A Preliminary System Dynamics Model of Insurgency Management: The Anglo-Irish War of 1916-21 as a Case Study

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Abstract

The aim of this paper is to demonstrate the potential of using the system dynamics computer simulation methodology to gain insight into the dynamic behavior of insurgencies. To this end, a basic model of insurgencies containing the dynamic mechanisms of incident suppression, insurgent creation, and war weariness is developed. The paper then shows how this model, properly adapted, can explain much of the behavior of insurgencies by examining the Anglo-Irish War of 1916-21. Then, to illustrate the potential usefulness of the system dynamics methodology to policy makers, the paper uses the model to determine which system parameters might have most affected the outcome of the Anglo-Irish War. As one example, the simulation suggests that the lack of British governmental legitimacy in Ireland may have hindered the simulated efficacy of insurgency suppression efforts. As another example, the paper shows how the effects of a "good works" policy might have aided insurgency suppression in Ireland by separating the insurgents from their supporting population. The paper then concludes by proposing how such a model and the system dynamics methodology in general might be developed to assist policy makers manage current insurgencies throughout the world.

1. Introduction

Over recent years, insurgencies (also known as asymmetric, low intensity, or guerilla conflicts) have re-emerged in the world's political consciousness. Part of this is due to the multiple insurgencies occurring in Iraq, which are interfering with attempts by the United States to reestablish an effective government within that nation. However, many other insurgencies are also extant world wide. A partial list of nations suffering from insurgencies would include the Philippines, Afghanistan, Chechnya, Kashmir, Yemen, Djibouti, Columbia, and Sri Lanka (Kaplan 2005, *Economist* 2005a, *Economist* 2005b, *Economist* 2006). Many of these insurgencies have religious or ethnic overtones, although some do not. For example, drug trafficking appears to drive the insurgency in Columbia (Kaplan 2005).

Historically speaking, insurgencies are nothing new. Raiding, from which insurgencies or "guerilla" warfare developed, in fact predate conventional warfare (Keegan 1994). The term "guerilla" itself was coined during the Napoleonic Wars when numerous Spaniards began to pursue tactics of sporadic raids to harass the occupying armies of Napoleon. These raiders would then fade into the countryside whenever French conventional army forces would pursue them. In the last century, however, three primary changes have occurred in the dynamics of insurgencies. Better communications have increased the reach and speed of news and propaganda from both insurgents and counter-insurgents. Also, many—though not all—insurgencies have shifted from a rural to an urban setting. Finally, the availability of weapons facilitating asymmetric warfare has increased enormously, particularly due to (1) the growth of overseas communities willing to support insurgent movements in their motherland with money, (2) the emergence of great powers willing to use insurgents to fight "proxy wars," (3) the growth and sale of narcotics as a cash crop to finance weapons procurement by insurgents, and (4) the

growth of international commerce and travel in general, which has increased the permeability of national borders to arms smuggling.

These factors taken together make the management of insurgencies more difficult than in former times, which has global implications. Depending on one's point of view, any particular insurgency may be seen as "good" or "bad." However, the most salient fact of any insurgency—and its resulting counter-insurgency—is the significant loss of life that often overwhelms whatever political benefits may accrue to either side in the conflict. Allied with this is the disruption or destruction of a region's infrastructure and institutions, leading to further chaos, deaths, and potentially more civil unrest. Hence, whether a given insurgency can be effectively suppressed and what is the minimum force method for doing so is of clear interest to policy makers world-wide. For these reasons, any methodology that can capture the essential dynamics of insurgency evolution at a strategic level and can improve policy makers' mental models would appear desirable.

Accordingly, the purpose of this paper is to demonstrate whether the methodology of system dynamics (Forrester 1958, Sterman 2000) can be used to develop a strategic computer simulation model to: (1) yield useful insights into how insurgencies evolve dynamically under modern conditions and (2) determine under which conditions insurgencies might be mitigated. In particular, this paper shall concentrate on insurgencies that occur primarily in urban rather than rural settings (see Coyle 1985 for an excellent treatment of rural insurgencies) and in which the primary opponent of the insurgency is based in a different nation. To meet theses goals, this paper will first develop a plausible model congruent with what is known about insurgencies using the system dynamics methodology (SD). Then the paper will test whether the model can reasonably replicate the dynamic behavior of the variables (e.g. active insurgents, foreign troops, etc.) associated with a case study of a particular insurgency. This testing will develop reasonable

confidence that any insights resulting from model—and hence the system dynamics methodology in general—are worth further study. Then, a brief sensitivity analysis of the model to its various parameters will be performed to determine some potential insights. Finally, the response of the model to an example pair of insurgency management policies will be tested. The purpose of both these analyses is not to determine final solutions for the problems of insurgency management—that will require much future work—but rather only to demonstrate that SD is a fruitful avenue for such inquiry.

The Anglo-Irish War (also known as the Irish War of Independence) of 1916-23 has been chosen as a benchmark for the model in this paper for several reasons. First, and perhaps most importantly, it is often considered the first modern urban insurgency (Keegan 2001), which influenced by example the course of events during insurgencies as far afield as Vietnam and Latin America (Hopkinson 2002). In particular, it was the first well-documented insurgency to display many of the characteristics of modern insurgencies, in particular (1) the severely asymmetric nature of the conflict, primarily the ability of the modern rifle to wreak apparently random mayhem at a distance with little risk for the assailant, (2) the relative plentitude of such weapons due to substantial financing of the insurrection (interestingly enough, in this case primarily by private citizens of the United States), (3) the occurrence of much of the conflict in an urban rather than a rural setting (particularly Dublin and Cork, see Hopkinson 2002), and (4) the exploitation of modern media to distribute news and propaganda to both the region in which the insurrection occurred as well as in the home region of troops engaged in suppressing the insurgency. Another interesting point of this particular insurgency is the oft-remarked quiescent nature of the Irish citizenry until 1916 (Kautt 1999). Additional reasons for choosing this conflict is the high degree of documentation available as well as the ability (within the United States, at least) to examine this conflict with relative dispassion.

The remainder of the paper is organized as follows. Section 2 presents the model structure. Section 3 describes the parameter and policy sensitivity analyses. Finally, Section 4 discusses the implications of this research for further model development.

