ワーキングペーパーシリーズ人工社会研究 No.46 (2015年2月)

Multi-Agent Simulation of State Collapse and Reconstruction: Analyzing the Past and the Future of Somalia

Takuto Sakamoto¹ and Mitsugi Endo¹¹

Abstract

Civil conflicts are frequently accompanied by significant political dynamics of the state integration and disintegration. Despite a substantial methodological advancement in the conflict literature during the past decade, the serious attempt to incorporate this aspect of conflict into analysis has been mostly lacking. In this paper, we present a multi-agent simulation (MAS) model of civil conflict that has distinctive focus on territorial integration and disintegration of the sovereign state. The model simulates diverse spatial dynamics of the state territorial rule caused by armed conflicts. We apply this model to a case of Somalia: a country that has experienced a drastic process of disintegration and reconstruction for more than two decades. The model is shown to capture several defining characteristics of this process including the strong tendency of the country to fragment. Through extensive simulations in a wide range of settings, we seek an explanation for this tendency. Several policy implications for the future of Somalia are also derived.

1. Introduction

For the past decade, the research on civil conflicts has undergone a substantial development with the aid of various computational methods and tools. As the term 'disaggregation' of conflict succinctly captures (Cederman and Gleditsch 2009), temporarily and spatially fine-grained datasets are now widely available, stimulating the flourishing endeavor of detailed empirical analyses of civil conflicts

ⁱ Visiting Scientist, ETH Zürich, Switzerland; Research Fellow of Japan Society for the Promotion of Science, Institute of Developing Economies, Japan External Trade Organization; corresponding author (e-mail: <u>takutos@mac.com</u>)

ⁱⁱ Professor, Graduate School of Arts and Sciences, University of Tokyo

(Cunningham and Weidmann 2010; Donnay and Filimonov 2014; Østby Nordås and Rød 2009; Schutte and Donnay 2014; Weidmann, Rød, and Cederman 2010). Modeling technique and its application have shown considerable advancement and sophistication as well. Owing to computational tools such as multi-agent simulation (MAS), researchers are now able to model armed conflict in a more spatially and temporarily explicit manner (Cederman 1997, 2008; Weidmann 2006; Weidmann, Hegre, and Raleigh 2006). Moreover, the wide availability of geo-referenced datasets such as the point distribution of conflict events (e.g., Raleigh et al. 2010) enables these researchers to seek the empirical validation of their models more rigorously (Bhavnani and Choi 2012; Bhavnani et al. 2014; Lim, Metzler and Bar-Yam 2007; Weidmann and Sulayen 2013).

There is, however, one missing element in this otherwise promising development: understanding the process of integration and disintegration of political entities, which much often accompanies the process of armed conflict itself. Armed conflict, in other words, is not simply a collection of discrete violent clashes. To most students of political science and international relations, these violent events are relevant and important because they reflect and/or drive a varying degree of changes—formation, consolidation, unification, disintegration, collapse etc.— in the basic political entities such as the state and a nation. In the recent conflict literature mentioned above, however, these significant aspects have been largely treated as given (like political division between Sunnis and Shias) or simply overlooked in the often-excessive focus on conflict dynamics *per se*.

This paper purports to fill this gap by offering an alternative MAS model. The model simulates diverse spatial dynamics of integration and disintegration of the state territorial rule caused by armed conflicts. Thus, the model is not simply about armed conflicts; it is more about the sovereign states where these conflicts take place.

This model has been shown to reproduce various spatial dynamics of territorial rule actually observed in several African countries (see Sakamoto 2013a; 2013b). Here, the analysis is more focused as well as more intensive: applying the model to a single case of Somalia. In Somalia, more than 20 years of civil conflict among countless armed factions led to the total disappearance of effective governance over the whole territory, rendering the country a near-perfect example of 'collapsed states' (Rotberg 2004; Zartman 1995). During the same period, the country has also seen emergence of several state-like entities such as Somaliland and Puntland especially in the northern part, offering intriguing examples of 'a fresh start' after the collapse (Doornbos 2006), 'states-within-states' (Kingston and Spears 2004), 'unrecognized states' (Caspersen and Stansfield 2010; Caspersen 2012) and so on. This intricate process of political entity formation and collapse is the main focus in the following analysis. More specifically, we try to generate the similar process in 'virtual Somalia' constructed in computer through the combined use of the MAS model and empirical data on Somalia. Extensive simulations including those with hypothetical settings will be conducted along the way. Several policy implications for the future of the country will also be derived.

