

**A Generic Simulation Model of the Relationship between State-Entities:  
Sovereign States, Empires and Confederations**

国家間関係の包括的シミュレーション・モデル：主権、帝国、国家連合

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- \* The model presented in this paper is constructed by using **artisoc**. You can get much more information about the simulator on the site “A Study on Dynamism of Social Order with Application of the Multi-Agent Simulator” (<http://citrus.c.u-tokyo.ac.jp/mas/english/index.htm>)

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## **1 Introduction**

### **1.1 A Blind Spot of International Studies**

International studies have cast their main attention to the relations among sovereign states. They have limited their interests to the world composed of sovereign states.

In reality, however, the relations among sovereign states were not always dominant in the international society. There have been various types of relations among states. Especially confederations and empires were very familiar existence even in the international society of these two or three centuries. International law studies displayed various types of states in the textbooks at the beginning of 20th century. The list contains states in real union, states in personal union, confederated states, federated states, suzerain states, vassal states and states under protectorates [Oppenheim 1905].

At the end of 19th century the international society was composed of about sixty sovereign states and some of them had dependent territories all over the world. Dependent entities covered more than 60% of the territories of the international society. This means that imperialistic relationships occupied more than half of the international society [Eto 1968][Mitsutsuji 2000]. Looking back the history of the international society, it is clear that models that presuppose the existence of sovereign states is not enough to think about the long-term changes in the international systems. For example, they cannot answer such questions as how a sovereign states system or an imperial system can emerge, be sustained and/or damaged.

### **1.2 The Simulation Models of International Systems**

In order to explore the transformation of international system, multi-agent (agent-based) simulation is a promising method. In the 1970s Bremer and Mihalka made a precursor model of the international system [Bremer and Mihalka 1977]. In their model the international system was exclusively composed of sovereign states. They made the model in order to examine the hypothesis that the checks and balances mechanism between powers can lead to the stability of international system. In some cases sovereign states can survive and achieve a stable relation among them and in other cases all states are amalgamated into one state or a world empire. In the Bremer and Mihalka model an empire is identical with one sovereign state.

Most of successor models share the assumption that international system is exclusively composed of sovereign members [Cusak and Stoll 1990] [Danno 1992]

[Cederman 1997]. Thus in these models the relationship among sovereign states is reproduced repeatedly. This is very natural in the tradition of international studies tradition as pointed out in section 1.1. However, there have been various types of relationships in the history of international society. In order to understand the long-term changes in the states relationship in the international society comprehensively, we need a model that covers various types of relationships among states.

There existed one model built upon such a perspective. Axelrod constructed his Tribute Model paying its attention to the integration and disintegration among political entities [Axelrod 1997]. Besides power relationship, Axelrod introduced commitment relationship. Political entities of the Tribute Model have “commitments” with each other and they can mobilize other agents’ resources according to the commitment between them. It gives us many hints to consider altering nature of the relations among states. The Tribute Model tried to describe a brand-new actor’s emergence from original entities.

What the Tribute Model does not cover is asymmetry in the relationship among states. A pair of states always has the same amount of commitments with each other. Axelrod’s interest lies in the integration and disintegration among political entities. He does not pay attention to how they are integrated. However, in the history of international society, asymmetric relationships were quite common. In the following section, we will introduce a model that can analyze both symmetric and asymmetric relations among states-entities.