2. The Model

Using the Anglo-Irish War as a base case, this section will build a system dynamics model of insurgencies. Because this paper's goal is not to develop a model of the Anglo-Irish War *per se* but rather only to take a first step towards developing a generic model of insurrections, the model will not attempt to capture all of the structure peculiar to the Anglo-Irish War nor tightly calibrate the resulting simulation. Instead, it will merely attempt to replicate most of the conflict's dynamic behavior in an approximate sense. For example, for the sake of simplicity, the dynamics in the northern six counties of Ulster with Protestant majorities, which willingly remained part of the United Kingdom, are ignored. These dynamics, needless to say, were somewhat different and more complex than those presented here, because the counties involved contained a sizable Catholic minority sympathetic to the insurgency. In contrast, there was no sizable minority of Protestants sympathetic to the British Crown in southern Ireland.

From many accounts (e.g. Kautt 1999, Hopkinson 2002), three factors—incident suppression, insurgent creation, and war-weariness—seemed to be of decisive importance in the Anglo-Irish War (as well as in many other urban insurgencies). There already exists some excellent work in the system dynamics literature on insurgencies by Coyle (1985). However, the present work differs from his treatment because of its emphasis on (1) urban rather than rural settings and (2) on the counter-insurgent's seat of government existing in a different nation from that in which the insurgency is taking place. This will lead to the causal mechanisms of two of

the three dynamic factors in this paper—insurgent creation and war-weariness—differing substantially from those found in Coyle's work.

The remainder of the section will present the causal mechanisms behind the three dynamic factors in the model as well as describe some associated behaviors in detail.

2.1 Incident Suppression

While Ireland had been under England's control to varying degrees since the twelfth century, it only officially became part of the United Kingdom in 1800 after a huge rebellion in 1798 frightened the British government in Westminster. However, problems with persistent disenfranchisement of the Catholic majority in Ireland, along with issues of land tenure and poor management of the potato famine by British authorities in 1845-49, led to further violent rebellions against British rule in 1803, 1848, and 1867. These latter three rebellions remained relatively unsupported by the population at large. Instead, the focus of popular sentiment shifted to support for reform through parliamentary action in Westminster. Home rule, which would have given Ireland a great deal of local autonomy, was finally passed by the U.K. parliament in 1914, but its implementation was suspended for the duration of World War I.

It is at this point, when the struggle for home rule had apparently been won and the Irish population by all accounts was content—though perhaps not enamored—with British rule, that one would least expect the outbreak of a successful rebellion. However, the presence of the First World War affected the structure of the system in place at that time. To see how this occurred, first consider the basic insurgency suppression structure in Figure 1.

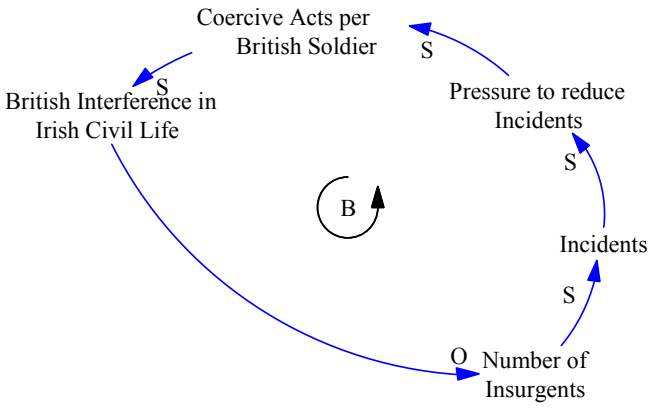

Figure 1: Insurgency Suppression Loop

Figure 1 is known in system dynamics terms as a causal-loop diagram. Following system dynamics conventions, each arrow in the diagram represents a link of causation between two variables. For example, *ceteris paribus,* an increase in the *number of insurgents*[1] active in Ireland will result in an increase in the number of *incidents* committed by those insurgents (including raids, snipings, acts of arson, bombings, or other incidents directed at elements of the British government[2]). Because any change (whether an increase or decrease) in the *number of insurgents* will *ceteris paribus* result in a change in the number of *incidents* in the same direction, the arrow is labeled with an "S" next to it. (An "O" label next to an arrow indicates, in contrast, that the two linked variables always move in opposite directions.) Finally, because it feeds back on itself, the entire chain of variables in Figure 1 is known as a "causal loop" or, more simply, a loop. Causal loops are the building blocks of all system dynamics models.

To examine the incident suppression loop in Figure 1 more closely, consider the lower right-hand side of Figure 1, beginning with the *number of insurgents*. Each of these insurgents commits a number of *incidents* per month. Over time, the rate of *incidents* builds up pressure for the representatives of the British government in Ireland to reduce the number of incidents. This

[1] Model variables (any quantity which can be imagined to go up or down) will be italicized to aid identification.
[2] These targets sometimes included civilians who worked for the British government as well as the Royal Irish Constabulary (RIC). The RIC was a paramilitary organization primarily composed of Catholic Irish, who nonetheless acted as agents of the British government in Ireland.

pressure to reduce incidents leads to an increase in the number of house searches, arrests, detentions, or other disruptions, resulting in an increased *British interference in Irish civil life*. This disruption does, however, eventually reduce the number of active insurgents. (Note the "O" next to the arrow linking *British Interference in Civil Life* and *number of insurgents*, indicating that an increase (or decrease) in interference will result in a pressure to decrease (or increase) in insurgents.) Hence, because of the chain of variables in the causal loop, any increase in the *number of insurgents* will *ceteris paribus* eventually result in a pressure to reduce (or vice versa) that same variable. Because of this behavior, this sort of loop is termed a "balancing loop." Balancing loops are marked within a causal-loop diagram by a "B" inside a circular arrow. Note that a short delay in this loop exists between *pressure to reduce incidents* and *coercive acts per British soldier*, because of the time needed to implement any new coercive policies. However, the delay is not marked in this causal loop because it is relatively short in comparison with delays contained within other loops in the model.