Name	Description	Properties
PopCell (Agent)	Represents a Tract of Territory and its Inhabitants	
-State	Indicates a <i>Ruler</i> to Which the Cell Belongs	The Same Value (i.e., Govt.) at First; Endogenously Generated Thereafter
-Traits	Describes Socio ⁻ cultural Traits (Ethnicity, Religion, Region) of the Inhabitants	Derived from Empirical Data
-Resources	Denotes the Amount of Resources	Derived from Empirical Data
Ruler (Agent)	Represents Government or Insurgent Organization	
-Traits	Describes Inclination toward Inhabitants' Traits	Derived from Empirical Data for Govt.; Randomly Generated for Insurgents
-Mobilization Level	Specifies the Fraction of PopCells' Resources to Collect	Exogenously Given for Each
-External Resources	Specifies the Amount of Externally Generated Resources	Exogenously Given for Each
Other Parameters		
-Number of Rulers	Specifies the Total Number of Ruler Agents	Exogenously Given
-Coercion Effect	Specifies Relative Strength of Military Coercion in a <i>PopCell's</i> State Transition	Exogenously Given
-Sensitivity to Frontline	Specifies Weight Attached to a 'Frontline' <i>PopCell</i> in a <i>Ruler</i> 's Deployment of Resources	Exogenously Given
-Stochastic Noise	Specifies the Extent to Which a <i>PopCelI's</i> State Transition Depends on Contingency	Exogenously Given

Table.1 The Structure of the Virtual State Model

2. The Model¹

The detailed description of the MAS model (Virtual State Model) was given elsewhere (Sakamoto 2013b)². Here, its essential aspects are briefly summarized based on the formal structure of the model shown in Table 1. The overall flow of the simulation is displayed in Figure 1.



Figure 1: The Flow of a Simulation Run

The model represents political and military competition between the central government and insurgent organizations over the exclusive rule of the state This territory, which is modeled by two-dimensional gridded space, territory. hosts numerous human residents with diverse socio-cultural traits (ethnicity, religion, region, etc.) At the start, the whole of the territory along with its inhabitants is under the rule of the central government, whereas plenty of latent insurgent organizations are trying to infiltrate the rule of the government from various locations on the territory. Each insurgent organization seeks support and loyalty from the local population, and, if these are available, mobilizes material resources necessary for the fight against the government as well as other competing The government does more or less the same things in order to insurgents. maintain its dominance. The inhabitants, on their side, respond differently to these calls, switching their loyalties among the competing organizations in their These mostly local interactions determine the ensuing dynamics of localities. territorial integration and disintegration in the state concerned.

In order to formalize this setting, the model introduces two sets of agents: *PopCells* and *Rulers* (see Table 1). A *PopCell* represents a tract of the state territory along with the inhabitants living on it. In the following simulations, the territorial space is gridded so that each *PopCell* has a size of 15 arc minutes (approximately 28km at the equator) both in length (latitude) and width (longitude). A *PopCell* is characterized by socio-cultural traits (*Traits*) of its inhabitants over several dimensions (ethnicity, religion, region) as well as the amount of material resources (*Resources*) it can offer. Here, the latter is crudely defined by the population of inhabitants on the cell and per-capita GNI of the country at large.

At each time step, each *PopCell* is governed by one of the competing *Ruler* agents. *Rulers* represent both the central government and insurgents. In the model, the government is simply the *Ruler* that holds the capital city of the state at a given time step. Otherwise, all the *Rulers* function in the exactly same manner: mobilizing *Resources* from *PopCells* under its rule, and deploying them for armed struggles against the surrounding *Rulers*. Along with the variables that control the resource mobilization (*Mobilization Level* and *External Resources*), *Traits* variable differentiates *Ruler* agents. This variable specifies a *Ruler*'s political stance as defined by its inclination towards socio-cultural traits of inhabitants (e.g., ethnically committed to Somali, religiously committed to Islam, etc.). It can also take a 'neutral' value (denoted as '**' below) in each dimension of traits (see Cederman 1997, chap.8). Thus, a *Ruler* might be indifferent to any ethnicity (religion, region...) rather than committed to a particular group of people.

Lastly, the defining aspect of the model is the stochastic rule that updates relationships between these two agents. Simply put, a *PopCell* is likely to be under the rule of a *Ruler* that can deploy more resources around the cell as well as is more inclined towards its inhabitants than any other *Ruler*s. In other words, a militarily competent and politically legitimate *Ruler* in a given locality tends to dominate in that locality. Starting from the initial condition where a single *Ruler* (*Initial Government*) governs all of the *PopCell*s, iterative application of this simple and plausible interaction rule can drive macro-dynamics of the territorial rule in a virtual state in quite diverse directions (see Figure 1).

3. The Case

Somalia has experienced a drastic process of state disintegration and reconstruction for more than two decades. This process directly flows from the civil war that began in the 1980s. Then the country was governed by the regime of Siad Barre. Almost 20 years after the coup d'état that brought him to power, the political support base for the regime was reduced to a narrow circle of the President's cronies formed around his own Marehan clan. Like the preceding regimes, his regime was largely southern-based in its regional inclination, alienating sizable population in the northern part of the country.