## **2 The Generic States-System Model: Structure and Rules**

### **2.1 What the model describes**

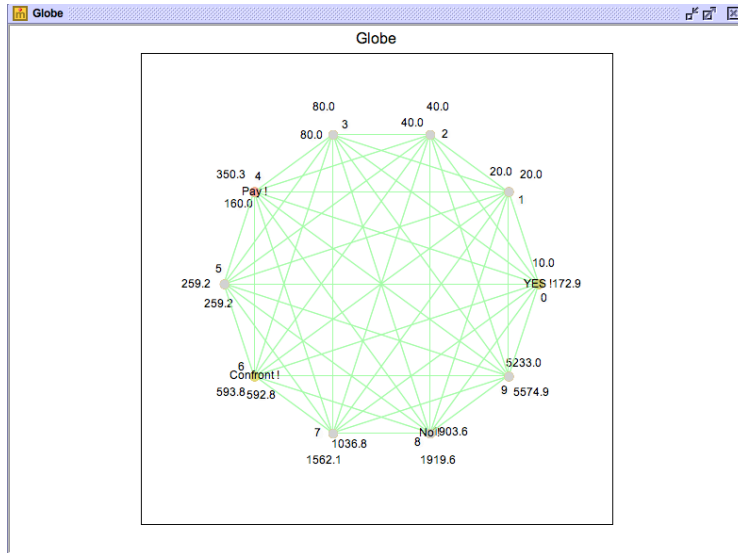
We will construct the Generic States-System Model (GSSM) in order to describe various types of relationship among states. In this model states can exist under the patronage of the other. A group of states that are nearly amalgamated into one political entity can exist, too. When one state has most of the other states under its patronage, we can say that an empire has emerged there, and when some states amalgamated into one entity, we can say that a confederation has emerged there. We will explain the model in detail below.

### **2.2 Political Units**

The GSSM is composed of some (a few / tens / hundreds) political units. In this paper the model is composed of 10 political units. These political units stand for political entities

that dominate a portion of territories and human beings. They can be sovereign states, dominant/subordinate members of empires, or member states that compose confederations. These political units have relationships with the other political units. The relations that each unit has determine what kind of state the unit is.

**Fig.1 Deployment of Political Units**



### 2.3 Resources, Mobilization and Power

Each political unit has its own resources. The resources stand for what political units can mobilize freely for the conflict against other political units.

Each individual political unit has influences (=mobilization rates) upon other political units probabilistically. The political unit can expect other units' support when it confronts the threat and the influences it has upon others decide whether those units support or keep neutral in the conflict. Every political unit has mobilization rates for all the other political units and these mobilization rates illustrate its influences upon others. In the GSSM consisting of ten members, for instance, every political unit has ten mobilization rates (including one for itself) and each mobilization rate, which distributes from 0% to 100%, means the probabilities that the political unit can get support from every other political unit. Initially all of political units' mobilization rates for other political units are zero and mobilization rates for itself is always 100%.

We can calculate an expected value of the amount of resources that each individual political unit can mobilize in the conflict. We defined this as the political power of the unit. The political power of each unit can be calculated as below.

$$P_i = \sum_{j=1}^N R_j M_{ij}$$

N: number of political units

P<sub>i</sub>: political power of political unit i

R<sub>j</sub>: the amount of resource that political unit j has

M<sub>ij</sub>: mobilization rate the political unit i has for j

\* M<sub>ii</sub> is always 1.0

**Fig 2. An Example of Mobilization Rates**

<b>R</b>							<b>P</b>	
		A	B	C	D	E		
<b>A</b>	<b>30</b>	1.0	1.0	1.0	1.0	1.0	<b>50</b>	
<b>B</b>	<b>5</b>	0.0	1.0	0.0	0.0	0.0	<b>5</b>	
<b>C</b>	<b>5</b>	0.0	0.0	1.0	0.0	0.0	<b>5</b>	
<b>D</b>	<b>5</b>	0.0	0.0	0.0	1.0	0.0	<b>5</b>	
<b>E</b>	<b>5</b>	0.0	0.0	0.0	0.0	1.0	<b>5</b>	

Figure 2 is an example of mobilization rates that political units have among them. R is resource and P is political power. Mobilization rate for itself (M<sub>aa</sub>, M<sub>bb</sub>, M<sub>cc</sub>, M<sub>dd</sub>, M<sub>ee</sub>) is always 1.0 (100%). In the example, political unit A has strong mobilizing power for all the other political units and his power is much more than his own resources. Other political units have no mobilizing power except for itself and their political power is equal to their resources.

Political power is defined as an expected value of the amount of resource that each political unit can use in the conflict against other units. Therefore, when the political unit succeeds / fails to get other's support, his/her political power increase / decrease temporarily. Political power fluctuates depending upon the situation with other units' decision makings.