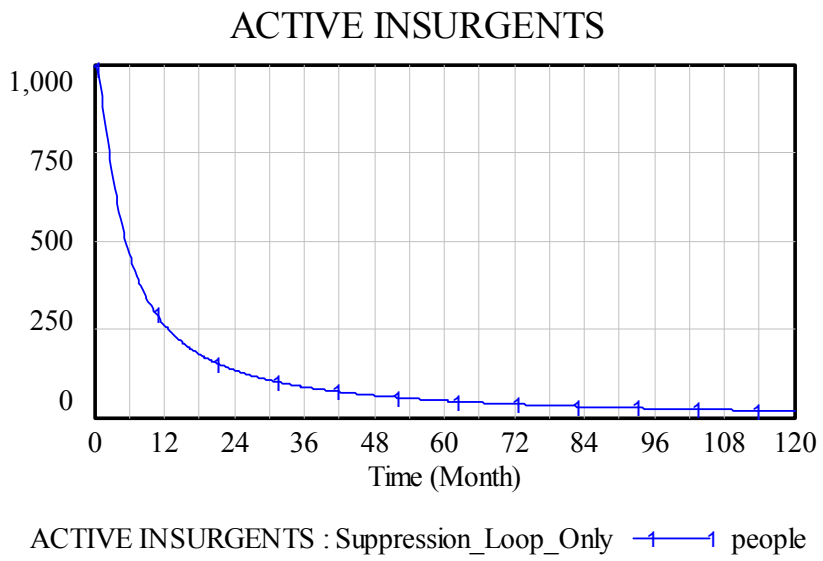

Figure 2: Simulated active insurgents vs. time when only the insurgent loop is active (Month zero represents the beginning of the rebellion in earnest in early 1919.)

Figure 2 presents a simulation of the incident suppression loop. (Note that the model equations in their entirety are presented in the Appendix.) There were only approximately 1000 active insurgents prior to 1918 in Ireland, although any and all figures from this war—as in most insurgencies—are notoriously fuzzy (Kautt 1999). In the absence of any other effects, our simulation model shows that these insurgents will quickly either be detained by British authorities or retire of their own accord. (For purposes of the model, insurgents are assumed to be active between the ages of 15 and 25 years.)

2.2 Insurgent Creation

However, the results of Figure 2 are misleading in isolation, because other causal loops are also active in the system. The one most often noted in insurgencies is the insurgent creation loop presented in Figure 3. This is the loop thought responsible for a tremendous expansion in size of the Irish Volunteers and their offspring, the original Irish Republican Army,[3] especially after 1918. It also seems to be active in many other insurgencies (Kautt 1999).

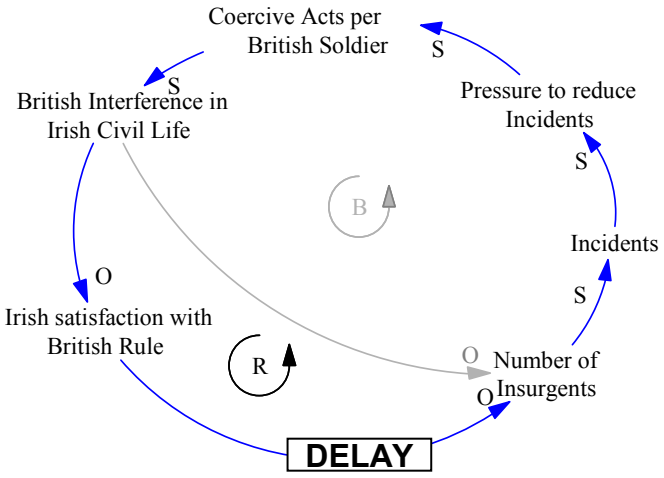

Figure 3: Addition of Insurgent Creation Loop

[3] The Irish Volunteers morphed into the original Irish Republican Army, which eventually became the National Army of the Irish Free State and, later, the Republic of Ireland. Despite its claims, the current Provisional Irish Republican Army, which has been active in Northern Ireland between 1969 and 2005, is considered by most observers to be a separate organization.

In this loop, British interference in Irish civil life, while leading to the suppression of current insurgents, also leads to the Irish public's general dissatisfaction with British rule. This dissatisfaction will lead to new individuals joining the insurgency. This creates the potential for a vicious cycle because, *ceteris paribus,* any increase in the *number of insurgents* will lead to more *incidents* by the insurgents and hence more *pressure to reduce incidents* by the British government. This pressure will result in a greater *Interference in Irish Civil Life,* which will further reduce *Irish Satisfaction with British Rule* and hence increase the *number of insurgents* even more, completing the causal loop. Because any change in the *number of insurgents* ultimately reinforces itself, this sort causal loop is termed a "reinforcing loop" and is marked with an "R" inside a circular arrow in the diagram. Reinforcing loops are most typically the engines of growth in SD models.

A further wrinkle in this causal loop is that, while some of the effect of dissatisfaction on increasing insurgents will occur immediately, the full force effect of dissatisfaction will take some time to percolate through the system. The reason for this is that *Irish satisfaction with British Rule* is more likely to fall under a prolonged regime of coercive actions than under a short one. In other words, Irish satisfaction with the British government has some inertia. Additionally, once potential insurgents are "activated," most of them will need some time before they can make the appropriate connections with the Irish Volunteers, receive training and weapons, and effectively add to its forces. These delays (or inertias) in the model are marked by a rectangle containing the word "delay" between *Irish Satisfaction with British Rule* and *Number of Insurgents.* The net effect of this delay is to keep the vicious cycle of the insurgent creation loop from immediately spiraling out of control once it is set in motion.

Finally, an additional "benefit" of a low *Irish Satisfaction with British Rule* to the insurgents is that widespread sympathy to the insurgency among the populace allows the

insurgents greater mobility and enables them to more easily evade capture. This factor will also lead to a greater number of insurgents over the long run.

From a historical perspective, the general populace of Ireland, according to all reports, was not sympathetic to violent rebellion prior to April 1916. Up to that point, a fairly stable equilibrium seemed to exist in which the Irish were reasonably satisfied with British rule; hence, insurgent incidents were fairly rare. This turned the vicious cycle of insurgency creation into a virtuous one in which low Irish dissatisfaction with British rule lead to a small number of insurgents and hence less interference by the British with Irish civil life, further reducing the number of insurgents. However, two critical things changed because of the First World War. The Irish Volunteers, realizing how much of the British Army was tied up in France, saw a chance to escalate the conflict. As one part of this effort, they staged a general uprising by seizing several governmental buildings in Dublin, including the General Post Office, on Easter Monday in 1916. After a week of fighting against five thousand British Regular troops, the participants in the Easter Rising surrendered. None of the sympathetic uprisings in outlying areas of Ireland assumed by the Rising's participants ever materialized. Nor did the participants receive any additional support from the citizens of Dublin. According to one source, prisoners from the Rising being shipped to Wales for detention were actually spat upon by angry Dubliners (*Wikipedia*, "Easter Rising," 2006). Overall, it appeared as if the Rising were a dismal failure similar to the failed rebellions in the previous century.