The fate of the regime and its lasting impact are well documented (Brons 2001; Lewis 2002; Somalia CEWERU 2013). Starting from the insurgent activities in the northwest and the northeast in the early 1980s, the regime's control over the whole territory deteriorated rapidly toward the end of the decade, leading to the complete collapse of the state authority in the 1990s. Incessant armed struggles among multiple factions ensued in the south, while a dozen of peace conferences failed to produce any lasting result. In the past decade, the Islamic Court Union, then far more militant Al-Shabaab, emerged, temporarily enjoying extensive territorial control over a large swath of the southern Somalia (Hansen 2013). Currently, Mogadishu and its environs are more or less controlled by an UN-supported government, which is moderately nationalistic and moderately Islamic. Yet, its presence on the ground is hardly felt over a large portion of the territory even with the massive support of the African Union (AU) peacekeepers.

Meanwhile, a rather contrasting development has been observed in the northern part of the country (Bradbury 2008; Höhne 2009; Renders 2012). In the northwest, self-declared Somaliland (since 1991) established itself after the rebellion there effectively wiped out the forces of Siad Barre in the early 1990s. Since then, this 'unrecognized state' has successfully held several reconciliation conferences as well as largely peaceful elections, consolidating its unity and peace even without the much-needed international recognition as an sovereign state. Similarly, an autonomous state of Puntland, which was formed in 1998, has retained its control over the northeastern part of Somalia³. As the lingering conflict in the eastern fringe of Somaliland (e.g., Sool and Sanaag regions) attests, neither of these political entities fully enjoys territorial integrity in their respective domains. Both, however, have shown a certain degree of achievement, given the otherwise disorderly political landscape that has governed Somalia to this day.

4. The Data

The MAS model introduced above is able to simulate complex dynamics of state integration and disintegration like that observed in Somalia in a sufficiently realistic setting. This will, in turn, offer a deeper understanding of the underlying political process in civil conflict in an empirically relevant manner. For this purpose, a variety of empirical data on the country concerned are necessary. Table 2 shows the list of input data for the model (see Sakamoto 2013b for further details).

Empirical Data	Data Garrage	Corresponding Variable in	
Empirical Data	Data Sources	a Virtual State	
Spatial			
-Population Count	Cridded Demulation of the World von 2 (CDW2) (CIECIN et al. 2004)	Resources of Each PopCell	
	Gridded Population of the World Ver.5 (GPW3) (CIESIN et al. 2004)	(multiplied by GNI per capita)	
	Constructed from the Existing Linguistic Distribution Maps (Asher		
-Ethnicity	and Moseley 1993); Lewis's Paper Map for Distribution of Somali	Traits of Each PopCell	
	Lineage Groups (Lewis 1998)		
-Religion	Derived from the Ethnicity Distribution; Also Consulting Other	Traits of Each PopCell	
	Sources (e.g., Yaken 1999)		
	Constructed from Supplementary Boundary Data of GPW3 for		
-Region (Administrative Units)	Ethiopia and the Sudan (CIESIN et al. 2004); Lewis's Paper Map	Traits of Each PopCell	
	for Somalia (Lewis 1998)		
Non-Spatial			
-GNI per capita	African Development Indicators (World Bank 2005)	Resources of Each PopCell	
-Government Inclination	Derived from the Existing Case Studies (e.g., Lewis 2002)	Traits of Government Ruler	

Table.2 List of Empirical Data Employed in the Virtual States

Among the different spatial and non-spatial datasets listed in the Table, those on population count (CIESIN et al. 2004) and GNI per capita (World Bank 2005) are employed to compute values for *Resources* variables of *PopCell* agents in a virtual The estimated demographic distribution in Somalia in 1990 is depicted in state. Figure 2. GNI per capita in the same year, \$120.009, is used in the following Regarding Traits of PopCells, the geo-referenced data on three simulations. distinct kinds of human grouping-ethnicity, religion, and region (based on the colonial boundaries)-are utilized given the political relevance of these traits for the case considered here. The spatial configurations of the three different categories of traits in Somalia are illustrated in Figure 3. Reflecting the much-emphasized political importance of the segmentary lineage structure of the Somali people (Lewis 1982), the data on ethnic groups in Somalia embraces the tree-like structure composed of clan-families, clans, sub-clans, and so on. Thus,

Traits of a *PopCell* can take a structured value like 'Somali-Darod-Marehan' or 'Somali-Hawiye-Abgaal' rather than simply 'Somali'⁴. The spatial information is taken from the paper map produced by an anthropologist I. W. Lewis in the 1950s (Lewis 1998): admittedly outdated but still outstanding sources on Somali lineage groups and their geographic distribution.