The relationship among resources, mobilization rates and political power is a core idea of GSSM. This relationship has very interesting nature. Actors who do not have a lot of resources for itself can be very powerful because of mobilization rates for others. An actor who is located in the hub of the network can be very powerful by virtue of probable support

from others and client states with a powerful patron can be very powerful, too. [Fig 3]

Fig 3. An Example of Mobilization Rates II

<Political Unit located at the Hub>

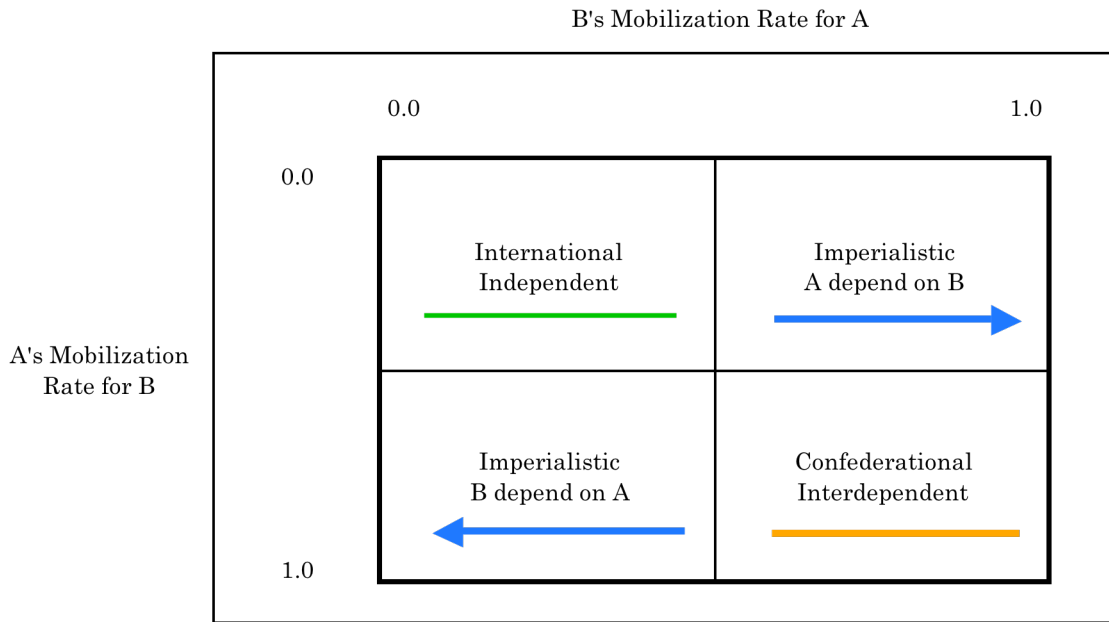
		R					P
<b>A</b>	<b>1</b>	1.0	1.0	1.0	1.0	1.0	<b>41</b>
<b>B</b>	<b>10</b>	0.0	1.0	0.0	0.0	0.0	<b>10</b>
<b>C</b>	<b>10</b>	0.0	0.0	1.0	0.0	0.0	<b>10</b>
<b>D</b>	<b>10</b>	0.0	0.0	0.0	1.0	0.0	<b>10</b>
<b>E</b>	<b>10</b>	0.0	0.0	0.0	0.0	1.0	<b>10</b>

<Client Unit which makes use of its Patron's Resource>

		R					P
<b>A</b>	<b>30</b>	1.0	0.0	0.0	0.0	1.0	<b>31</b>
<b>B</b>	<b>10</b>	0.0	1.0	0.0	0.0	0.0	<b>10</b>
<b>C</b>	<b>10</b>	0.0	0.0	1.0	0.0	0.0	<b>10</b>
<b>D</b>	<b>10</b>	0.0	0.0	0.0	1.0	0.0	<b>10</b>
<b>E</b>	<b>1</b>	0.5	0.0	0.0	0.0	1.0	<b>16</b>

