devolution by central government (Qing government) of specific functions-With fiscal and military attributes that these entail- to regional governments (Provincial governments) that are substantial autonomy within given functional domains.

important role in state-building (Bai et al., 2023; Garfias and Sellar, 2012; Slater, 2010), and second, war is not an exogenous event; different states' institutions can have different impact on the process of war. Thus, a "good" or "bad" institution may be a cause (instead of the consequence) of war.⁵¹ In our historical context, compared to Koyama et al. (2018), who argue that decentralization in the late Qing China was a response to an external threat, our work places more emphasis on the important role of internal conflict (civil war) in shaping the Qing China's decentralization, and the impact of decentralization on the China's interstate war in the late 19th century. Our findings can further enrich the understanding of Tilly famously argues that "states made war, and war made states."

This paper also contributes to classic debates on the role of self-strengthening movement in the China's modernization (e.g., Elman, 2004; Gasster, 1972; Hsu, 1970; Chen, 2006; Wright, 1962;). In these historians' works, both external threats such as Western imperialism or Japanese empire, and intrinsic constraints such as conservative ideology or political struggle predetermined the self-strength movement as a successful reform. In contrast to the view of "failure" self-strength movement, some empirical studies suggested that the movement promoted the development of Chinese industry (Bo et al., 2023) and succeeded in spreading Western ideas and even changing Confucian ideology (Kwong, 1984; David, 1994). However, beyond these debates, there remains agreement that the self-strengthening movement was not a broad-base reform. In this paper, we link selfish officials with self-strengthening movement. We argue that governors (with fiscal and military functions) were consistent with our theoretical prediction that maintaining autonomy resulted in their higher willingness to invest in bargaining power and weaker incentives for broad base reforms.

The rest of this paper is organized as follows. Section 2 first discusses the historical background to motivate our model. Section 3 presents the model. Section 4 presents further historical evidence mainly based on the late Qing China and connects them with the main results of our model. Section 5 makes the conclusion.

3.2 Historical Setting

Both the concept and practice of centralized rule has a long history in China, and this system developed to its greatest maturity under the Qing Dynasty (1644-1911). Prior to 1850, the Qing emperor effectively exercised governance over a large empire of 14 million square kilometers with more than 300 million people through a centralized bureaucracy. This empire was emperor-centered, without hereditary nobility or force outside the center that could place on the power of the emperor and his agents. After 1850, however, the Qing Empire rapidly shifted from centralization to decentralization. Why did decentralization occur in the late Qing Dynasty? What impact did decentralization have on the Qing Empire? This section provides a historical background. We first describe the shift in the political structure of the late Qing China, followed by the state capacity under the decentralization. Within state capacity, we focus on fiscal capacity and military power that motivate our analysis.

3.2.1 From Centralization to Decentralization

After 1644, the Manchus conquered most of China in a few years and established the Qing Empire. To govern the vast territory, Manchu rulers largely took over the governmental structure of the Ming, including the three-tier administrative structure of province-prefecture-county. A

⁵¹ Fascist states, for example, then saw war as an important means to achieve national recovery and thus were more belligerent. (Payne, 1995)

province was a large administrative unit: it with tens of millions of people and almost one million of square kilometers. The central government appointed governors to head one or more provinces (Guy, 2010a).⁵² Although governors were the leaders of provinces, they merely implemented the established policies of the central government and had no unauthorized policymaking, let alone having fiscal and military autonomy (Liu, 2003).

Before 1850, the Qing Empire implemented a solid centralized fiscal system. Under the system, there was no fiscal agency independent of the board of revenue (*Hubu*), which had direct fiscal authority in each provinces (Deng, 1998).⁵³ The provinces collected their taxes according to the central government's tax rates and transferred them to the board of revenue, which regulated the amount of provincial expenditures, and the governors reported the provincial revenues and expenditures to the central government each year, with detailed explanations for any excesses (Shi and Xu, 2008). The board of revenue was subordinate to the emperor, reporting to him at all times on the state's fiscal status and providing policy advice, and ultimately, the emperor decided the direction and implementation of the state's finances.

Like the centralized fiscal system, the central government also controlled the military of each province. Although the governors had a certain number of direct troops and were charged with the responsibility of monitoring provincial armies (Liu, 2003).⁵⁴ However, the supreme commander of a province's army (the Eight Banners and the Green Standard Army) was the *Tidu* (Infantry Commander), not the governor, who took orders directly from the emperor; and in case of war, the central government's dispatched officials, not the governor or *Tidu*, led one or more provinces' armies into battle, (Luo, 1984). The emperor had absolute control over the national army, and neither the governor nor the *Tidu* had the power to move their troops without the emperor's permission. Any disobedience or discretion would result in severe punishment.

Not only did governors have no autonomy, their appointment and removal were also decided by the central government. The emperor asserted his authority through frequent appointments and dismissals of governors, with nearly 40% of governors serving for less than one year and nearly 20% serving for less than six months before 1850 (Zhang, 1980). As Guy (2010b) pointed out, during the high Qing era, governors were merely local representatives of the monarchy and did not have an independent political function.

In the context of imperial China in the 19th century, a political shift toward decentralization took place in the late Qing dynasty. According to Zhang (1980), after 1850, less than 20% of governors served less than one year, and the number of governors serving less than six months decreased from 103 in the first half of the 19th century to 21, while some governors even served more than nine years.⁵⁵ Notably, the number of dismissed governors also declined from 143 before 1850 to 28.

⁵² The *Dufu* of the Qing Dynasty included the governor who administered one province and the viceroy who administered several provinces, but there was no huge difference between the two. In this paper, the governor is used to refer to *Dufu*.

⁵³ The board of revenue set up *Buzhengshi* (Provincial administration office) in each province, who was responsible for managing the fiscal system of a province and had the right to report directly to the central government.

⁵⁴ Governor's direct command of only a few hundred troops, and in wartime these troops will also be transferred to a unified command system which is led by the central government. See, Liu (2003).

⁵⁵ For example, Zhang Zhidong, served for 9 years as the governor of Hubei and Hunan. And Li Hongzhang was the governor of Zhili for 13 years.

This change in the appointment and removal of governors coincided with an increase in their autonomy. After the 1850s, the central government allowed governors to raise their own armies, such as the Xiang Army and Huai Army. Unlike the Green Standard Army and the Eight Banners, which were controlled by the central government, these armies were financed by the regional governments and were under the command of the governors (Peng, 2021). After the 1860s, the emperor further empowered the governors to control the province's armies, including the Green Green Standard Army and the Eight Banners (Liu, 2003). In addition to the decentralization of the military system, one dimension of decentralization during this period was fiscal. After the 1850s, the central government granted more fiscal autonomy to the provinces. Consequently, the governors established their own fiscal agencies to manage the provincial finances instead of the fiscal organs directly under the board of revenue (Deng, 1998). Meanwhile, after transferring a portion of their revenues to the central government, the provinces were allowed to distribute the remainder without having to follow the amount of spending regulated by the central government (Shi and Xu, 2008). Provincial governments were also allowed to collect new taxes, such as transit taxes known as *Lijin*, to increase their tax sources, thus gaining greater fiscal autonomy.

3.2.2 Late Qing China: "Jumbo" but Weak

After decentralization, the Qing Empire not only survived the domestic rebellions (Taiping Rebellion, Nian Rebellion and Hui Rebellion), but also entered what historians call the "Tong-Guang Restoration" period (1862-1894) (Qian, 2011; Wright, 1962). During this period, as the political situation stabilized, not only did the social-economic development, but also the state capacity of the Qing Empire, especially her fiscal and military capabilities, also grew significantly.

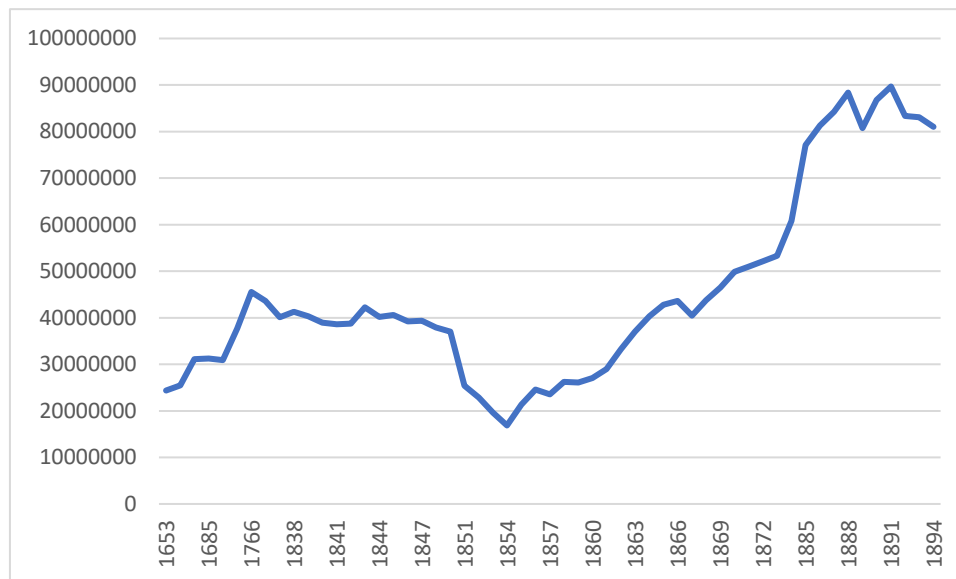


Figure 18 Qing China fiscal revenue, 1653-1894 (Silver Taels). Source: Deng (1998), Ni (2017), Zhou (2000), Shi and Xu (2008)

Before 1850s, the Qing empire relied heavily on land taxes and collected low taxes. (Ma, 2013; Sng, 2014; Wang, 1973) However, after 1860, this picture was changed. Figure 18 shows that

after peaking in the mid-18th century, revenues in the Qing Empire continued to decline and fell to a low point in the mid-19th century but rose again from the 1850s onward. By the end of the 19th century, the Qing Empire's revenues were five times higher than those of the early 19th century and about twice as high as the 18th century peak. Moreover, according to Shi and Xu (2008), if the fiscal revenue at the disposal of the provinces is included, the national revenue would have reached 140 million silver taels by 1894, which is seven times the lowest point of the fiscal revenues before 1860 and three times the highest point of the fiscal revenues.