Figure 2: Estimated 1990 Population Distributions in Somalia

The yellow to red gradation displays different sizes of local population on each cell as measured by its logged population count.

As is mentioned above, the simulation starts from the situation in which a single *Ruler*—*Initial Government*—governs the whole territory. The *Traits* of this *Ruler* is given a value that is derived from empirical properties of the actual government to be simulated. For example, in the case of Siad Barre regime described above, its defining characteristics can be captured by *Traits* 'Somali-Darod-Marehan, **, South,' which state 'ethnically committed to Somali-Darod-Marehan; religiously indifferent; and regionally committed to the south (i.e., alienating Somalilanders in the north).' *Traits* of other *Rulers*—insurgent *Rulers*—are randomly generated. Reflecting the added structural complexity in the *Traits* of *PopCell* agents, a *Ruler* may also have somewhat complicated *Traits* in its ethnicity dimension, for instance, 'Somali-Darod-**' (committed to Darod clan family, but indifferent to any clan that belongs to this clan family) and 'Somali-**-**' (committed to Somali as a whole, but indifferent to any clan family)



Figure 3: Trait Distributions in Somalia

Each of colored polygons in each map describes the spatial spread of a population group with a specific trait. In the ethnicity category, different colors correspond to different clan families.

5. Simulations and Results

In 'virtual Somalia,' which was constructed from these different sources of empirical data, the MAS model was repeatedly run while systematically changing its parameters and variables. The results, first of all, confirm the strong tendency of this virtual state to disintegrate.

Reproducing Historical Dynamics

This section reports about simulations in the setting that approximates Somalia in the late 1980s: just like Siad Barre regime in actual Somalia, the *Traits* of *Initial*

Government are set to be 'Somali-Darod-Marehan, **, South.' In what follows, unless otherwise stated, various parameters are given the values that are specified in Table 3.

The Number of Periods	1000
The Number of Rulers (including	100
the Initial Government)	
Mobilization Level	1.0 for all the Rulers
Futonnal Passunas	0.0 for all the Rulers except the Initial
External Resources	Government
Coercion Effect	0.2
Sensitivity to Frontline	2.0
The Amount of Stochastic Noise	0.2

Table.3 Common Parameters of the Virtual States

Figures 4 and 5 visually capture the said tendency to disintegrate. In both, *External Resources*, which controls the amount of material resources exogenously given to the *Initial Government* in each time step, is set to be zero. The former figure displays snapshots of territorial rule in different simulation runs after sufficient time has elapsed (at 1000 steps). PopCells are differently colored according to which Ruler each of them is governed by. The latter figure summarizes macro-dynamics of territorial integration and disintegration in virtual Somalia in 20 different runs. Here, the degree of order and disorder in territorial rule is measured by *Disintegration Index* (DI): the amount of entropy that is computed from the fractions of territorial areas under control of each Ruler agent⁵. Its value is non-negative, and increases as the territorial rule in a virtual state becomes more fragmented. DI=0 implies the total unity under a single *Ruler* while the equal split of the territory between two *Rulers* implies DI=1.0. In the case of virtual Somalia, DI mostly remains around 3.0 even after a long period of time has passed: a substantially high level of disorder. Moreover, in all of the runs, Initial *Government* has lost all of the *PopCells* to other competitors, entirely disappearing from the scene. Thus, not unlike Siad Barre regime in history, near-hopeless prospects are waiting for *Initial Government* as well as the country at large.



Figure 4: Snapshots of Long-Term Territorial Order in Virtual Somalia 1

Each PopCell is colored according to the *Ruler* that it belongs to. Each snapshot was taken at 1000 time step. The simulation parameters are as specified in Table 3. *ExternalResources* of *InitialGovernment* is set to 0.0.



Figure 5: Long-Term Territorial Dynamics in Virtual Somalia

The territorial dynamics in virtual Somalia in 20 simulation runs are represented by 20 different time-series of *Disintegration Index* (DI) during 1000 time steps. The simulation setting is exactly the same as in Figure 4.

More systematic results are shown in Figure 6. This illustrates how the long-term condition of territorial rule in virtual Somalia is affected by changes in *External Resources* available to *Initial Government*. The simulation was run 20

times at each value of *External Resources* (increasing the value from 0 to 4000 at the increment of 200), and these 20 runs at each resource level were classified according to values of DI after 1000 time steps. In the figure, more sparsely shaded areas indicate more disorderly state of the territorial rule, while the color of the shades denotes either occurrence (blue) or non-occurrence (red) of the disappearance of *Initial Government* in the sense mentioned above. Quick inspection of the figure confirms that the observed tendency of the territorial rule to fragment in virtual Somalia is actually quite persistent in a wide range of parameter values: except with massive infusion of outside resources, *Initial Government* cannot expect to hold the country together in the long run even though the regime might somehow survive the ensuing conflict as one of competing military factions.