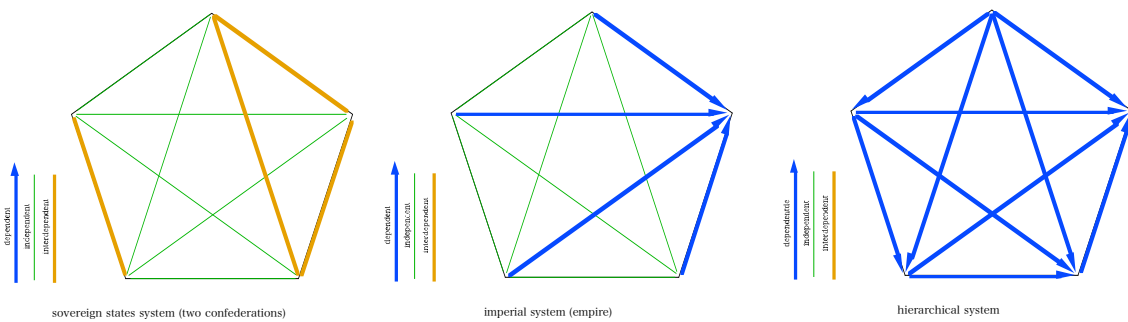
We can classify the relation between two units into three groups. [Fig.4] One is international; mobilization rates of two units are low. They are independent. Another is confederational; mobilization rates of two units are high. They are interdependent. The other is imperialistic; One is dependent on the other.

Fig.4 The relation between two political units



Here we can present some of the ideal types of the states-system. One is a sovereignty system. When all political entities have either independent or interdependent relations with each other, we can say it is a sovereignty system. Another is an empire or an imperial system. When all entity depends upon one entity, we can say it is an empire. The other ideal type is a hierarchical system. When the strongest dominates all the others, the second strongest is subordinated to the strongest and dominate the others, and the weakest is subordinated to all the other, we can say it is a hierarchical system. [Fig. 4.5]

Fig. 4.5 Ideal types of states systems





## 2.4 Turn Sequence: Submission, Deterrence or Confrontation

A run of the model starts with the selection of a political unit as an initiator. After initiator selection a series of decision-making by political units follows and a series of decision-makings results in an event. After an event is resolved, next turn starts and a new initiator is selected again. [Fig. 5]

**Initiator selection** : Nature selects one political unit and activates it. The selected political unit is called “an initiator” in this turn. The initiator is selected stochastically. The probability of selection for any particular political unit is equal to a percentage of its political power in the system. This rule depends upon the empirical fact that more powerful actors tend to be more active [Axelrod 1997].

**Target selection** : The initiator unit selects the least intimate political unit as its target and requires the target to submit to an initiator’s claim. The intimacy is measured by the sum of mobilization rates for each other. The initiator chooses the political unit as a target that has least intimacy with the initiator.

**Target decision** : In the model, a parameter named “give-up-ratio” is given. Any political unit gives up its challenge when the opponent is “give-up-ratio” times as powerful as the unit or more. When give-up-ratio is two, political unit gives up its challenge if the opponent is twice as powerful as that political unit at any moment. This rule is common both for the initiator and the target. When the target is too powerful, the initiator stops demanding a submission, and when the initiator is powerful enough, the target surrenders soon.

**Target diplomacy** : When the target does not surrender, he/she tries to confront these threats by calling for supports from other political units. The target selects a political unit from which the target can expect the resources the most. That is the political unit that has the highest value of resources multiplied by mobilization rate from the targeted unit. The target asks for its support and the political unit decides according to the mobilization rate (= probability) that the target has for the political unit. When it decides to support the target, the target becomes more powerful because it becomes certain that the target can mobilize it. And the initiator becomes less powerful because it loses a chance to mobilize it. Conversely when the target fails to summon support from it, the target becomes less powerful.

**Initiator diplomacy** : When the initiator does not give up his challenge, the initiator can summon supports from other political units with the same procedures.