Along with the increase in fiscal capacity, the military power of the Qing Empire was further strengthened after 1850s. Before mid-19th century, the Qing Empire's military consisted of the Eight Banners and the Green Standard Army. However, from the late 18th century, the fighting capacity of these armies declined and were successively defeated by domestic rebellious forces in the 19th century.⁵⁶ As a result, the Green Standard Army and the Eight Banners were gradually phased out, and patrol and defense troops (e.g., Huai Army), equipped with Western-style weapons and with more fighting capacity, were established in the provinces (Luo, 1984). Beginning in the 1860s, a group of governors spearheaded the Self Strengthening Movement. The main purpose of the movement was to strengthen the Chinese army through the use and mastery of Western weapons and technology. From 1862 to 1894, the Qing government invested 270 million taels of silver to acquire Western weapons to equip its armies (Fan, 2009). From the 1870s, armies were equipped with breech-loading guns and in the 1890s, they were updated with the new Mauser rifles, and some armies were even equipped with hand-cranked Gatling machine guns⁵⁷; in terms of artillery, the government also purchased a large number of artillery pieces, including Krupp guns, by the 1880s, the Huai army alone with 370 breech-loading guns of various types (Xia, 1992). Along with the purchase of Western weapons, the governors also established a number of modern military industries to meet the army's weapons needs. From 1861 to 1894, 30 western-style military factories and 4 shipyards were established across the country to produce military equipment. For example, Jiangnan Arsenal, the largest military factory in East Asia, was able to mass produce breech-loading Armstrong guns (with a range of 7,000-11,000 yards) and produced millions of rounds of breech-loading ammunition annually by the 1880s, and further succeeded in producing rapid-fire machine guns that could load 40-pound and 100-pound shells by the 1890s (Elman, 2004; Meng, 1999).⁵⁸ Besides western equipment, the Qing government employed British and French military officers to train the army and Chinese officers since the 1860s; after the Franco-Prussian War, the Qing government studied the German army, hired a large number of German commanders to teach military knowledge in China, and sent officers to Germany to study military technology, while establishing a number of Western-style military academies in China to train professional army officers (Powell, 1955; Xia, 1992). By the end of the 19th century, the Qing Empire had built up a standing army of more than 300,000 troops equipped with advanced Western weapons, unlike the Green Standard Army and the Eight Banners, which were mainly cold-armed (Moll-Murata and Theobald, 2013).

In addition to the reform of the army, the Qing Empire also reformed its navy after the mid-19th century. From 1860 to 1894, the Qing Empire spent more than 69 million taels of silver to acquire

⁵⁶ The Green Standard Army and the Eight Banners had already shown lower combat power in the pacification of the White Lotus Rebellion, and were even defeated in the subsequent suppression of the Taiping Rebellion and the Nian Rebellion.

⁵⁷ For example, the Sheng army led by Weirugui was equipped with Gatling machine guns in the 1870s.

⁵⁸ By contrast, Japan did not begin its artillery program until the early 20th century. For details, see Meng (1999).

a large number of battleships from Germany and Britain (Fan, 2009). By the 1890s, the Chinese navy had 65 large ships and 43 torpedo boats, surpassing not only the Japanese navy but also the French and Russian fleets in the Far East, and approaching the size of the British China Station (Fan, 2009; Kawasaki, 1896). The most impressive battleships were *Ding Yuan* and *Zhen Yuan*, each weighing 7,430-tons and armed with 12-inch Krupp guns, which were more powerful than the largest U.S. Navy ships of the time, *Maine* and *Texas* (Elleman, 2021). While purchasing warships from Europe, the Qing government also sent officers to England to learn about the navy knowledge and introduced the British naval training model, by the end of the 19th century the naval officers and men had acquired a high level of military education.⁵⁹ Like the land force, the domestic military industry also provided weapons and equipment for the navy. In the 1870s, the Jiangnan Arsenal was able to produce iron-hulled warships with 1800 horsepower and 26 guns, and the Fuzhou Shipyard could also mass-produce warships with 80-250 horsepower to form flotilla; in the 1880s, the Arsenal further produced the 1900 horsepower steel gunboat (Zhou, 1971; Meng, 1999).

However, compared to a broad-base reform of the Meiji Restoration (e.g., overhaul of the land ownership system; the introduction of compulsory education and western ideas; implementation of constitutionalism) during the same period, the Qing Empire only improved its fiscal and military capabilities, and even some significant endeavors of the Self-Strengthening Movement were quite limited.⁶⁰ As a result, greater military power did not prevent the Qing Empire from losing in international competition. Even the gap between Chinese army and French Army had been closed technologically, the Qing state still lost the Sino-French (1883-1885) War and lost its suzerainty over Vietnam (Rawlinson, 1967). During the Sino-Japanese War (1894-1895), the Qing army even had more advanced weapons and equipment than the Japanese army in many local battlefields, but the Qing army still experienced humiliating defeats; eventually, the Qing empire not only lost its suzerainty over Korea, but also had to cede the Taiwan island to Japan and pay huge reparations (Fung, 1994; Paine, 2003).

Next, we will build a theoretical framework to analyze the origins of decentralization and how the interact between the decentralization and state-building to shape the response of the late Qing China to the interstate war in late 19th century.

3.3 The Model

In this section, we model the relationship between a ruler (as the personification of the central government), and a local governor (*Dufu*). The ruler needs the governor's military support to help ensure stability of his ruling so that he can receive the profits of holding power when facing challenges, the governor considers whether to cooperate with the ruler to fight the challenge or not, depending on the level of decentralization offered as well as the ruler's strength.

3.3.1 Setup

The model includes two players: A ruler (*R*), who has the choice to determine the level of decentralization to be offered. There are two types of rulers – strong ruler (a priori with a

⁵⁹ For example, in a Japanese report on the Beiyang fleet, the officers and men of the Beiyang fleet were described as serious in their discipline, well-maintained in their weapons, and adequately trained. The fleet was also able to maintain good formations while underway. See, Chen (2010).

⁶⁰ These endeavors included: Setting up foreign language schools; translating western works of science and technology; investing in civilian industry such as steel mills, cotton-spinning and weaving companies, iron foundries, and steam navigation companies.

probability of $1 - p$) and weak ruler (a priori with a probability of p). We define a strong ruler as one that will 100% survive a challenge and can fully punish the uncooperative governor by fully confiscating its asset when the governor does not cooperate. A weak ruler, on the other hand, will only survive by a chance, and will only be able to partially punish the local governor even if he or she survives. A local governor (G), who has the choice to decide whether to cooperate with the ruler or not. Cooperating with the ruler means getting the decentralization offered but having to help the ruler to fight the challenge, and not cooperating with the ruler means enjoying the current power yet would be punished by the ruler if the ruler survives the challenge. The governor does not know the type of ruler when it makes decision.

The game is a one-shot game in the following order:

1. Ruler knows its type, a strong ruler or a weak ruler.
2. Severity of challenge (θ), the probability that the weak ruler can survive given the challenge without local governor's help, is revealed and known by both players. When the challenge is severe, θ would be low. When the challenge is mild, θ would be high. When there is no challenge at all, θ is 100%. A strong ruler will always survive the challenge so is not affected by θ .
3. Given the severity of the challenge, the ruler decides the level of decentralization $a \in [0,1]$ that he would like to offer. By offering a , if the governor accepts a , deciding to cooperate with the ruler, the ruler can have chance $\theta + F$ surviving the challenge (where F is the relative strength between the ruler and the governor), compared with the original chance of θ . However, his profit of holding power would also decrease. The specific explanations will be given later.
4. The governor decides to cooperate with the ruler or not, given the action a offered by the ruler. The uncooperativeness action can take place in terms such as rebellion or obedience. We define the action by γ , where cooperating with the ruler means $\gamma = 1$ and not cooperating with the ruler means $\gamma = 0$.

The Ruler Learns Its Type

The ruler learns that whether it is a strong or weak ruler and knows it as a private information. Nature determines the severity of challenge $\theta \in [0,1]$.

Ruler Chooses the Level of Decentralization

Given the severity of challenge θ , the ruler chooses its level of decentralization a it would like to offer. By offering a higher a , the governor is more likely to cooperate with the ruler, because they are able to receive higher level of decentralization. Historically, this a could be the grant of local autonomy, such as granting the right to collect tax, build the governor's own army, etc.