Figure 6: *External Resources* and Territorial Order in Virtual Somalia

Possible territorial conditions that virtual Somalia can face in the long run are summarized by successive histograms of 20 simulation runs. Each run is classified according to its DI value at 1000 time step. The vertical axis measures the frequency of each class, while the horizontal axis denotes the changing amount of *External Resources* of *Initial Government*.

As several annotative labels in the figure suggest, there is a considerable degree

of variation in this overall pattern of territorial disintegration, depending on simulation runs as well as parameter values. Here, interesting questions are whether and how often one observes the formation of autonomous regional entities— -just like Somaliland and Puntland in post-Siad Barre Somalia—amidst the collapsing authority of the central government. As Figure 7 illustrates, such entities in fact emerged in virtual Somalia, sometimes showing an impressive level of unity and persistency in an otherwise chaotic environment. Yet, from a statistical point of view, this scenario is rather a rarity. More often, these *Rulers*, even if they emerge at all, sooner or later suffer from their own versions of serious internal turmoil. This implies one of the following two: the model, in its current formulation, does not capture the reality well, or political entities like Somaliland and Puntland have made unlikely things happen.



Figure 7: Snapshots of Long-Term Territorial Order in Virtual Somalia 2

These snapshots, taken at time step 1000, clearly show the emergence of relatively stable regional entities in the northern part of country. The red area in the south consists of *PopCells* under the rule of *Initial Government*. The left panel depicts a run where *External Resources* is 400, while the right displays a run where the variable is set to be 2000.

All these results pose one question: why is the tendency towards the fragmented territorial rule such prevalent force in virtual Somalia, troubling the government and rebels alike? The often-cited factors (in the context of actual Somalia) such as narrow-based 'clanism' might have some share in this force (Kapteijns 2012), but something more is involved. Figure 8 illuminates this. The figure, just like

Figure 6, displays successive histograms of 20 simulation runs, which are classified according to the long-term territorial condition of each run as measured by DI. Unlike the previous figure, the horizontal axis in the current figure denotes a change in GNI per capita. The default empirical value, \$120.009, is also indicated with the dashed vertical line.



Figure 8: GNI per capita and Territorial Order in Virtual Somalia



As is clearly seen from this figure, there are several distinctive phases of long-term territorial order, in addition to the high level of disintegration that has been dominant so far. Generally speaking, increasing GNI per capita, which directly affects an overall level of *PopCells' Resources*, makes the territorial rule in virtual Somalia more structured in the long run. On the other hand, the long-term survival of *Initial Government* remains impossible in a wide range of GNI per capita values. At a moderately high level of *PopCells' Resources*, its rule is quickly replaced by an alternative *Ruler*, or it simply disappears amidst the persistent territorial division that is formed between the north and the south (see Figure 9). If GNI per capita increases still further, there emerges the realistic prospect for

Initial Government to maintain the unified rule even without any infusion of *External Resources*.



Figure 9: Snapshots of Long-Term Territorial Order in Virtual Somalia 3 These snapshots, taken at time step 1000, show a more structured phase of long-term territorial order in virtual Somalia. In both runs, GNI per capita is set to be \$500.

Such transitions among different territorial orders suggest one explanation for the enduring fragmentation of virtual Somalia: the weak resource base, conditioned by the low level of income as well as the sparse population distribution, sets a serious limit on the prospect for *any* political organization to sustain its governance over a wide area for an extended period of time.

Alternative Futures for Somalia

It might be instructive to run the model in more hypothetical settings, since such an exercise not only aids understanding of the conflict at hand, but also offers some practical insights to policy arguments for the future. One example can be seen in Figure 10. The top and the bottom graphs in this figure mostly correspond to Figure 6 and Figure 8 in the preceding simulations, respectively. The simulation parameters remain the same as before (see Table 3). The only difference is the *Traits* of *Initial Government*: this time, the variable is set to be (Somali-**-**, Muslim, South) rather than the narrowly based (Somali-Darod-Marehan, **, South). In other words, the new central government adopts a somewhat integrative stance of avoiding excessive 'clanism.' In stead, it emphasizes the common socio-cultural elements-Somali ethnicity and Islam-shared by the most of the population in Somalia (but still remains southern-based in its regional inclination). These aspects also roughly characterize the current government in actual Somalia.



SOM: Unity Government

Input to InitGovt.



SOM: Unity Government

Figure 10: Long-Term Territorial Order under an Alternative Government

Traits of Initial Government changes to (Somali-**-**, Muslim, South). The top graph is similar to Figure 6, while the bottom one is similar to Figure 8.