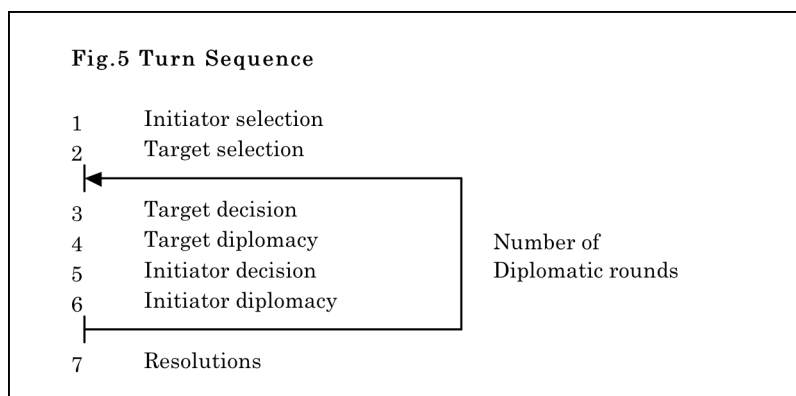
**Diplomatic rounds continue** : Target diplomacy and initiator diplomacy are done in this order again and again. The maximum number of diplomatic rounds is given

exogenously. In this paper diplomatic rounds repeat five times. Therefore the confronters (the initiator and the target) can get support from several political units, if they succeed.

**Resolutions** : A series of decision-making can lead to three kinds of events; submission, deterrence and confrontation.

When the initiator owns or can mobilize enough resources, the target accepts the initiator’s requirement [i.e. submission]. When the target can mobilize enough resources, the initiator gives up his challenge. The target stops initiator’s intention [i.e. deterrence]. When neither side gives up their challenges, confrontation happens [i.e. confrontation].

As written above “give-up-ratios” play important roles in decision makings. Political units with high give-up-ratio do not give up their claims in the conflict and with low give-up-ratios they give up their challenges easily. In this paper political units are given the same give-up-ratio in each experiment. High give-up-ratios mean that the world is composed of bold agents and low give-up-ratios mean the world is composed of cautious agents.



## 2.5 Resolutions: Mobilization and Resources

The mobilization rates of each political units change according to these three kinds of events and resolutions. [Fig.6]

When the interaction results in submission, the initiator’s mobilizing power for the target increases [i.e. subservience]. The initiator’s mobilization rate for the target increases by 15 points. On the other hand the target’s mobilizing power increases, too [i.e. protection]. In return for the submission, the target can increase its mobilization rate for the initiator by 10 points. The logic of subservience and protection is the same as Axelrod’s Tribute

Model, but here we introduced asymmetry. In the Tribute Model subservience is equal to protection (10 points), while in GSSM subservience is higher than protection. We judge this is more realistic. When the interaction results in deterrence, the initiator's requirement is refused and its mobilization rates for others decrease by 10 points [eclipse]. When the interaction results in confrontation, friendship and hostility rules change the mobilization rates. Political units that fight on the same side increase their mobilization rates by 10 points each other [friendship] and political units that fight on the opposite side decrease their mobilization rates by 10 points [hostility].

How do these resolutions affect political units' resources? Here we can introduce two kinds of worlds. In one world some of the resolutions have significant impacts upon political units' resources and in the other world we can suppose political units' resources are affected little through the resolutions. We call the former a severe world and the latter a secure world.

In the severer world, the target has to pay 10% of its resource to the initiator when submission happens [payment]. And in confrontations both sides are damaged and lose resources as much as 10% of the opponents' resources [attrition]. Besides, the loser has to pay compensation to the winner [compensation]. The compensation is equal to 20% of the loser's political power. Win and loss are decided probabilistically according to the power ratio between initiator and target. Damages and compensations are shared among allies (initiator or target, and their supporters) in proportion to the amount of each unit's resources. Deterrence does not change political units' resources. These rules indicate that the interactions in the severe world have a strong effect upon the existences of the political units. Oppositely in the secure world the interactions have an effect only upon the relations among political units.