However, another change had occurred because of World War I. The British government felt much greater pressure to suppress dissent in Ireland because of World War I than they would have in a time of peace. These two effects are represented in the diagram in Figure 4.

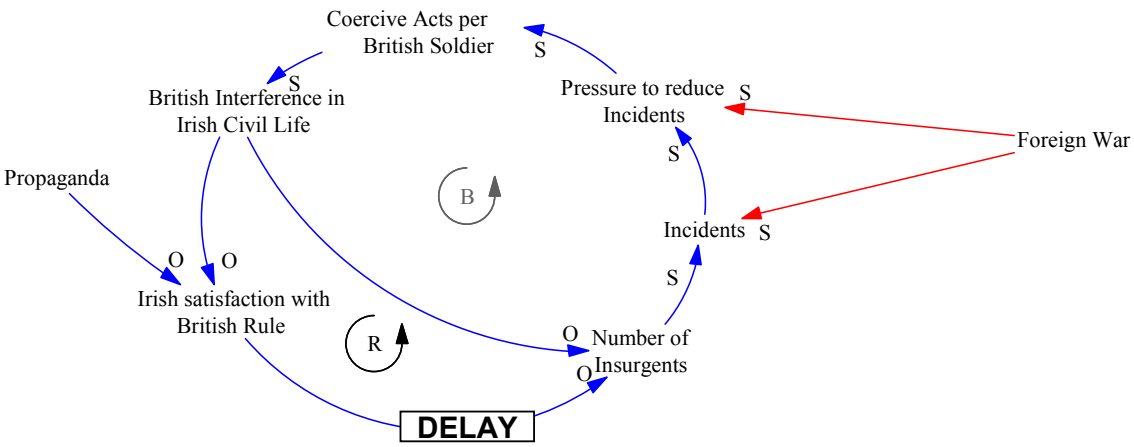

Figure 4: Effect of World War I on Model

After the Rising, martial law was immediately declared in Ireland; the first of somewhere between twenty and forty thousand unannounced home searches were begun; and approximately 3500 Irish citizens were arrested. (All of this in a country of only some four million people.) Fifteen of the Rising's leaders were executed by firing squad after secret trials. The Irish populace viewed the executions as unwarranted (Kautt 1999).

These effects are represented in the model shown in Figure 4 by increasing the number of incidents per month per number of insurgents as well as increasing, *ceteris paribus*, the pressure on the British government to react for any given number of incidents. Figure 4 also shows the effects of propaganda, which the remaining leaders of the Irish Volunteers—having learned from the general indifference to the Easter Rising—began to exploit to dramatize to the Irish people the perceived excesses of the British government. This was carried out primarily by means of the newspapers including the underground, but widely distributed, *Irish Bulletin*, published by Irish Volunteer leaders Desmond FitzGerald and Erskine Childers. Interestingly, counter-propaganda efforts by the British government had little impact, perhaps because they were directed primarily at bolstering public opinion in Great Britain as well as the loyal counties in Ulster for the counter-insurgency rather than de-legitimizing the insurgency among the populace of the remainder of Ireland.

In the simulation, the effect of the reinforcing loop of insurgent creation is shown in Figure 5. Instead of the incident suppression loop immediately decreasing the number of insurgents as in Figure 2, the number of insurgents actually increases in Figure 5 because the insurgent creation loop is activated. However, the full effect of the loop is not felt for nineteen months because of the inertia in public opinion and the time it takes for potential insurgents to become active. However, after twenty months, the mass influx of new insurgents disappears. In fact, the drop in the number of simulated insurgents is slowed only by new potential insurgents becoming of age to actually fight, partially balancing the loss of those insurgents who are captured by British forces.[4]

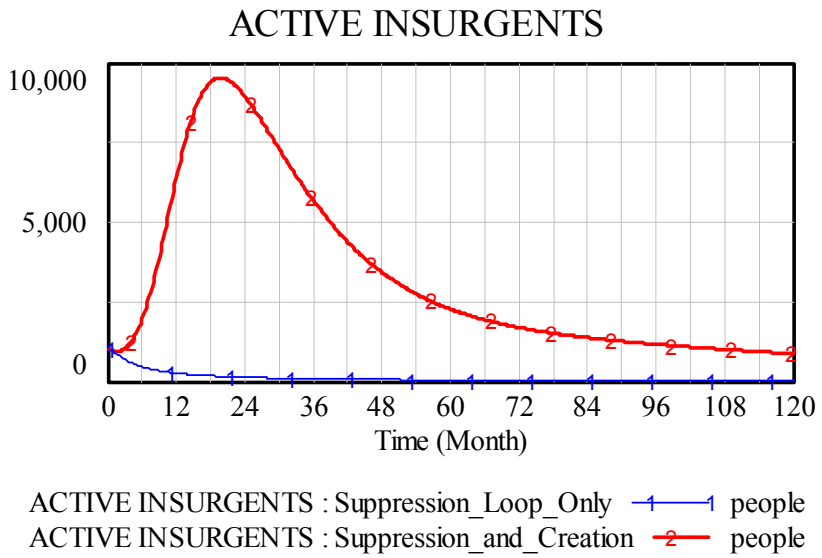

Figure 5: The simulated effect of the insurgent creation loop on active insurgents

Figure 6 shows that under this simulated scenario, Ireland enters a state of relatively high rate insurgent activity at the same time that the population becomes permanently dissatisfied with British rule. Both of these effects occur because of the British troops' heavy interference in normal Irish civil life.

[4] While this effect is not captured explicitly in the causal loop diagram in Figure 4, it is contained in the model listing in the Appendix.