Level of decentralization (a): The central government can allow the governor to be more autonomous, giving them the right to organize army, collect taxes by themselves, etc. Such offer of decentralization can effectively enhance the local government's incentives to cooperate with the ruler. However, in the meanwhile, this is a cost for the ruler, as offering decentralization is not only costly but also weakens the ruler's power. This is a tradeoff that the ruler must consider.

The Governor Acts

The governor, based on the observed severity of challenge θ and the ruler's level of decentralization a , decides to cooperate with the ruler or not. Cooperating with the ruler means that the governor will help the ruler fight against the challenge, and bear related costs.

Parameters

Stability reward (ψ): The reward the ruler can enjoy by staying in power, surviving the challenge, i.e. the profits of holding power. It can also be understood as the ruler's strength.

Governor strength (ϕ): The strength that the governor originally holds. If the governor is not autonomous at all, ϕ is 0. If the governor is very autonomous, ϕ can be large.

Relative Factor (F): $F = \frac{\phi}{\psi}$. It measures the relative strength between the local governor and central ruler.

Ruler's Payoffs

Without the governor's help, the weak ruler can survive the challenge for the chance θ . And the strong ruler can survive the challenge regardless of the governor's action. We define that the ruler offers a level of decentralization $a \in [0,1]$.

The payoff for the ruler is simple. When the governor accepts the level of decentralization and cooperates with the ruler, the ruler receives $(1 - a)\psi$ if she survives and receives 0 if she fails. If the governor does not cooperate with the ruler instead, the offer of a is not formed, so the ruler receives ψ if she survives and receives 0 if she fails.

Thus, we have

$$U_R = \begin{cases} \psi & \text{if ruler survives, } G \text{ does not cooperate} \\ (1 - a)\psi & \text{if ruler survives, } G \text{ cooperates} \\ 0 & \text{if ruler fails} \end{cases}$$

Governor's Payoffs

When the governor cooperates with the ruler, besides the original strength ϕ she or he had already held, she or he also receives the decentralization offered by the ruler, namely $a\psi$. However, cooperating with the ruler to fight the challenge requires cost. Here because the severity of challenge is θ , we model the governor's payoff when cooperating with the ruler as $(\phi + a\psi)\theta$. When the challenge is more severe (θ is smaller), the governor needs to pay higher price fighting the challenge, resulting in a smaller utility. Notice here that in our model, even the ruler fails, the governor still gets the payoff if she cooperates with the ruler. This is because the transfer of strength (e.g. talents, money, etc.) has already been transferred to the governor, unlike the case that such kind of transfer is not done when the governor does not cooperate with the ruler.

When the governor does not cooperate with the ruler, and the ruler happens to be weak and fails to survive, although the governor cannot receive the level of decentralization offered $a\psi$, it can maintain its original strength ϕ . When the governor does not cooperate with the ruler, but the ruler survives, the ruler will likely punish the governor for its inaction. Here we model the governor's utility as 0 when the ruler is strong and ϕF when the ruler is weak, because the strong ruler will fully punish the uncooperative governor, and for weak rulers, relative strength between the governor and the ruler matters in terms of how severe the ruler can punish the governor. If the governor is relatively weak, it will easily be punished and lose its strength significantly. However,

a strong governor with a strong army would be less likely to be successfully punished by the weak ruler.

Thus, we have

$$U_G = \begin{cases} (\phi + a\psi)\theta & \text{if cooperate} \\ \phi & \text{if not cooperate, and the weak ruler fails} \\ \phi F & \text{if not cooperate, but the ruler survives, and the ruler is weak} \\ 0 & \text{if not cooperate, but the ruler is strong} \end{cases}$$

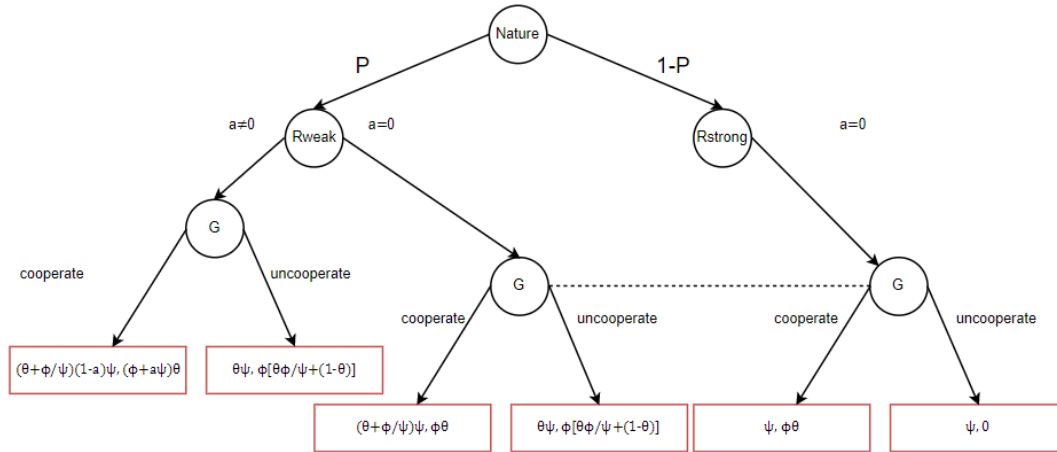


Figure 19 Game Tree

3.3.2 Players' Responses

Result 1. Governors are more likely to cooperate with the ruler when the challenge is weak and the governor himself is weak

Proof:

When cooperating with the ruler, the governor gets utility $(\phi + a\psi)\theta$.

When not cooperating with the ruler, if the ruler is a weak ruler, the ruler has chance θ to survive and chance $1 - \theta$ to fail, so the governor's expected utility by choosing to not cooperate is $\theta\phi F + (1 - \theta)\phi$ if the ruler is weak. If the ruler is strong, the governor's expected utility is zero when not cooperate.

Thus, the governor will only cooperate with the ruler when

$$(\phi + a\psi)\theta \geq p(\theta\phi F + (1 - \theta)\phi)$$

That is,

$$a \geq \left(\frac{1 - \theta}{\theta} F + F^2 \right) p - F$$

As we can observe from this inequality, if the ruler is a weak ruler ($p = 1$), when the challenge is weak (θ is large), the right side of the inequality is smaller, allowing a lower a that can still force the governor to cooperate. Moreover, when the governor's relative power is small (F is small), a small a can make the inequality hold. The governor is more likely to cooperate with the ruler

when the challenge is weak and the governor itself is weak. On the other hand, however, when the governor is strong, or that the challenge is strong, it is unlikely for the governor to cooperate with the ruler as the right side of the above inequality is large, making the inequality less likely to hold.

When the ruler is strong ($p = 0$), however, the governor needs to cooperate with the ruler regardless of any level of decentralization.

Result 2. A strong ruler always chooses to offer no power, while a weak ruler may disguise himself as a strong ruler by offering no power.

Proof:

We first consider the case when the ruler is strong.

A strong ruler will never offer actions other than $a = 0$, because this action weakly dominates the other actions. Because a strong ruler always survives a challenge, any $a > 0$ for him generates lower utility when the governor cooperates. Thus, he always offers $a = 0$. A weak ruler, on the other hand, might try to disguise himself as a strong ruler by offering $a = 0$.

When offering a , the ruler knows that the governor will cooperate if and only if

$$a \geq \left(\frac{1-\theta}{\theta} F + F^2 \right) p - F$$

When a weak ruler offers $a > 0$, the governor immediately knows that the ruler is weak, because a strong ruler will never offer such an action. Thus, $p = 1$, and the governor will cooperate if

$$a \geq \frac{1-2\theta}{\theta} F + F^2$$

Suppose that the weak ruler offers $a \geq \frac{1-2\theta}{\theta} F + F^2$ so that governor cooperates.

The weak ruler's payoff would be $(\theta + F)(1 - a)\psi$.

Suppose that the weak ruler offers $a < \frac{1-2\theta}{\theta} F + F^2$ so that governor does not cooperate.

The weak ruler's payoff would be $\theta\psi$.

Thus, if $(\theta + F)(1 - a)\psi \geq \theta\psi$ holds for at least one a where $a \geq \frac{1-2\theta}{\theta} F + F^2$, namely $(\theta - 1)^2 + F\theta \leq 2\theta^2 F$, the weak ruler prefers the governor to cooperates, and thus chooses the value a that maximizes $(\theta + F)(1 - a)\psi$ given $\frac{1}{F+1} \geq a \geq \frac{1-2\theta}{\theta} F + F^2$.

So, if $\frac{1-2\theta}{\theta} F + F^2 \geq 0$, namely when $\frac{1}{\theta} \geq 2 - F$, the weak ruler chooses $a = \frac{1-2\theta}{\theta} F + F^2$, and has utility $(\theta + F) \left(1 - \frac{1-2\theta}{\theta} F - F^2 \right) \psi$. If $\frac{1}{\theta} < 2 - F$, the weak ruler chooses $a = 0$, and has utility $(\theta + F)\psi$.

If instead $(\theta + F)(1 - a)\psi \leq \theta\psi$ holds even for the smallest a , namely $0 \geq \frac{\phi}{\theta\psi + \phi}$, the ruler is better off by not letting the governor to cooperate. However, this is not possible because $\phi > 0$.

Then let us examine the case where he disguises himself as a strong ruler by choosing to offer $a = 0$.