**Fig.6 The Change of Mobilization Rates and Resource**

mobilization rate					
a	<submission>	Initiator increases its mobilization rate for Target	subservience	15%	
b	<submission>	Target increases its mobilization rate for Initiator	protection	10%	
c	<confrontation>	The units that fight on the same side increase mobilization rate	friendship	10%	
d	<confrontation>	The units that fight on the opposite side decrease mobilization rate	hostility	10%	
e	<deterrence>	Initiator that gives up its requirement decreases mobilization rate for all	eclipse	10%	

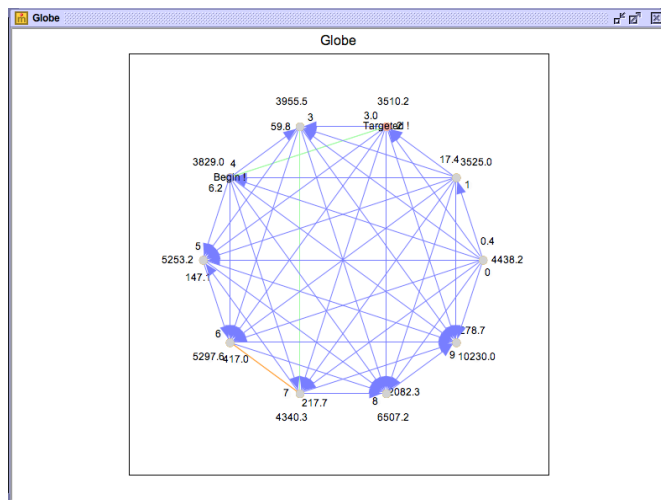
resources			
f	<submission>	Target pay 10% of its resource to Initiator	payment
g	<confrontation>	Both sides lose their resource as much as 10% of the opponents' resource	attrition
h	<confrontation>	Winner take 20% of the opponents' resource	compensation

### 3 Emerging Systems and Their Histories

#### 3.1 Emerging Systems

Now we show one typical history of the system. The model contains a positive feed back mechanism. A stronger unit gathers more mobilization rates (and resources in the severe world) and as a result it becomes more powerful. Conversely the weaker one gets weaker and weaker. With most settings, there exists a tendency that considerable power differentials emerge. The ideal hierarchical system does not emerge, but almost all of emerging systems contain a kind of hierarchi-ness [Fig.7]. There exist many historical examples of this type, including European medieval system and Japanese early modern political orders.

Fig.7 hierarchical system



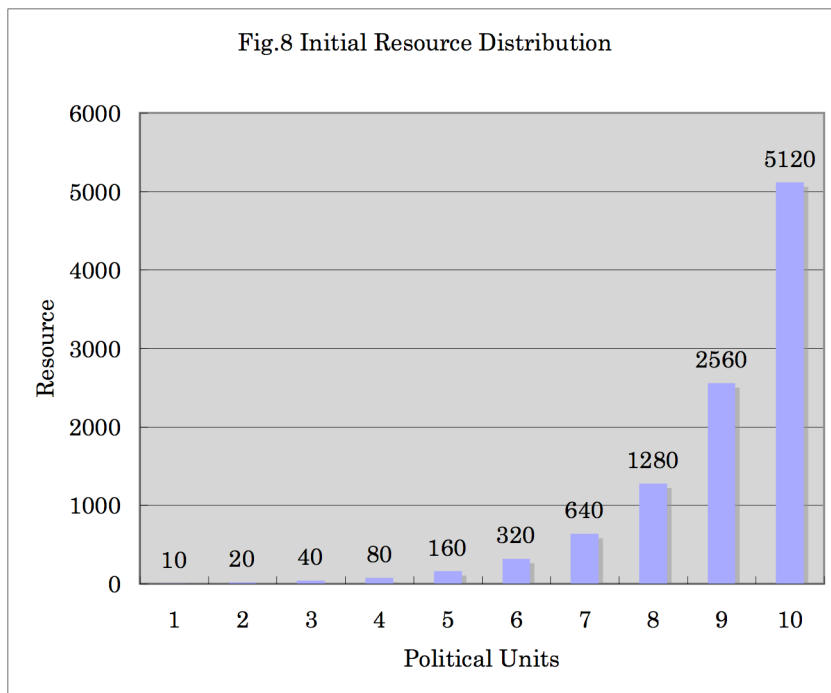
Our model can describe states relationship very generally. We do not presuppose the existence of sovereign states relations and through interactions various states relations, including empires (imperial systems), feudal systems (hierarchical systems) and sovereignty systems, can emerge. We will check what conditions give birth to what kind of systems.