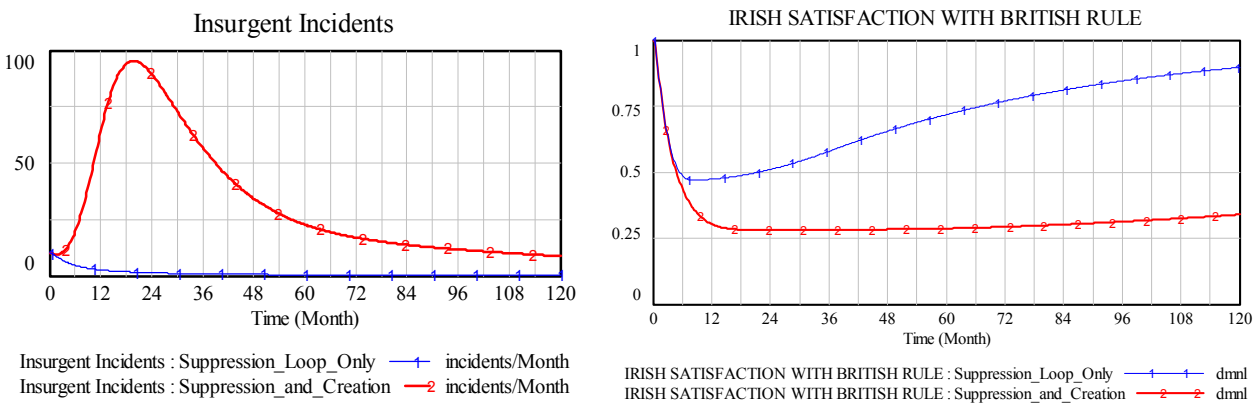

Figure 6: Simulated Insurgent Activity and Satisfaction with British Rule

3.3 War Weariness

However, Figures 4, 5, and 6 do not account for how the insurrection ultimately ends. Figure 7 completes the model by including a war weariness loop for Great Britain.

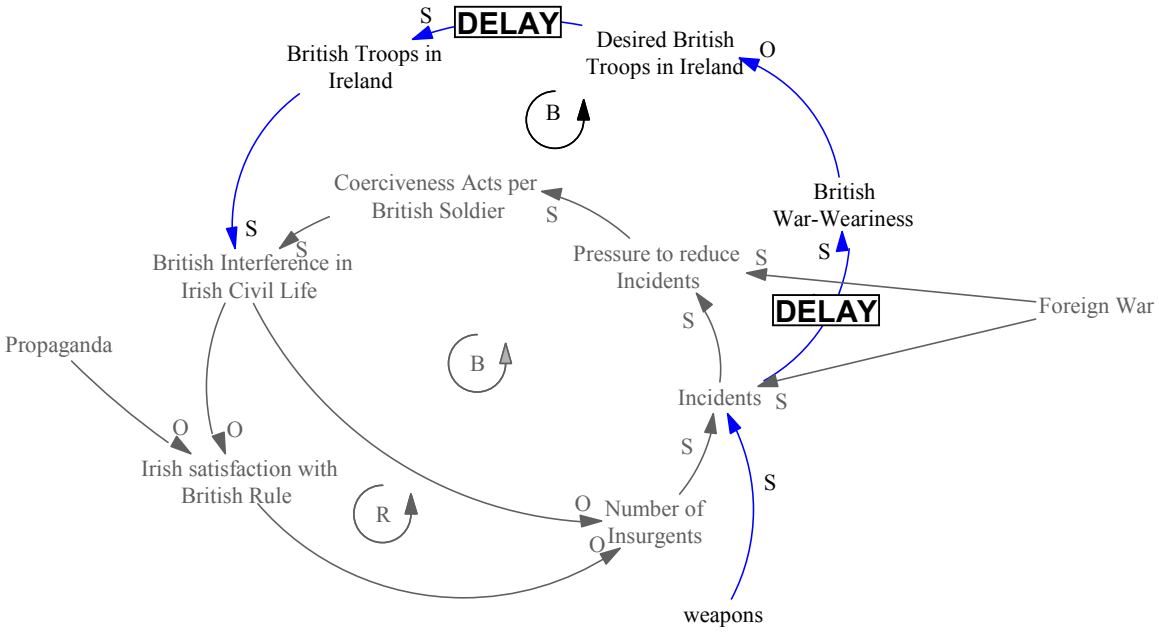

Figure 7: The war weariness loop completes the model

In this loop, as the number of incidents rises, *British war weariness* increases after a long delay. This leads to a removal of troops from Ireland after another, shorter delay reflecting the time it takes to issue orders and physically arrange for transport of the troops back from Ireland.

This loop is marked as a balancing loop because it seems to come into effect only once the insurgent creation loop has begun to dominate the model. As a final note, Figure 7 also shows the impact of weapons availability on keeping the insurgency alive. This turned out not to be a deciding factor in the Anglo-Irish War, primarily due to the financial creativity of Michael Collins, the finance minister for the insurgent Irish government. However, lack of guns has exercised a decisive impact on other occasions (including the rebellion of 1798). The factors determining weapons availability are more fully explored in Coyle (1985).