The figure tells that the prospect for peace and unity is not so bright under this government. Multi-sided conflicts and the accompanying division of territorial rule among multiple factions are still a significant possibility, especially when the resource availability from outside (*External Resources*) or inside (GNI per capita) is at a low level. Thus, even the drastic restructuring of the government orientation does not easily compensate the basic resource constraints on sustainable territorial rule mentioned above. On the other hand, there is a notable difference: the amount of *External Resources* or GNI per capita required to evade serious disintegration is considerably reduced. With enough supporting resources, the new *Initial Government* is far more likely to attain the unity of virtual Somalia than the Siad-Barre-like regime in the previous simulations.

Lastly, Figure 11 summarizes yet another set of simulations. Here, the difference is not only in *Traits* of *Initial Government* but also in the territory of virtual Somalia itself. Actually, the simulations were conducted only in its northwestern part, that is, Somaliland. Among the three categories of socio-cultural traits, the regional dimension is omitted here because the north-south divide in the context of wider Somalia is no longer relevant. The *Traits* of *Initial Government* in 'virtual Somaliland' is rather integrative (Somali-**-**, **): ethnically committed to Somalis and religiously neutral. Otherwise, the simulation conditions including the empirical datasets used are exactly the same.

The figure again illuminates the persistent tendency for disintegration even in this reduced spatial context (see Figure 12). The secession from the rest of Somalia itself does not assure the lasting peace and unity for virtual Somaliland. Rather, substantial infusion of *External Resources* or drastic improvement in GNI per capita is necessary for avoiding the territorial fragmentation in the long run. Such a grim prospect can be expected given that the area frequently fails to retain its unity as a regional entity in wider virtual Somalia, as is reported above. The notable feature here is that the most frequent and persistent occurrence of conflict is observed in the eastern part of virtual Somaliland. This is instructive because the roughly same area (Sool and Sanaag regions) in reality, which has a relatively homogeneous population of Harti clan members (Darod clan family), has seen occasional uprisings and disturbances since the 'independence' of Somaliland in

1991 (Höhne 2006; Renders and Terlinden 2010)⁶.



SOM: Somaliland Independence





Figure 11: Long-Term Territorial Order in Virtual Somaliland

Two graphs illustrate possible long-term territorial conditions in virtual Somaliland, which is completely separated from the rest of virtual Somalia.



Figure 12: Snapshots of Long-Term Territorial Order in Virtual Somalia 3 These snapshots, taken at time step 1000, show typical conditions of territorial rule in virtual Somaliland. The left panel depicts a run where *External Resources* is 0, while the right displays a run where the variable is set to be 400.

6. Conclusion

In this paper, we presented a MAS model of civil conflict that has distinctive focus on territorial integration and disintegration of the sovereign state. The state territorial rule and its dynamics sometimes drive and sometimes reflect the spatio-temporal process of armed conflict itself. Yet, the attempt to seriously incorporate these dynamics into analysis has been mostly lacking in the preceding models of civil conflict. Being applied to the case of Somalia, this model was then shown to be able to capture various defining aspects of the complex spatial dynamics of the actual state fragmentation (e.g., the extensive territorial disintegration with the formation of incipient territorial entities in some areas such as Somaliland), along with notable discrepancies from what happened in reality (e.g., the general lack of sustainability of these territorial entities). As was elaborated elsewhere (Sakamoto 2013b), these defining aspects are broadly conditioned by spatial configurations of the state concerned such as population distribution and lineage group distribution. On the other hand, the analysis here also suggested the significance of the nationwide resource constraints for the near-universal occurrence of fragmentation of political entities. In the ensuring hypothetical simulations, it was shown that these constraints might to some extent (but never completely) be alleviated under more inclusive central government. Since the model has open-ended nature in its formulation as well as in its possible parameter combinations, there is an obvious possibility that a more certain path to peace will be found out by continuing such 'policy experiments' in virtual Somalia.

Lastly, brief comments on possible improvements are in order. Firstly, more rigorous empirical test of the model is needed. It is not always easy to collect or construct detailed spatio-temporal data on the state territorial division among conflicting parties; especially so in countries like Somalia, which has suffered a substantial level of the state fragmentation. Yet, given the increasing availability of geo-referenced datasets on civil conflict (e.g., Raleigh et al. 2010) as well as the recent trend towards more quantitative validation of MAS models (Bhavnani et al. 2014; Weidmann and Sulayen 2013), efforts should be made in this direction.

Secondly, a more fine-grained and more flexible MAS model is necessary. For example, in its current formulation, the model is not able to differentiate 'militant' Islam like al-Shabaab from 'moderate' Islam because it simply does not have a variable or logic to incorporate such a difference. This can limit the empirical applicability of the model. In other words, the model should be enhanced in its representation of the reality.