In this paper we pay attention to two important factors: give-up-ratio and resource transfer. As written above, political units with low give-up-ratio tend to give up their challenge easily and when challenged they submit easily, too. Oppositely political units with high give-up-ratio do not give up so easily and even when threatened by stronger

political units, they try to find a way by calling for allies. High give-up-ratio means that the world consists of bold political entities and low ratio means the world consists of cautious entities.

Resource transfer is another important factor that decides the character of the struggle. We suppose that there exist two extreme worlds. One is severe and the other is secure. In the severe world resource transfer takes place and the struggle affects political units' existence. In the secure world resource transfer does not take place and the struggles affect only the relationship among them.

We assumed that political units' initial resource is distributed unevenly. It is distributed according to the geometric series with factor of 2[Fig 8]. Empirically most resources in the real world are unevenly distributed and we presuppose this unevenness in the model. We call the ratio of the geometric series unevenness ratio.

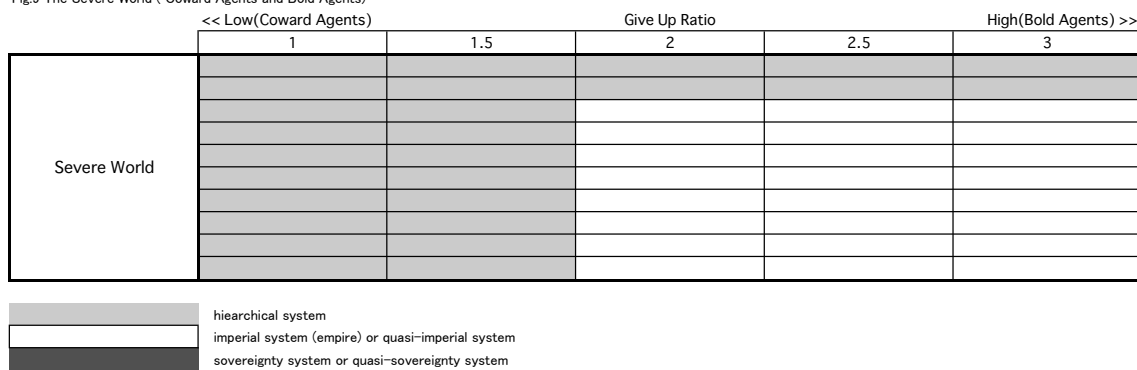


### 3.2 Cautious Agents and Bold Agents

We examined the model's behavior with various values of give-up-ratio and the severe world setting. We run ten trials in each setting. With the give-up-ratio lower than two, hierarchical systems emerge, while with the give-up-ratio larger than two, empires tend to emerge [Fig 9]. As written above the parameter that decides resource distribution unevenness is set as two. If the parameter is set three, the threshold is three.

With low give-up-ratios there exists little chance that confrontations happen. Higher give-up-ratios trigger confrontations between political units and through confrontations the political units except the strongest are weakened and they lose power (resource and mobilization rate for others) to dominate other units.

Fig.9 The Severe World ( Coward Agents and Bold Agents)



### 3.3 Severe World and Secure World

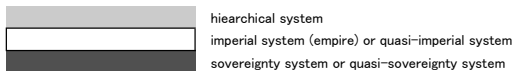
We can imagine a different world in which the interactions change only mobilization relationships and have no significant effect upon the resources. In this world resources that every political unit has are immune, and only the fluctuations of mobilization rates affect their political power.

When the interactions change only the mobilization rates and do not have effects upon resources, and additionally when political units are bold, sovereign states systems emerge. On the other hand when political units are cautious, hierarchical systems emerge again. [Fig 10]

When political agents are “bold” and the world is “secure”, political units continue to try to call for friends. These trials give birth to, eventually, a system composed of two confederations.