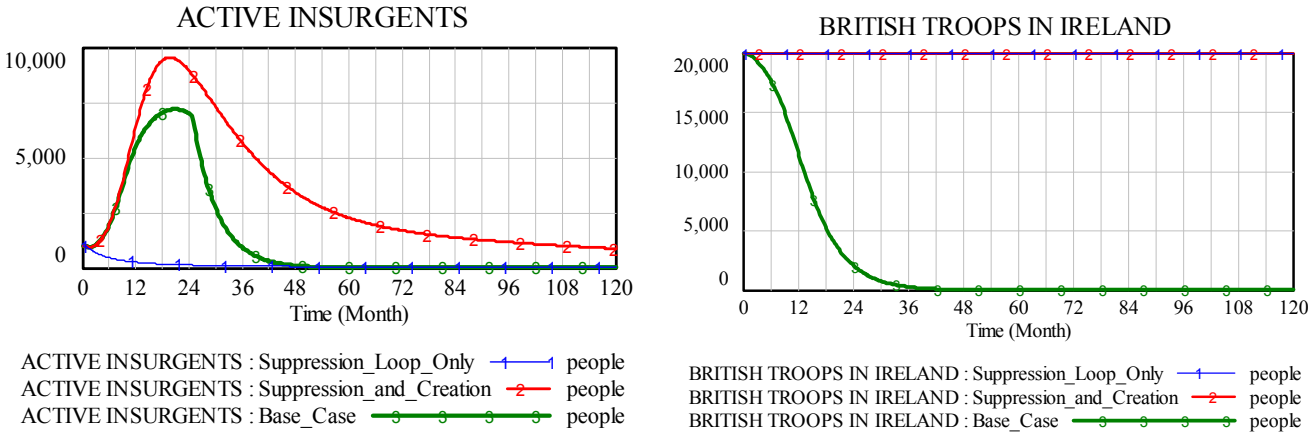

Figure 8: Simulated British Troops and Active Insurgents in Full Model

The effect of the war-weariness loop on the simulated Irish Insurgency is shown in Figure 8. It is important to note that the simulated number of insurgents does not fall at the same rate as does the number of British Troops. In fact, the number of simulated insurgents does not begin to fall in earnest until after the British withdrawal of troops. Even then, however, the demobilization takes some time. One could imagine that it would take a while for the insurgents to demobilize if for no other reason than that there is likely no extant procedure for decommissioning weapons. This lag in the demobilization of insurgents points to a problem that occurred after the end of the Anglo-Irish War as well as many other insurgencies. After the insurgency is won, there remain a number of armed insurgents who are habituated to settling

their arguments with violence. This often leads to a situation in which one faction of the insurgents will begin fighting the remainder due to some political disagreement. While it is not simulated in the model, this is indeed what happened with the Irish Volunteers. After the conflict with the British ended, a civil war began in Ireland between pro and anti-peace-treaty forces that did not end until 1923.

To summarize: in this section, a system dynamics model based on the three causal loops of incident suppression, insurgent creation, and war weariness was developed. Furthermore, the model was able to approximately replicate the dynamic behavior of the Anglo-Irish War. Thus, the methodology of system dynamics appears to have some explanatory power for insurgencies. However, of even more interest is whether a system dynamics model might be used as a decision aid by policy makers. We will examine this topic in the next section.

3. Sensitivity Analysis

Because the ultimate aim of this paper is to determine whether the system dynamics methodology can be used to aid policy makers, we will explore the sensitivity of the model developed in the previous section to a limited set of parameters and policies to see whether any intriguing results arise.

3.1 Reduced Distrust

For example, one would expect, based on sections 2.2 and 2.3, that if the war-weariness loop is sufficiently slow or weak, it is possible that the withdrawal of occupying troops might actually have improved the overall insurgency's outcome from the British point of view. In reality the Irish were acutely suspicious of British intentions due to the turbulent nature of their centuries-long relationship. (The simulation captures this by having the time required to satisfy

the Irish public be much longer than the time to dissatisfy it.[5]) However, in other countries, in which the legitimacy of the ruling power is not so suspect, such may not be the case. Under these conditions, a less suspicious populace may permit a more aggressive policy of incident suppression. To examine this idea, the simulation in Section 2.3 is run with two changes: (1) an Irish public more willing to respond favorably to a British reduction of interference in civil life and (2) a policy of more coercive acts per soldier per month to suppress insurgency incidents.[6]

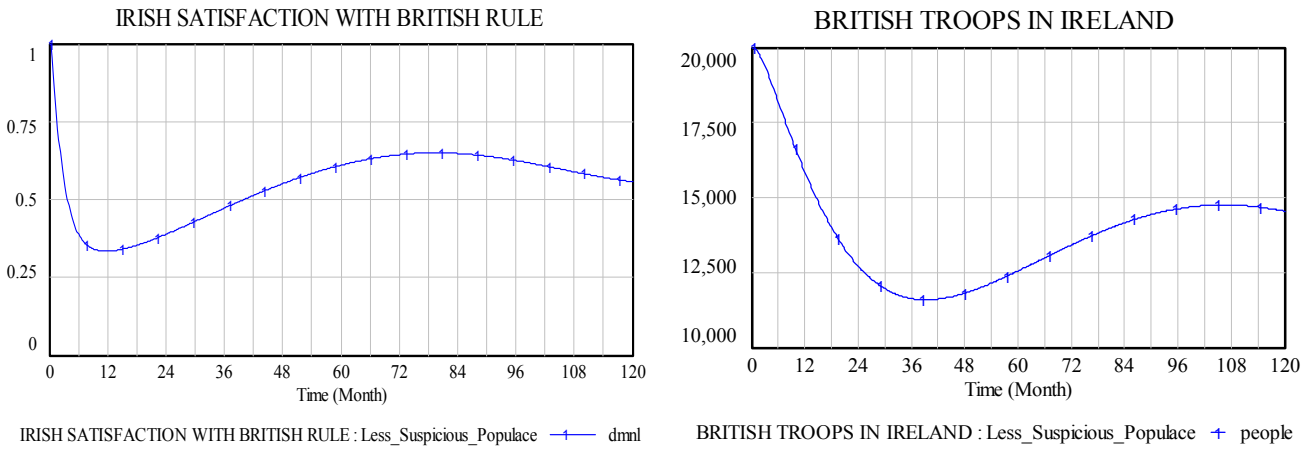

Figure 9: Less Suspicious Populace Scenario

It should be noted that either of these two changes implemented in isolation will not prevent a simulated British withdrawal. However, Figure 9 shows that both changes taken together do in fact lead to a sustainable British presence, with a relatively content Irish populace as a bonus. Hence, the long-standing attitude of the populace towards the government in power can indeed make a difference between success and failure of an insurgency, if it is properly exploited. However, Figure 10 also shows that, while these changes will indeed reduce the

[5] For readers familiar with system dynamics, this is captured by an exponential smooth formulation of satisfaction formulation with two time constants: one for when satisfaction is increasing (5 years) and a different one for when satisfaction is decreasing (3 months). This formulation follows Oliva and Sterman (2001).

[6] This is implemented in the simulation by reducing the "time to dissatisfy" from 60 months to 3 months, and reduced the "insurgent parameter" from 2.5 to 0.5. The maximum number of "coercive acts per British soldier" is set from 0.2 to 0.4 per month.
See the Appendix for how these parameters influence the model. The maximum number of "coercive acts per British soldier" per month.

insurgent problem to a sustainable level, they cannot wipe it out entirely. Hence, even under the best of circumstances, successful insurgency management may not necessarily end all insurgent activity.