When the ruler chooses $a = 0$, the governor cooperates with the ruler when

$$0 \geq \left(\frac{1-\theta}{\theta} F + F^2 \right) p - F$$

This is when $p \leq \frac{1}{\left(\frac{1-\theta}{\theta} + F\right)}$. Utility of the ruler in this case is $(\theta + F)\psi$. When $\frac{1-2\theta}{\theta} F + F^2 \geq 0$, namely when $\frac{1}{\theta} \geq 2 - F$, $(\theta + F)\psi$ dominates $(\theta + F) \left(1 - \frac{1-2\theta}{\theta} F - F^2\right) \psi$, so the weak ruler deviates to choose $a = 0$. When instead $\frac{1}{\theta} \leq 2 - F$, the two utilities are the same, so the weak ruler chooses $a = 0$.

When $p \geq \frac{1}{\left(\frac{1-\theta}{\theta} + F\right)}$, however, the governor chooses to not cooperate. The utility of the ruler in this case is $\theta\psi$. So, if $(\theta + F) \left(1 - \frac{1-2\theta}{\theta} F - F^2\right) \leq \theta$, the weak ruler deviates to choose $a = 0$. However, if $(\theta + F) \left(1 - \frac{1-2\theta}{\theta} F - F^2\right) > \theta$, the weak ruler does not deviate to choose $a = 0$, but keeps $a = \frac{1-2\theta}{\theta} F + F^2$ instead.

3.3.3 Perfect Bayesian Nash Equilibrium

From the above discussions, we are able to have the perfect Bayesian equilibrium result.

We first consider the case where $\frac{1-2\theta}{\theta} F + F^2 \leq 1$. Then suppose the weak ruler chooses $a = \frac{1-2\theta}{\theta} F + F^2$, not disguising himself as a strong ruler. From the ruler's message, the local governor is able to perfectly know that the ruler is weak, and his best response is to cooperate in such an action. Knowing that the local governor will choose to cooperate, the weak ruler deviates to $a = 0$. So this is not an equilibrium.

When the weak ruler chooses $a = 0$, the governor cooperates if $p \leq \frac{1}{\left(\frac{1-\theta}{\theta} + F\right)}$, and this is an equilibrium, where the governor can have any probability belief about the weak ruler, because even if the ruler is weak, it is still the governor's best response to choose to cooperate.

If $p \geq \frac{1}{\left(\frac{1-\theta}{\theta} + F\right)}$ so that the governor does not cooperate, and if $(\theta + F) \left(1 - \frac{1-2\theta}{\theta} F + F^2\right) \psi \geq \theta\psi$, the ruler deviates to choose $\frac{1-2\theta}{\theta} F + F^2$, so this is not an equilibrium. If $(\theta + F) \left(1 - \frac{1-2\theta}{\theta} F - F^2\right) \psi \leq \theta\psi$, however, this is an equilibrium, where it should hold that the governor's belief on the ruler's type when seeing $a = 0$ follows the Bayesian rule. Specifically, it should hold that

$$0 \geq \left(\frac{1-\theta}{\theta} F + F^2 \right) q - F$$

Where q is the probability that the ruler is weak. We find $q = \frac{1}{\left(\frac{1-\theta}{\theta} + F\right)}$.

Suppose instead that $\frac{1-2\theta}{\theta}F + F^2 \geq 1$, so choosing any $a > 0$ means that the local governor will never cooperate. The ruler's payoff will be $\theta\psi$. When the ruler deviates to choose $a = 0$, the governor cooperates if $p \leq \frac{1}{\left(\frac{1-\theta}{\theta}+F\right)}$, so that the ruler is strictly better by deviating, and this is not an equilibrium. When $p \geq \frac{1}{\left(\frac{1-\theta}{\theta}+F\right)}$, the local governor does not cooperate, and the ruler's payoff will also be $\theta\psi$, so he is indifferent between deviating or not. A Perfect Bayesian Nash equilibrium is thus ruler choosing any $0 \leq a \leq 1$, and the local governor does not cooperate. The local governor's belief when seeing $a = 0$ should follow Bayesian rule where the probability of the ruler offering $a = 0$ being weak should be $\frac{1}{\left(\frac{1-\theta}{\theta}+F\right)}$.

We first define strategy profile σ as the strategy profiles of the two players: $\sigma = (\sigma_R, \sigma_G)$.

R's strategy profile σ_R is a mapping $\{strong, weak\} \rightarrow [0,1]$

G's strategy profile σ_G is a mapping $[0,1] \rightarrow \{0,1\}$

We then define belief μ as the belief of M on the ruler's type, where $\mu(a)$ measures the belief of the percentage that G views R to be weak.

We define Perfect Bayesian Nash Equilibria (hereafter abbreviated as PBNE) as:

A pair of strategy profile σ and belief μ is a PBNE if,

- (1) at each information set ρ , each player maximizes his or her conditional expected payoff given μ
- (2) at each information set ρ , μ_ρ is calculated by Bayes' rule whenever it is reached, and μ_ρ takes any value if ρ is unreached.

Perfect Bayesian Nash Equilibria are:

- (1) Suppose $\frac{1-2\theta}{\theta}F + F^2 \leq 1$ and $p \leq \frac{1}{\left(\frac{1-\theta}{\theta}+F\right)}$,

σ, μ is a PBNE where

$$\sigma_R(strong) = 0, \sigma_R(weak) = 0$$

$$\sigma_G = 1$$

$$\mu(0) = 0$$

- (2) Suppose $\frac{1-2\theta}{\theta}F + F^2 \leq 1, p \geq \frac{1}{\left(\frac{1-\theta}{\theta}+F\right)}$ and $(\theta + F) \left(1 - \frac{1-2\theta}{\theta}F - F^2\right) \leq \theta$,

σ, μ is a PBNE where

$$\sigma_R(strong) = 0, \sigma_R(weak) = 0$$

$$\sigma_G = 0$$

$$\mu(0) = \frac{1}{\left(\frac{1-\theta}{\theta} + F\right)}$$

- (3) Suppose $\frac{1-2\theta}{\theta}F + F^2 > 1$, and $p \geq \frac{1}{\left(\frac{1-\theta}{\theta}+F\right)}$,

σ, μ is a PBNE where

$$\begin{aligned} \sigma_R(\text{strong}) &= 0, \sigma_R(\text{weak}) \in [0,1] \\ \sigma_G &= 0 \\ \mu(0) &= \frac{1}{\left(\frac{1-\theta}{\theta} + F\right)} \\ \mu(1) &= 1 \end{aligned}$$

Result 3. Weak rulers were forced to offer decentralization of power when they are perfectly identified as weak rulers, and when the challenge is strong.

Proof:

The equilibrium (3) shows this result.

Result 4. After decentralization, local governments who receive power would be less likely to cooperate with the ruler.

Proof:

The offered decentralization strengthens local government's power. Consider a new round of game, where ϕ increase by the amount of received power. A higher ϕ , namely higher F , would naturally lead to $\frac{1-2\theta}{\theta}F + F^2 \geq 1$ to be more likely to hold even when the new challenge is weaker, namely when θ is higher. Thus, the equilibrium is more likely to be the Result 3 case.

3.4 History: Nineteenth Century China

In this section, we present historical evidence to showcase the effectiveness of our model. We focus on the historical case of late Qing China, which underwent a transition from a centralized to a decentralized system. While this transition led to significant improvements in the state's fiscal and military capabilities, it failed to prevent successive defeats in inter-state competition. Despite these setbacks, studying this case offers valuable insights into the complex interplay between centralization, decentralization, and state capacity.

Table 2 Timeline for warfare and conflict in late Qing China

Year	Warfare/Conflict	Purpose
1839-1842	First Opium War	Land cessions, reparations, commerce
1850-1864	Taiping Rebellion	Overthrowing the Qing empire
1856-1860	Second Opium War	Land cessions, reparations, extraterritorial rights
1858	Territorial Conflicts (Russia)	Land cessions
1883-1885	Sino-French War	Acquisition of Vietnamese suzerainty
1894-1895	First Sino-Japanese War	Land cessions, acquisition of Korea suzerainty, reparations

3.4.1 Conquest, Shocks and Power Shift

In the early years of the Qing Empire's military conquests, the Manchu rulers faced mainly Han Chinese armed forces, including former Ming Loyalists (the Southern Ming regime) and autonomous military forces such as the Han Chinese Fanwang (vassals) with relatively

autonomous power based in Southern China, as well as the Zheng family who occupied the island of Taiwan. This changed in the 1680s when the Qing Empire eliminated the Southern Ming regime in 1662, put an end to the so-called “Three Feudatories Rebellion” in 1681, and defeated the Zheng regime two years later, integrating the island of Taiwan into Qing administration (Meng, 2006). From the end of the 17th century, the main rivals of the Manchu rulers were the Russian Empire and the nomadic Dzungars. In 1689, the Qing empire curbed Russian encroachment on the northern frontier by signing the Treaty of Nerchinsk. After more than seventy years of warfare, the Qing empire completely destroyed the Dzungars by the early 18th century and incorporated Tibet and China's northwestern territories into their empire (Mancall, 1971; Perdue, 2005). Figure 20 shows that the frequency of wars in which the Qing Empire was involved declined significantly from the early 18th century until the 19th century, when the incidence of warfare rose again. Even though the Qing Empire's armies encountered some battle losses before the 19th century, they still emerged victorious in the vast majority of wars.⁶¹ The combination of more victories and a smaller frequency of wars made it difficult for warfare to be a threat to Manchu rule. Here, the Qing dynasty clearly showed the characteristics of a strong ruler, and as the equilibrium result has shown, it offered few powers to local governors, resulting in strong centralization of power.