Fig.10 The Severe and the Secure World ( Coward Agents and Bold Agents)

	<< Low(Coward Agents)		Give Up Ratio		High(Bold Agents) >>
	1	1.5	2	2.5	3
Severe World	hierarchical system	hierarchical system	hierarchical system	hierarchical system	hierarchical system
	imperial system (empire) or quasi-imperial system	imperial system (empire) or quasi-imperial system	imperial system (empire) or quasi-imperial system	imperial system (empire) or quasi-imperial system	imperial system (empire) or quasi-imperial system
	imperial system (empire) or quasi-imperial system	imperial system (empire) or quasi-imperial system	imperial system (empire) or quasi-imperial system	imperial system (empire) or quasi-imperial system	imperial system (empire) or quasi-imperial system
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	imperial system (empire) or quasi-imperial system	imperial system (empire) or quasi-imperial system	imperial system (empire) or quasi-imperial system	imperial system (empire) or quasi-imperial system	imperial system (empire) or quasi-imperial system
Secure World	hierarchical system	hierarchical system	hierarchical system	sovereignty system or quasi-sovereignty system	sovereignty system or quasi-sovereignty system
	hierarchical system	hierarchical system	hierarchical system	sovereignty system or quasi-sovereignty system	sovereignty system or quasi-sovereignty system
	hierarchical system	hierarchical system	sovereignty system or quasi-sovereignty system	sovereignty system or quasi-sovereignty system	sovereignty system or quasi-sovereignty system
	hierarchical system	hierarchical system	sovereignty system or quasi-sovereignty system	sovereignty system or quasi-sovereignty system	sovereignty system or quasi-sovereignty system
	hierarchical system	hierarchical system	sovereignty system or quasi-sovereignty system	sovereignty system or quasi-sovereignty system	sovereignty system or quasi-sovereignty system





### 3.4 Agents, Worlds and Systems

The relationship between the characteristics of political unit and of world on one hand, and the emerging system on the other is obvious. When political units are cautious, there is no chance that empires or sovereign states emerge. When political units are bold, empires will emerge. Additionally, when world is secure, there emerge sovereign states system (two confederations). [Fig 11]

It is counter-intuitive that both empires and sovereign states systems require the same condition. Political units' boldness is indispensable for both systems. Additionally we found that from almost same settings and with a small difference in a condition (whether resource transfer takes place or not) either imperial system or sovereignty system can emerge.

Fig. 11 summary

		agents	
		cautious	bold
world	severe	hierarchical system	empire
	secure	hierarchical system	sovereignty system

## 4 Conclusions

Although the result is a tentative one, due to the model being very simple, we can show that various types of states system can emerge from the Generic States-System. The generic logic of interrelationship between resource, influence and the decision making can be applied to any political units.

The simulation result and its implications are very rich. In this paper we can show three different and historically very common types of systems that can emerge from the Generic States-System. They are hierarchical, imperial and sovereignty system. These systems emerge with almost the same settings. Interestingly, imperial and sovereignty system require the same condition. That is actors' boldness. It triggers confrontations among political entities and these confrontations differentiate these systems from hierarchical one. In a severe world only one entity can keep its resource and power in a series of confrontation and the system leads to empire. In a secure world political entities

repeat alliance and rupture, again and again. Finally the system leads to sovereignty system.

As the model depends on assumptions, we cannot assert these are general results. With different values of the parameters, we will get other results. However, these trials of the GSSM show that there exists a possibility that subtle differences in political entities' behavior can culminate into a big difference in the world order. How did the sovereignty system emerge in Early Modern Europe? There are some answers to the questions.

Some arguments assert the deployment of coercion and capital decides what kinds of states prevail in the system and the balance between these two elements in Early Modern Europe made sovereign states prevalent [Tilly 1990]. Other arguments said high organizational efficiency enabled sovereign states to survive in the system. Compared to empire, city-league, city-states or other forms of states, sovereign states showed its advantage in the competition in terms of war makings or institutional arrangements [Tilly 1990][Spruyt 1994].

The results of the simulation runs in this paper show that some difficulties in resource transfer in confrontations enable sovereignty system to emerge, even though all the other settings remain the same. For example, fortification developments in the military revolution of Early Modern Europe might improve defensive power of political entities [Parker 1988]. This might make resource transfers in Early Modern Europe insignificant or less, compared to other civilizations. And this can result in the emergence of sovereign states system in Europe.

Multi-agent (agent-based) simulation is still a niche methodology in international studies. We hope that the model we have constructed stimulate discussions not only on the model, but also the methodology of multi-agent simulation.

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