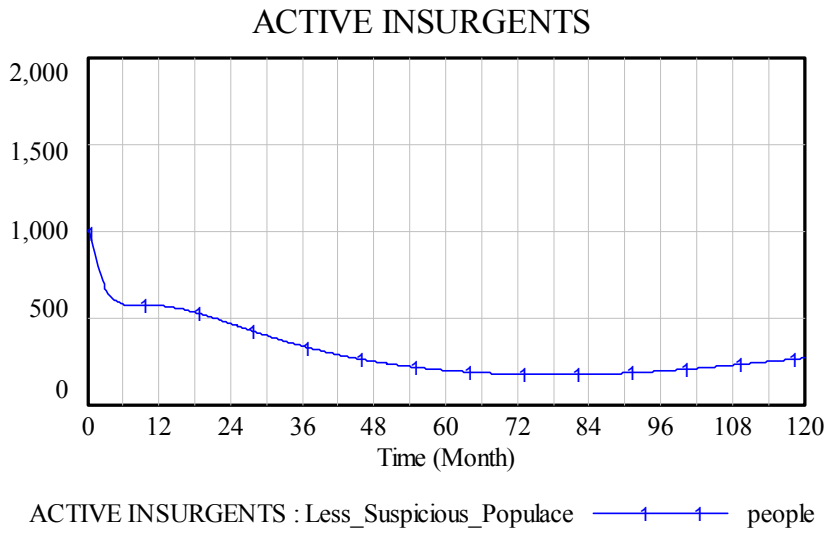

Figure 10: Active Insurgents under Less Suspicious Populace Scenario

3.2 The "Good Works" Policy

As another example of potential policy analysis using system dynamics, recall from the simulations in Sections 2.2 and 2.3 that the British could have stayed on in Ireland indefinitely if they were indifferent to war weariness. However, this is an unrealistic assumption in most cases, particularly if the nation opposing the insurgency is a democracy. Thus, the question arises: if the war-weariness loop is indeed active, is there another way to eliminate the insurgency or at least marginalize it? One proposal often mooted is to (1) have the troops suppressing an insurgency perform a steady number of "good works" such as health and dental clinics for the benefit of the populace afflicted by the insurgency and (2) utilize troops drawn from the populace as much as possible (Kaplan 2005). This "good works" policy is purported to have the following benefits:

- It reduces the distrust of the populace for the insurgency-suppressing forces and consequently the populace's desire to help the insurgents. Without the populace's help, the insurgents' mobility is compromised, hence reducing their ability to create incidents and to evade capture.
- It allows the counterinsurgent troops to obtain valuable intelligence from people speaking "off-the-cuff" while being treated during these medical clinics (or other similar activities) that lead to more efficient capture of insurgents. Some authorities opine that intelligence gathered in this manner is of superior value to that obtained during interrogation (Kaplan 2005).

The effects of this policy are simulated by doubling the base rate of capture of an insurgent per coercive act (which is proxied in the model in the Appendix by halving the *base coercion fruitfulness*) and halving the *incidents per insurgent* per month. The simulated results of this policy compared with the base case are presented in Figures 11 and 12.

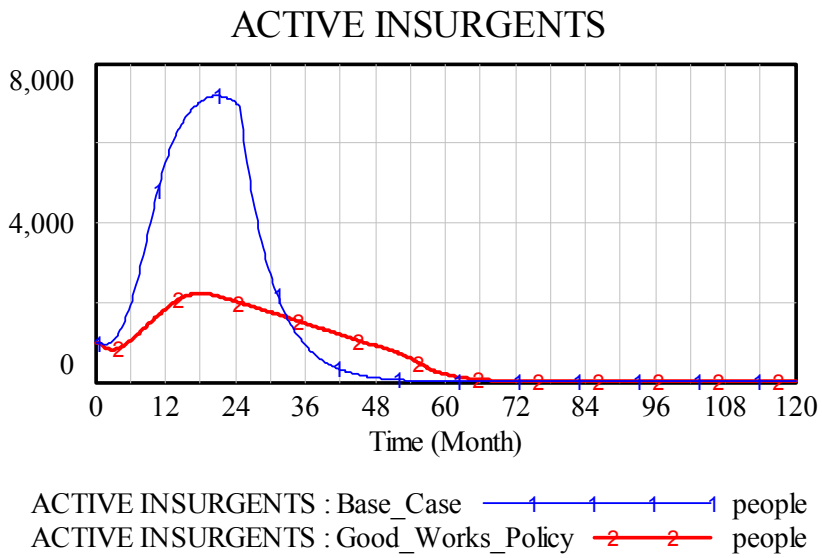

Figure 11: Active insurgents under the base and "good works" scenarios

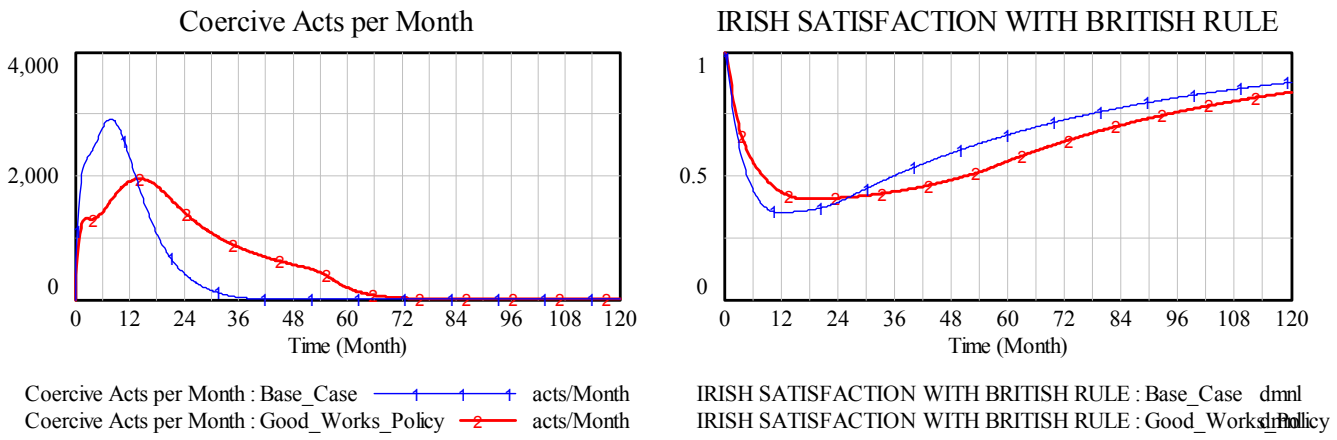

Figure 12: Coercive acts by British Troops and Irish Satisfaction with British Government under base and "good works" scenarios.