After the 19th century, long periods of peace and obsolete weapons greatly weakened the fighting capacity of the Green Standard Army and the Eight Banners, leaving the empire with a declining military power. While they were still able to suppress domestic rebellions, it often came at a very high cost.⁶² For example, the Qing government had to spend millions of taels of silver, mobilize thousands of troops, and even resort to local armed forces (*Tuanlian*) before finally suppressing the White Lotus Rebellion (1796-1804) (Fairbank and Liu, 1980; Kuhn, 1970).⁶³ Here, the Qing dynasty still did not offer much decentralization of power to its local governors (*Tuanlian*, for example, must be quickly dissolved after the rebellion was suppressed), and this corresponds to the case in our model where a weak ruler disguises himself as strong ruler. However, the weakened military power was less able to cope with invasions from Western powers and the Taiping Rebellion after the early 19th century. The lack of modernization and obsolescence of the military's weapons and tactics left the Qing dynasty struggling to respond to these new threats. Also, it demonstrated to the local governors that the central Qing ruler was already weak enough, so that it started to offer power a to local governors.

It should be noted that such case where government disguises itself as a strong ruler by not offering decentralization did not only take place in Qing China. For example, in the early and middle periods of the Ming Dynasty, the system of provincial governors and regional governors was not stable. Although central government found that provincial governors and regional governors enhanced local conscription and taxation, these positions were typically established in response to local needs and could be dissolved when those needs subsided. (Jin, 1996) However,

⁶¹ For example, in the battle of Khoton Lake in 1731, more than 20,000 Manchu troops were surrounded by Dzungars, and eventually only 2,000 of them were able to break the siege, and the Qing army was almost completely wiped out.

⁶² Corruption was also an important factor in the decline of the Qing army's fighting capacity. According to Mao (1995), military officers around the country embezzled large amounts of military pay, thus forcing soldiers to rely on side jobs to make ends meet and thus lacking regular military training.

⁶³ The *Tuanlian* was a militia system composed of males from a certain area whose function was mainly to defend the village and maintain order in the area, and was sometimes integrated into the regular army to support the regular army in combat; the *Tuanlian* was disbanded immediately after the end of the war.

by the later period of the Ming Dynasty, the system of provincial governors and regional governors gradually stabilized, particularly after the Tumu crisis. Provincial governors and regional governors gradually became the highest military and political authorities in their respective regions, and the areas under their jurisdiction gradually evolved into practical high-level administrative regions. (Tan, 1987)

We then turn our attention to θ . Specifically, instead of defining θ purely the military power of the challenge, we define θ , the severity of the challenge, to be the chance that the challenge cannot overthrow the government. The more likely the ruler can survive a challenge and not be overthrown, the larger θ . In 1842, the Qing army suffered defeat by the British army in the First Opium War (1839-1842), and the emperor was compelled to sign the Treaty of Nanking. This treaty resulted in the cession of Hong Kong to the British and the opening of Shanghai and other ports to foreigners for trade and residence (Lovell, 2014). This marked the beginning of a series of unequal treaties, which Western powers forced China to sign through war or conflict, to gain economic benefits and territory. It is worth noting that although the Qing Empire lost successive international wars, as Table 2 shows, Western powers invaded China only to gain greater economic or political benefits, rather than to overthrow the Qing Empire. The Second Opium War (1856-1860) exemplifies this, where even though the Anglo-French army invaded the city of Beijing, the capital of the Qing Empire, and burned the Old Summer Palace (*Yuanmingyuan*), a royal garden that they had sacked, they did not attempt to overthrow the Qing Empire (Ringmar, 2013). Instead, after the war, the British and French forced the Qing government to cede the Kowloon Peninsula through the Treaty of Peking, which increased the number of ports of commerce, granted extraterritoriality, and compensated for military expenses. The logic is clear: economy and trade were prioritized over overthrowing the Qing Empire.⁶⁴ So although the western armies' military power is stronger, their θ is small.

The Taiping Rebellion erupted in 1850 in the southwestern province of Guangxi, then defeated Qing forces in Hunan and Hubei, and established Taiping Tianguo in 1853 with the capture of Nanjing (renamed Tianjing) (Luo, 1991). At its zenith, the Taiping army controlled a huge area of 1.5 million square kilometers, including China's most affluent lower Yangtze River region, and controlled population of more than 30 million. In contrast to the Western forces, the aim of the Taiping was to overthrow the Qing Empire. The leader of the Taipings was Hong Xiuquan, a man who claimed dominion over the entire Qing empire. The *Fengtian Taohu Jiao* (Against the Manchu people under the will of heaven), an important platform of the Taiping army, discussed in detail the rationality of liberating the Han people from Manchu rule and advocated the establishment of a fully Han regime (Jin, 1959). In order to accomplish this political goal, the Taiping Army, after seizing power in 1853, launched a "Western Expedition" and "Northern Expedition" in an attempt to occupy the remaining territories of the Qing Empire, with its Northern Expedition army once capturing the surrounding areas of Beijing (Jian, 1973). This clearly shows the large scale of θ for the Taiping Rebellion.

It is also worth noting that the Taiping Rebellion was not only the bloodiest civil war of the 19th century, but also the deadliest in Chinese history, with at least 20 million people killed in the war (Lee and Wang, 1999).⁶⁵ Additionally as showed in Figure 20, the frequency of war peaked in

⁶⁴ According to Hevia (2003), the British Empire's diplomatic objective toward China was to "bring China low" and thus engage it in a British-led strategic goals in Asia.

⁶⁵ If we take Cao's (2000) estimate, the loss of population due to the Taiping Rebellion was as high as 70 million, or 16.3% of the total population at the time; in contrast, the loss of population in the American Civil

1850s before declining gradually. From 1850 onward, the Taiping army captured more than 600 cities, fought the Qing army in 18 provinces, and dealt a severe blow to their military strength, as in the Battle of Sanhe, where 6,000 Qing troops, including 400 officers, were annihilated in just one day. On the contrary, while Western forces defeated the Qing army several times, the Western armies fought in the coastal provinces and did not penetrate into the interior, causing less damage to the Qing military. For instance, in the First Opium War, the total number of Qing soldiers killed was only about 3,000.

These insights help explain why Manchu rulers shifted from a centralization pre-1850 to a decentralization post-1850. Before the 19th century, higher military power, more military victories, and less frequent warfare all made the Qing Empire's rule less threatened by war, and firmly holds its power as a strong ruler. In the post-19th century, lower military power, fewer military victories, and higher war frequency making Manchu rule more vulnerable to war threats, transferring to a weak ruler and eventually being identified by the local governor. Additionally, domestic rebellions posed a greater threat to the Qing dynasty than external conflicts. Under these conditions, when the Taiping army crushed the Great Camp of Jiangnan for the second time in 1860 and the imperial army was completely wiped out, the Qing government adopted a decentralized strategy of granting greater military and fiscal autonomy to governors to counter the Taiping army. This strategy significantly enhanced the empire's military power, as evidenced by the Xiang Army remaining undefeated in all 33 campaigns after 1860 (Wang, 2014), ultimately leading to the victory of the throne. Another ruling strategy was to make peace with Western powers by ceding land, granting extraterritoriality, and giving up tariff autonomy. These practices would undoubtedly have greatly damaged the China's interests, which were secondary or minor importance to the longevity of Manchu ruling.

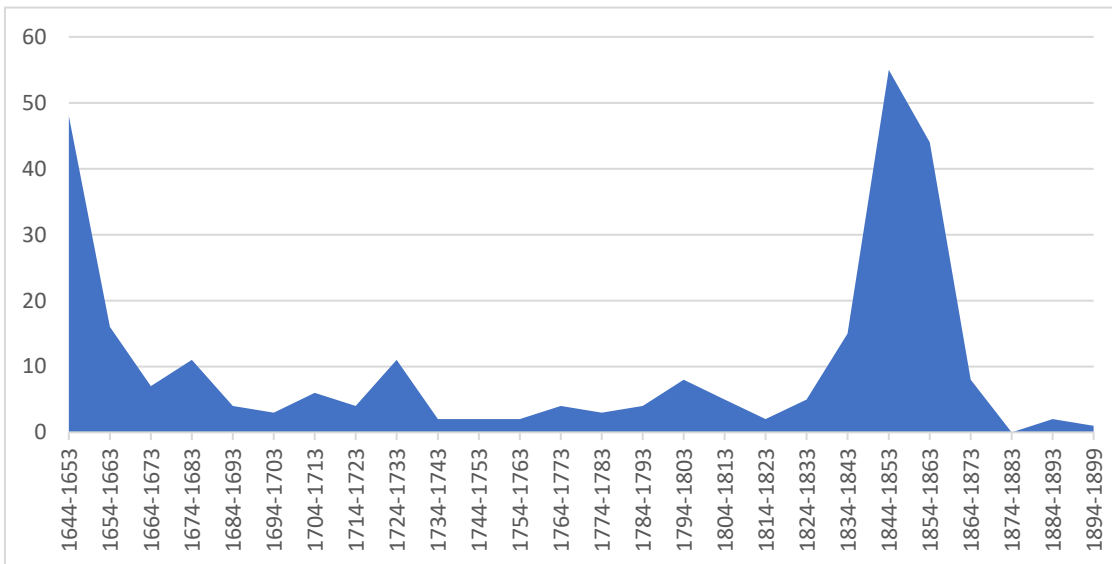


Figure 20 Incidences of warfare per decade in Qing China. Source: ZLZN (2006)

War, which took place at the same time, was estimated by Hacker (2011) to be 752,000 or 2.4% of the total U.S. population at the time.