Thirdly, more extensive simulations are fruitful. Particularly, the ongoing conflict in Somalia has attracted countless attempts to influence the course of events from outside the country: from a dozen of peace making initiatives to forceful military interventions of the neighboring countries such as Ethiopia. It is thus important to assess the impacts of these recurrent external involvements on the ensuing dynamics of conflict and territorial rule. Although the existing model specifications such as *External Resources* of *Rulers* can partially capture these factors, the model can more explicitly incorporate them by variously setting the 'boundary condition' of the virtual state concerned (see Sakamoto 2013a for more detail). Practical insights about a desirable role of external actor might be gained from such an extension.

Notes

¹ The model was constructed and implemented on a general-purpose multi-agent simulator *artisoc* (version 3.0).

² The referred article is downloadable at

http://cdr.c.u-tokyo.ac.jp/Quarterly/Vol8_Sakamoto.pdf.

³ Unlike Somaliland, Puntland does not officially seek the status of an independent sovereign state.

⁴ In reality, the depth of Somali lineage layers extends far beyond that indicated here (three levels). In the following simulations, this crude assumption of three levels is adopted. No such sub-structure is assumed for other ethnic groups such as so-called Bantu-Somalis.

⁵ More specifically, *DI* is defined as $DI=\Sigma ter(k)\log_2 ter(k)$, where ter(k) denotes the ratio of a total area of *PopCells* under the rule of *Ruler k* relative to that of the whole territory. The summation is taken over all *k*.

⁶ This is even more instructive because, in virtual Somaliland, uprisings and disturbances in the area take place without any external involvement (e.g., intervention from neighboring 'virtual Puntland'), which is often cited as an instigating factor in the existing literature (Höhne 2006).

References

- Asher, Ron. E., and Christopher Moseley. eds. 1993. *Atlas of the World's Languages*. Oxford: Routledge.
- Bhavnani, Ravi, and Hyun Jin Choi. 2012. "Modeling Civil Violence in Afghanistan: Ethnic Geography, Control, and Collaboration." *Complexity* 17, no. 6: 42-51.
- Bhavnani, Ravi, Karsten Donnay, Dan Miodownik, Maayan Mor, and Dirk Helbing. 2014."Group Segregation and Urban Violence." *American Journal of Political Science* 58, no. 1: 226-45.
- Bradbury, Mark 2008. Becoming Somaliland, London: James Currey.
- Brons, Maria. 2001. Society, Security, Sovereignty, and the State in Somalia : From Statelessness to Statelessness? Utrecht: International Books.
- Caspersen, Nina 2012. Unrecognized States The Struggle for Sovereignty in the Modern International System, London: Polity.

- Caspersen, Nina and Gareth Stansfield, eds. 2010. Unrecognized States in the International System, London: Routledge.
- Cederman, Lars-Erik. 1997. Emergent Actors in World Politics : How States and Nations Develop and Dissolve. Princeton Studies in Complexity. Princeton, N.J.: Princeton University Press.
- Cederman, Lars-Erik. 2008. Articulating the Geo-cultural Logic of Nationalist Insurgency. In Order, Conflict and Violence, ed. Stathis N. Kalyvas, Ian Shapiro, and Tarek Masoud. Cambridge: Cambridge University Press.
- Cederman, Lars-Erik, and Kristian Skrede Gleditsch. 2009. "Introduction to Special Issue on "Disaggregating Civil War"." *Journal of Conflict Resolution* 53, no. 4 (August 1, 2009): 487-95.
- Center for International Earth Science Information Network (CIESIN), Columbia University, and Centro Internacional de Agricultura Tropical (CIAT). 2004. *Gridded Population of the World (GPW), ver. 3.* Palisades, Washington, DC: CIESIN, Columbia University.
- Cunningham, Kathleen Gallagher, and Nils B. Weidmann. 2010. "Shared Space: Ethnic Groups, State Accommodation, and Localized Conflict." *International Studies Quarterly* 54, no. 4: 1035-54.
- Donnay, Karsten, and Vladimir Filimonov. 2014. "Views to a War: Systematic Differences in Media and Military Reporting of the War in Iraq." *EPJ Data Science* 3, no. 1: 1-25.
- Doornbos, Martin R. 2006. Global Forces and State Restructuring : Dynamics of State Formation and Collapse. International Political Economy Series. New York: Palgrave Macmillian.
- Hansen, Stig Jarle 2013. Al-Shabaab in Somalia: The History and Ideology of a Militant Islamist Group, 2005-2012, London: Hurts & Company.
- Höhne, Markus V. 2006. "Political Identity, Emerging State Structures and Conflict in Northern Somalia." *The Journal of Modern African Studies* 44, no. 03: 397-414.
- Höhne, Markus V. 2009. "Mimesis and Mimicry in Dynamics of State and Identity Formation in Northern Somalia," *Africa*, 79, no.2: 252-281.
- Kapteijns, Lidwien 2012. *Clan Cleansing in Somalia: The Ruinous Legacy of 1991*, Philadelphia: University of Pennsylvania Press.
- Kingston, Paul W. T., and Ian Spears. 2004. States-within-States : Incipient

Political Entities in the Post-Cold War Era. 1st ed. New York: Palgrave Macmillan.