3.4.2 Local State-building under Decentralization

Despite the domestic rebellions and external clashes in the mid-19th century, the Qing Empire survived and even thrived. As Figure 20 shows, the frequency of warfare declined sharply after the 1860s and reached its lowest point in the 1870s. As the threat of war diminished, the Qing government attempted to regain some control over the provinces by increasing the amount of taxes that the provinces sent to the central government and reporting new tax sources to the central government, and by abolishing some of the provincial armies (Luo, 1984; Ni, 2017). Although the Qing government attempted to take back provincial autonomy and restore centralization, it was opposed by governors, leaving the provinces with substantial fiscal and military autonomy (He, 2013; Luo, 1984; Zhu, 1999).⁶⁶ Our model predicts that under decentralization, governors with higher local strength force the weak ruler to offer a higher level of decentralization. Thus, local governors have a natural desire to increase local strength in order to secure autonomy and the power they have already gained, and the high local strength gave them enough confidence to oppose the central ruler's decision. We measure local strength in terms of provincial fiscal income and military expenditures.

First, let's discuss fiscal income. After the mid-nineteenth century, the *Lijin* was the main source of revenue for provincial governments. Unlike the land tax, which was controlled by the central government and had a fixed amount, the *Lijin* was at the disposal of the provincial government and had no limit on the amount that could be collected, except for a small portion that was transferred to the central government (Shi and Xu, 2008). Therefore, after the 1860s, the *lijin* became the main means for provincial governments to raise income. As seen in Table 3, except for Beijing's Zhili province and Manchuria, most provinces had a *Lijin* rate set by the provincial government above 5%, and some provinces such as Jiangsu had a *Lijin* rate of 20%. In contrast, before 1850, the inland tariff rate set by the Qing government was only around 1% (Ni, 2016). As a transit tax, the size of the commodity circulation determined the amount of *lijin* income in each province. In the Qing dynasty, governors regulated markets through a system of *Yaren*, who were granted as official brokers to provide commercial services (e.g., regulating price and quality or exchanging information) and managing the market (Mann, 1987; Yamane, 1995). However, *Yaren* often embezzle merchants' goods and are rarely punished or even defended by magistrates in commercial litigation (Fan, 2007). The embezzlement by the *Yaren* undoubtedly had a greater negative impact on the flow of goods and, in turn, may have reduced the *Lijin* income. To address this issue, the Hubei provincial government introduced a new type of *Yatie* (Licence of broker) in the 1860s that clearly stipulated the *Yaren* could not embezzle goods and provided legal protection for merchant rights, and then other provincial governments also issued similar new type of licence. Figure 21 shows that the number of this new licence was on the rise from the 1860s and reached its peak in the 1890s.

Table 3 *Lijin* rates in each province

⁶⁶ For example, Dingbaozhen, the governor of Sichuan, ignored the central government's request in 1880 on the grounds that the Sichuan army was supported by provincial revenue and therefore did not need to be cut. See, Liu (2003).

Provinces	Ratio	Provinces	Ratio
Jiangsu	10%-20%	Jiangxi	10%
Anhui	8%	Fujian	10%
Hubei	8%	Guangdong	7%
Guangxi	8%	Hunan	6%
Gansu	8%	Sichuan	4%
Zhejiang	10%	Shanxi	4%-12%
Shandong	2%	Fengtian	1%
Heilongjiang	1%	Jilin	2%
Yunnan	5%	Henan	5%
Shanxi	4%	Zhili	1.25%
Guizhou	Unknown	Xinjiang	Unknown

Source: Luo (1936)

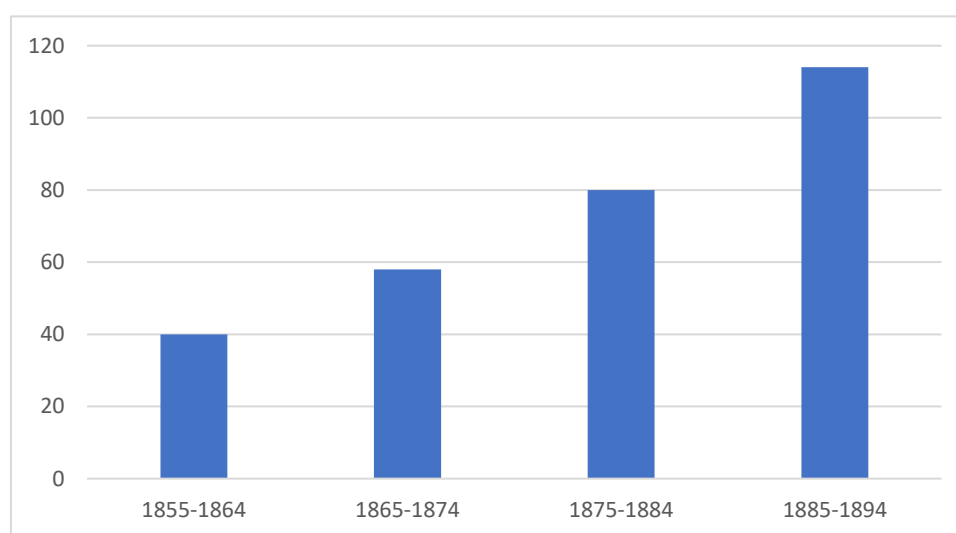


Figure 21 The number of Yatie (1855-1894). Source: Yamne (1995).

With higher tax rates and stronger protection of merchants' rights, the revenue from the *Lijin* increased considerably. Figure 22 reconstructs series of *Lijin* income. From the 1850s onward, the revenue from the *Lijin* continued to rise, and by the 1890s the revenue from the *Lijin* in the provinces had reached more than 25 million taels of silver, nearly 60 times the *Lijin* income from the 1850s. This significant increase in revenue from the *Lijin* also contributed to the improvement of the fiscal capacity of late Qing China. According to He (2018), by the 1890s, the Qing government's revenue was nearly doubled compared to that of the 1740s, with more than 40% of the increase in revenue coming from the *Lijin*.

Foreign borrowing was another important source of income for the provincial government after the mid-19th century; prior to the 1850s, the Qing empire adopted a fiscal policy of living within its means, with additional expenditures covered by the fiscal surplus, and thus did not develop long-term debt.⁶⁷ After the mid-19th century, with the introduction of Western financial system (e.g., banks) in China, borrowing foreign debt became possible. However, at that time, the

⁶⁷ Meanwhile, to cope with unexpected financial expenditures, selling official titles and encouraging private donations were also among the means by which the Qing government raised funds in the short term. See, Xu (1950)

provincial government, rather than the central government, was the main borrowers of foreign debt. As shown in Figure 23, from 1865 to 1874, all foreign debts were owed to the provincial governments, and after 1875, although the proportion of the central government's borrowing increased, the provincial governments still accounted for more than 80% of the total borrowing. As in the case of the *lijin*, the debts of each province were at the disposal of the provincial government, thus increasing the provincial income. Moreover, since the debts were secured by customs duties, the provinces indirectly turned part of the customs duties into the provincial government's income.⁶⁸

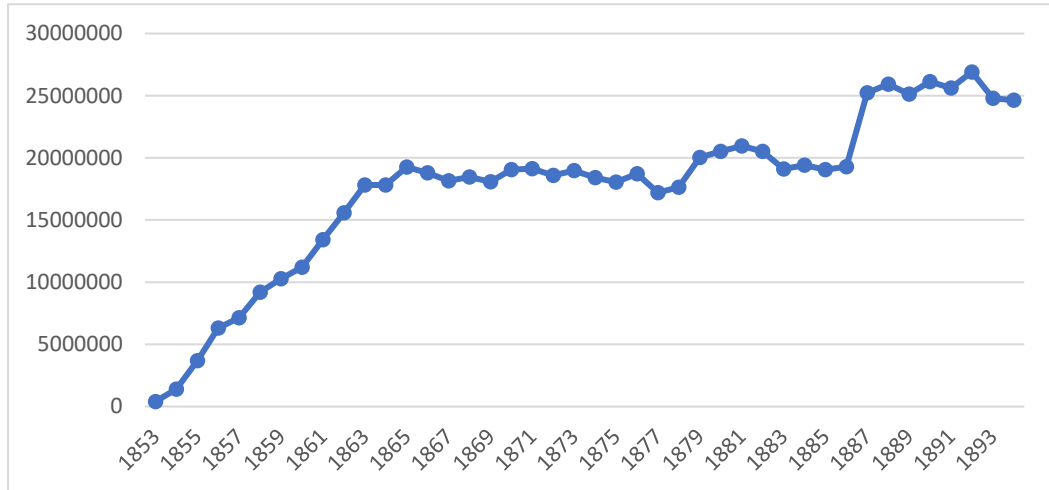


Figure 22 *Lijin* income in the late Qing China, 1853-1894 (Silver Taels). Source: Ni (2017), Zhou (2011).

⁶⁸ According to Tang (1992), from the 1880s to the 1890s, 10-15% of customs revenues were used to pay off foreign debts.

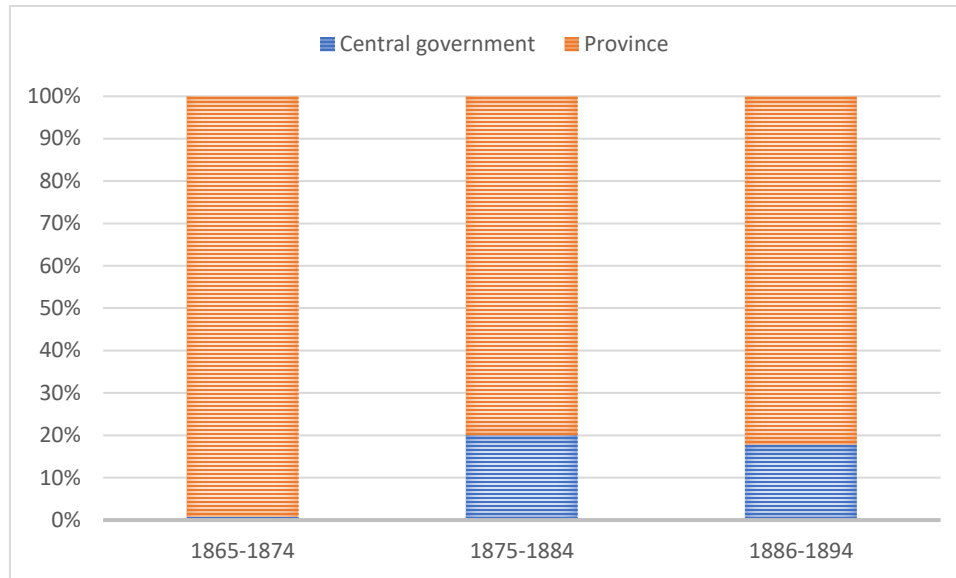


Figure 23 Borrower of foreign loans. Source: Shi and Xu (2008), Xu (1962)

The provincial governments increased provincial incomes by means of *Lijin*, foreign borrowing, etc., and these incomes were mainly transformed into military expenditures for the provinces. As seen in Figure 24, after the 1870s, 70% of *Lijin* revenues were spent on military expenditures. Some provinces spent nearly 90% of their *Lijin* revenues on military expenditures, such as Shaanxi Province, which spent annual 85%-90% of its *Lijin* revenues on military expenditures, and in some years, all of *Lijin* revenues were spent on military expenditures (Luo, 1936). Table 4 shows that 86% of the foreign debt was also used by the provincial governments for military expenditures (e.g., purchasing weapons, building armies), and only 5.5% was used to provide public goods (e.g., building river banks).

The investments made in the self-strengthening movement, as described in section 2, were mostly financed by the provincial governments. Table 5 shows that the provincial governors allocated 53.1% of their investments to military industries. When taking into account that railroads, shipbuilding, and telegraph lines were also utilized for military purposes, the investment in military-related industries amounted to 88.9% of the total investment. Only 11.1% of the investment was directed towards the development of civilian industries, such as cotton spinning. Moreover, in addition to the provincial incomes for investment, the governors also utilized the revenues that belonged to the central government to invest in the military industries of their provinces. For instance, the governors of Jiangsu and Zhejiang utilized 40% of the Shanghai Customs revenue to fund the Jiangnan Arsenal (Wei, 1969). As these military industries were under the control of the governors, the revenues that should have been allocated to the central government became part of the provincial military expenditure in disguise. With such revenue increase and military investment, we can clearly see that the local governors are building their local strengths.

Importantly, unlike the top-down Meiji Restoration of the same period, the self-strengthening movement was a bottom-up reform initiated by the governors, and as the guiding principle of the reform, "Zhongti Xiyong (Chinese learning for fundamentals and western learning for practical applications)", advocated the introduction of advanced Western technology without changing the imperial system. However, this approach made it difficult for the movement to become a broad-

base reform. Our model highlights that the role of the governors' natural tendency in shaping the limited nature of reforms, specifically that increasing military power would push the ruler to offer more autonomy. Institutional reform or investment in civilian industries to promote economic development did not help increase governors' power compared to increasing provincial incomes and thus provincial military power.⁶⁹ As a result, governors had a greater incentive to promote the growth of fiscal and military capacities, and less incentive to touch on deeper socio-economic reforms.

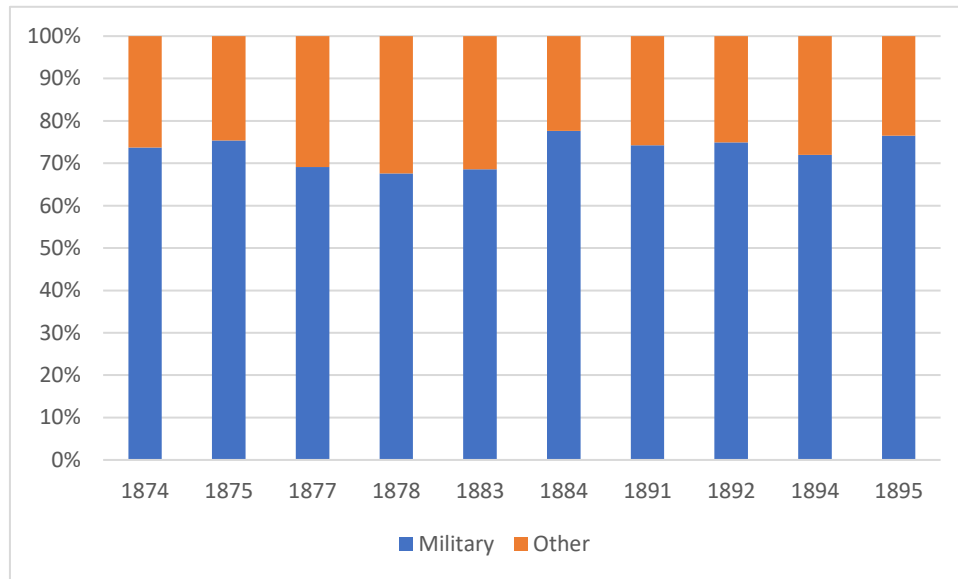


Figure 24 Lijin uses in the provinces. Source: Luo (1936)

Table 4 Purpose of provincial foreign borrows

Purpose	Taels	Ratio
Military	30,273,000	86%
Public Affairs	1,969,000	5.5%
Others	2,993,000	8.5%

Source: Shi and Xu (2008), Xu (1962), ZRCB (1991)

Table 5 Estimation of governors' investment in industry in the late Qing China

Industry types	Taels	Ratio
Military	54710000	53.1%
Textile	2363889	2.3%
Coal mining	3000000	2.9%
Smelting iron	4529629	4.4%

⁶⁹ For example, Li Hongzhang then tried to ensure the autonomy of the Huai army by investing in army construction and introducing a large number of new weapons to enhance the fighting power of the Huai army, thus replacing the Green Standard Army and the Eight Banners, thus making the central government need to rely on the Huai army to fight. See, Wang (2014)

Mental mining	1542000	1.5%
Railway	15000000	14.5%
Shipbuilding	16943428	16.4%
Telegraph line	5000000	4.9%

Source: Deng (1998)

3.4.3 Wars in post-1860s

Finally, we now apply our modeling insights to the Qing Empire's interstate wars in the late 19th century. Despite effectively suppressing domestic rebellions after the 1860s and attaining greater military power, the Qing Empire suffered successive defeats in interstate wars. Result 1 predicts that governors were more reluctant to cooperate with the ruler when they with higher autonomy under the decentralization. In what follows, we focus on the actions of provincial armies during the Sino-French and First Sino-Japanese wars.

Despite its independence from China in the 10th century, Annam (Vietnam) remained an important Chinese tributary state until the 19th century (Anderson, 2013). However, this picture was changed after 1850. The French military power forced Annam to sign a series of unequal treaties, and by 1880, France not only became a protectorate of Annam but also occupied part of its territory (Elleman, 2001). In order to halt the French expansion, Annam sought help from the Qing Empire, its suzerain. In response, Beijing sent troops to Annam in 1883, and in the same year, after diplomatic efforts failed, the Sino-French War broke out. Unlike the Green Standard Army and the Eight Banners, which were equipped with cold weapons at the time of the Opium War, the patrol and defense troops were already equipped with a considerable number of Western weapons, and there was no major gap in weapons with the French army, but the Qing army still suffered a massive defeat at the beginning of the war. In the battle of Son Tay, the first battle between the Chinese and French armies, the Yunnan and Guangxi armies were reluctant to reinforce the Son Tay garrison, and even the few reinforcements that were sent were immediately defeated after the battle with the French (Huang, 1998). The same situation occurred in the Battle of Bac Ninh, while the Yunnan and Guangxi armies had gathered more than 20,000 soldiers, received large amounts of military funds and supplies from the central government, and built massive fortifications in Bac Ninh; when faced with the French army (with a strength of about 10,000 men), both armies quickly retreated and the French occupied Bac Ninh with a feeble resistance (Liao, 2002). Not only the Yunnan and Guangxi armies, but also other governors were reluctant to fight the French, such as Li Hongzhang who refused to send his own Beiyang fleet to reinforce Fuzhou against the French Navy (Elleman, 2001). During the Sino-French War, it was common for provincial armies to flee and save their strength by not reinforcing friendly forces. Only when the governors faced greater incentives which could trigger the provincial armies have a greater willingness to fight. This clearly matches with the result in our model that the higher the local governor's strength ϕ , the less likely that the governor would cooperate with the ruler in fighting – meaning that they prefer to save their own power.