- Lewis, I. M. 1982. A Pastoral Democracy : A Study of Pastoralism and Politics among the Northern Somali of the Horn of Africa. New York, N.Y.: Africana Pub. Co. for the International African Institute.
- Lewis, I. M. 1998. *Peoples of the Horn of Africa : Somali, Afar, and Saho*. 1st Red Sea Press, Inc. ed. Lawrenceville, NJ: Red Sea Press.
- Lewis, I. M. 2002. A Modern History of the Somali : Nation and State in the Horn of Africa. Eastern African Studies. 4th ed. Oxford; Hargeisa, Somaliland; Athens: James Currey; Btec Books; Ohio University Press.
- Lim, May, Richard Metzler, and Yaneer Bar-Yam. 2007. "Global Pattern Formation and Ethnic/Cultural Violence." Science 317, no. 5844 (September 14, 2007): 1540-44.
- Østby, Gudrun, Ragnhild Nordås, and Jan Ketil Rød. 2009. "Regional Inequalities and Civil Conflict in Sub-Saharan Africa." *International Studies Quarterly* 53, no. 2: 301-24.
- Raleigh, Clionadh, Andrew Linke, Håvard Hegre, and Joakim Karlsen. 2010.
 "Introducing Acled: An Armed Conflict Location and Event Dataset: Special Data Feature." *Journal of Peace Research* 47, no. 5 (September 1, 2010): 651-60.
- Renders, Marleen 2012. Consider Somaliland: State-Building with Traditional Leaders and Institutions, Leiden: Brill.
- Renders, Marleen and Ulf Terlinden (2010) "Negotiating Statehood in a Hybrid Political Order: the Case of Somaliland," *Development and Change*, 41, no.4:723-746.
- Rotberg, Robert I. 2004. When States Fail : Causes and Consequences. Princeton, N.J.: Princeton University Press.
- Sakamoto, Takuto. 2013a. "Conflict Analysis in Virtual States (CAVS): A New Experimental Method Based on the Extensive Use of Multi-Agent Simulation (MAS) and Geographical Information System (GIS)." *JICA-RI Working Paper* 56 (March 2013): 1-27.
- Sakamoto, Takuto. 2013b. "Exploring Spatial Dynamics of Civil Conflicts in Virtual Africa: A New Research Design." *CDR Quarterly* 8 (October 2013): 28-58.
- Schutte, Sebastian, and Karsten Donnay. 2014. "Matched Wake Analysis: Finding

Causal Relationships in Spatiotemporal Event Data." *Political Geography* 41: 1-10.

- Somalia CEWERU. 2013. From the Bottom up: Southern Regions: Perspective through Conflict Analysis and Key Political Actors' Mapping of Gedo, Middle Juba, Lower Juba, and Lower Shabelle. Mogadishu: Somalia CEWERU (Conflict Early Warning Early Response Unit).
- Weidmann, Nils B. 2006. "Settlement Patterns and the Success of Insurgencies: The Territorial Control Model." Paper presented at the 1st World Congress on Social Simulation, Kyoto, August 21–25.
- Weidmann, Nils B., Håvard Hegre, and Clionadh Raleigh. 2006. "Modeling Spatial and Temporal Patterns of Civil War." Paper presented at the 102nd Annual Meeting of the American Political Science Association, Philadelphia, August 31– September 3.
- Weidmann, Nils B., Jan Ketil Rød, and Lars-Erik Cederman. 2010. "Representing Ethnic Groups in Space: A New Dataset." *Journal of Peace Research* 47, no. 4 (July 1, 2010): 491-99.
- Weidmann, Nils B., and Idean Salehyan. 2013. "Violence and Ethnic Segregation: A Computational Model Applied to Baghdad." International Studies Quarterly 57, no. 1: 52-64.
- World Bank. 2005. World Bank Africa Database 2005 (CD-ROM). Washington, DC:World Bank Publications.
- Yaken, Mohamad Z. 1999. Almanac of African Peoples and Nations. London: Transaction Publishers.
- Zartman, I. William. 1995. Collapsed States : The Disintegration and Restoration of Legitimate Authority. Sais African Studies Library. Boulder: L. Rienner Publishers.