For example, in the Lang Son campaign, with the advance of the French army, the Guangxi army quickly abandoned Lang Son, which was the headquarters of the Guangxi army, and retreated to China, while the French army continued to advance northward and once occupied Zhennan Pass, which was at the border between Guangxi and Annam; and only when the French army increased the threat to Guangxi province did the Guangxi army under the leadership of General Feng Zicai and Governor Pan Dingxin engaged the French army with a higher willingness to fight at Zhennan Pass, and repel the French army (Liao, 2002; Elleman, 2001). However, the Guangxi army was satisfied with the limited victory and was rather slow in pursuing the French and did

not reoccupy the Lang Son until after the French were in full retreat. Turning to the Taiwan battlefield, Liu Mingchuan, a general of Xiang army, was awarded the governor of Fujian with military authority over Fujian and Taiwan. As a result, Liu fought aggressively against the French upon his arrival in Taiwan, repulsing French attacks at Tamshui and Keelung, thus thwarting their plans to completely occupy Taiwan, and he served as governor of Taiwan province until his retirement after the war (Fairbank and Liu, 1980; Huang, 1998).

Like Annam, Korea remained an important Chinese tributary state until the late 19th century. However, from the 1870s, Japan forced Korea to sign a series of treaties by force, thereby gaining the right to send and garrison troops to Korea (Kim, 2012). In 1894, when the Qing government sent troops to assist the Korean government in suppressing the rebellion (Donghak Rebellion), Japan took the opportunity to declare war on the Qing Empire, the First Sino-Japanese War broke out. Although comparing the Qing army during the Sino-French war, the Qing Empire having a much stronger military force, and the West generally predicted that the Qing army could win the war, the Qing army once again staged a massive flee. In the Battle of Pyongyang, the Japanese army faced food shortages, weapons shortages, and frequent attacks by the Koreans; in contrast, the Qing army, primarily consisting of the Huai army, was well equipped and well supplied, and had the advantage of terrain and strong fortifications, and was assisted by the Korean population. Ironically, while the Japanese suffered heavy losses at the beginning of the battle, the Qing army surrendered to the Japanese on the first day of the battle and retreated into Chinese territory (Harada, 2008; Qi, 2005).⁷⁰ The flee of the Qing army in Pyongyang was only the prelude to the flee of the Qing army in the First Sino-Japanese War. In the Battle of Yalu River, after the Japanese defeated a small group of Huai army, the remaining nearly 30,000 Qing troops were full retreated on all fronts and the Japanese captured the strategic Jiuliancheng (Dandong) without any casualties. And in the Battle of Tianzhuangtai, when 6,000 Japanese troops launched an attack on 20,000 Qing troops under the cover of artillery, they found that the Qing army had already abandoned their positions and retreated (Sun, 1986). In the Battle of Jinzhou-Lvshunkou, not only did the Qing army not take the initiative to attack the Japanese and let them land in the Liaodong peninsular, some provincial troops even abandoned their positions and retreated without engaging the Japanese (Qi, 1995). This clearly corroborates our model's result, that local governors have strong tendency to save their own power, rather than fighting for the weak central ruler.

The story is different, however, when the safety and power of local governors themselves are in danger, the local governors would fight as fiercely as they can. When the Japanese threatened Lvshunkou and Weihaiwei, which were important bases for the Huai Army and the Beiyang Navy, the Japanese encountered fierce resistance in both areas (Lone, 1994). However, the fiercest resistance occurred in Taiwan. After the signing of the Treaty of Shimonoseki between China and Japan, the provincial government of Taiwan refused to recognize the treaty and established the "Republic of Formosa" to resist the Japanese occupation of Taiwan. From May to November 1895, the Taiwanese army engaged in several fierce battles with the Japanese, which ultimately failed to prevent the Japanese from capturing Taiwan, but still inflicted significant losses on the Japanese (Lian, 1983) When the local governors themselves are directly at danger, their fights were much fiercer, comparing with the case fighting for the ruler.

⁷⁰ Despite Japanese optimism that they would quickly take Pyongyang before the attack, the Japanese did not make significant advances in the battle on the 15th. Some of their troops suffered heavy losses, for instance, including six commanders and 140 soldiers who were killed, and over 300 who were wounded from the Oshima Brigade in just one day of the attack.

3.5 Conclusion

This paper provides a theoretical model on decentralization in authoritarian states. The paper finds that authoritarian rulers would not voluntarily decentralize. Decentralization took place when the ruler faced challenge, and the local governors viewed the central ruler to be weak. Moreover, the paper finds that strong local governors are less likely to cooperate with the ruler – they prefer to save their own power. Thus, local governors who receive power from decentralization tend to become disobedient to the central government. This easily causes civil war to even collapse of an empire. Also, the paper suggests that offering decentralization shows the ruler's weakness, so that many weak rulers would still continue pretend to be strong, offering no decentralization, despite knowing the fact that it might be beneficial to do so.

The paper applies the model to the historical contexts of Qing China, demonstrating the model's accuracy. As the last empire in China, the Qing empire, which had been centralized for a long history, moved toward decentralization in the second half of 19th century. We demonstrate that whether decentralization occurs or not hinges on the capacity of war to overthrow existing regimes. Thus, Qing China's decentralization was a result of the strong challenges by the internal wars (Taiping rebellion) rather than external wars, during which the Qing empire is revealed to be weak. The weak Qing ruler, in this case, was forced to offer power decentralization to gain local governors' support.

Our findings also provide new insights into the self-strengthening movement. In contrast to traditional accounts, which attribute the failure of the self-strengthening movement to endogenous culture against reform or policymakers' Confucian ideology and lack of competence, we argue that late Qing China lack of base-broad reform is best understood by the lack of governors' incentives: Under decentralization, stronger local governors are more likely to cause the ruler to offer higher decentralized level of power. The governors have a natural tendency to increase their relative strength. Thus, they tend to invest in the local fiscal and military power rather than develop local economy. Hence, in contrast to top-down comprehensive reforms, the Self-Strengthening Movement was a limited bottom-up reform.

This paper also shed new light on studies of the war and state from decentralized power perspective. In our context, Qing state rewarded governors with power as an incentive for them to be involved in war mobilization and suppressing Taiping rebellion; but the Qing state also faced difficulties in re-centralizing power. Furthermore, once governors with stronger power, however, became less willing to cooperate with the ruler, and more willing to save their own power, defeats of Qing armies in the Sino-Japanese and Sino-French war became inevitable. Late Qing China offers an important case which can enrich our understanding of how war shapes the state, and the state shapes the war.

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Conclusion

The three chapters of this dissertation collectively delve into the application of game theory to various strategic decision-making scenarios influenced by economic, social, and political factors. Each chapter presents theoretical models to elucidate real-world phenomena and historical events, emphasizing optimal or efficient strategies within specific contexts.

In Chapter 1 - A Location Selection Model in Discount Store and Fast-food Industry, the analysis of location selection strategies for discount store chains and fast-food chains reveals a nuanced understanding of their distribution patterns. The key variable, ϵ , representing the ability to continue attracting customers, elucidates why discount store chains tend to cluster while fast-food chains disperse. Moreover, the paper finds that for a chain with a much weaker ability to continue attracting customers than its competitor, it is optimal for this chain to avoid building stores close to each other. Real-world applications validate the theoretical findings, showcasing the impact of player strength on the spatial distribution of stores. The proposed location selection framework provides insights into real-world distribution scenarios, distinguishing between monopoly and segregated equilibria based on firms' preferences for connected or unconnected stores.

Chapter 2 - Weak Central Government, Strong Legal Rights, investigates the formation of legal institutions in Qing China and Tokugawa Japan, focusing on the rice market. The subversive regime game model articulates the dynamics in legal rights leading to the divergence in the rice market between the two regimes. The equilibrium results highlight that stronger central governments, like Qing China, opt not to offer legal protections, while weaker ones, like Edo Japan, find it optimal. The chapter also finds that strong rulers would be able to hold power in rice market in spite of not offering legal protections. The implications extend beyond the rice markets, shedding light on the broader impact of legal rights formation on state stability and longevity. The chapter also contributes to understanding global legal rights formation throughout history.

Chapter 3 - The Price of Survival, employs a signaling game model to analyze decentralization under authoritarian regimes. The findings underscore that authoritarian states do not voluntarily decentralize but do so in response to external shocks challenging their rule. The model suggests the potential disobedience of local governors following decentralization, leading to civil unrest. Moreover, offering decentralization shows an authoritarian state's weakness so that local governments would start to not obey the central government's ruler. Thus, it was often the case that authoritarian states chose to not offer decentralization in spite of knowing its necessity. Historical evidence from late 19th-century China validates the model, particularly in the context of the Taiping Rebellion.

In conclusion, these chapters collectively contribute to the field of game theory by providing insights into strategic decision-making across diverse contexts. The synthesis of theoretical models and empirical evidence enhances our understanding of the intricate interplay between economic, social, and political factors in shaping strategic outcomes. The dissertation's findings not only contribute to the academic discourse but also offer practical implications for businesses and policy decisions navigating complex decision landscapes. Future research can be made in terms of allowing more dynamics in location selection, such as introducing the Hotelling model setting for Chapter 1, and carrying out empirical studies and calibrations for Chapter 2 and 3.