In this simulation, the *Irish satisfaction with British Rule* under the "good works" policy is almost as high as it was in the base case. However, the number of coercive acts by British troops *remains higher* after month 14 (Figure 12). Combined with an increase in effectiveness *per coercive act* resulting from improved intelligence, the British in this simulation are able to keep the maximum number of insurgents about seventy percent lower than in the base case (Figure 11). Unlike in Section 3.1, the insurgents do eventually completely disappear. More importantly, the British are also never compelled to leave Ireland (which is the only thing that eliminates insurgents in the base case).

Because of these results, it would be of interest to examine both components of the "good works" policy in isolation. From Figure 13, a higher simulated "fruitfulness" of coercive actions (e.g. improving the odds that a house search will lead to a detention of an active insurgent) seems to be the primary factor that reduces the maximum number of insurgents in the "good works" policy. However, this reduction is not enough to prevent a simulated complete withdrawal of British troops beginning in month 29. (The sudden drop to zero of insurgents beginning around at this time only occurs because of a British withdrawal.) Hence, this simulation suggests that there may be a synergistic effect between increasing the odds of capturing insurgents as well as hampering the

ability of insurgents to launch attacks. This might explain the observed strength of "good works" policies because they change a number of system parameters simultaneously in a mutually supporting manner.

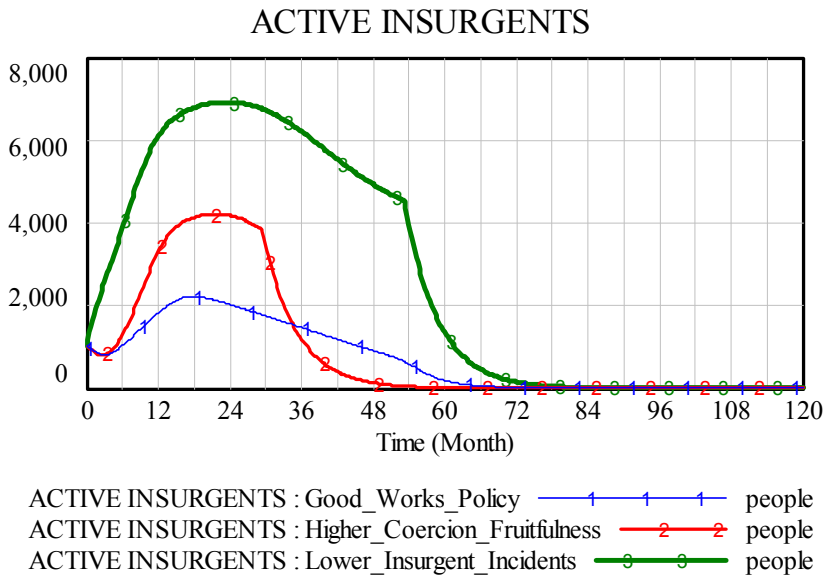

Figure 13: Sensitivity of Outcome to Coercion Fruitfulness & Incident Rate

In this section, it should be remembered that no attempt has been made to fully calibrate or validate the model. Hence, any conclusions drawn from the current model should be viewed with some caution, especially with respect to other insurgencies. Rather, in alignment with the goals of this paper, the purpose of the analyses presented herein is merely to illustrate some of the ways in which a system dynamics model of insurgency suppression might aid policy makers in their decision making.

5. Discussion

The aim of this paper was to demonstrate the potential of system dynamics to aid policy makers in developing better insights into the dynamic behavior of insurgencies. In particular, Section 2 suggested that a model containing the three causal loops of insurgency suppression, insurgency creation, and war weariness, might drive the dynamic characteristics behind many

insurgencies. The case history of the Anglo-Irish War of 1916-21 was used to help illustrate these dynamics as well as to make a preliminary examination of some high-leverage system characteristics that may be of interest to policy makers. As illustrations of this capability, the paper explored how a lack of government legitimacy—such as that faced by the British in Ireland—could hamper efforts to suppress an insurgency. Additionally, to illustrate how a system dynamics model might aid policy testing, Section 3 explored how the effects of a "good works" policy might contribute to successful insurgency suppression. While it was not a specific goal of this paper, two general insights did emerge from these analyses. One insight is that no one parameter or policy change is likely to be sufficient, in itself, to successfully manage an insurgency. Rather successful insurgency management demands policies that create many simultaneous, synergistic changes. A second insight is that even a successful insurgency management policy may very possibly fail to completely eliminate insurgent activity; it will merely reduce it to an acceptable level.

These insights should be enough to demonstrate the usefulness of utilizing the system dynamics methodology as a tool for insurgency management. However, because this paper was intended primarily as a "proof-of-concept" test of using system dynamics for managing insurgencies, much work remains to be done before such an approach can be deployed in real life. First of all, the model in this paper must be calibrated to any particular conflict of interest, because no two conflicts are exactly alike. As stated in the U.S. Marine Corps' *Small Wars Manual* (1940), "Small wars seldom develop in accordance with any stereotyped procedure." The psychology of the people involved, the physical nature of the territory, the nature of the insurgents' grievances with the incumbent government and what portion of the population has natural sympathies with the insurgents: all of these will vary from insurgency to insurgency. Primarily, model calibration should involve changes in the numerical parameters in the model.

However, it may also involve including some additional structure to the model, such as the weapons availability model structure in Coyle (1985).

Next, a detailed examination of parameter and policy sensitivities must be performed for each insurgency, similar to, but more extensive than that presented in this paper. For example, policy bundles such as the "good works" policy presented in this paper or the substitution of air for ground forces (e.g. the United States in the Vietnam conflict) must be examined, as well as many others in order to determine which policy bundle might work best in any given conflict.

Finally, after the model has been calibrated and used in a number of real-world situations, it should become reasonably general. That is, because the basic principles of warfare and psychology that govern all conflicts remain consistent, the changes in behavior between models calibrated to any two particular conflicts should become merely a function of numerical changes in model parameters. This is compatible with the theory of system dynamics, in which the structure of the dynamic system creating behavior and events is assumed to be similar in many situations, but the parameters governing that structure may create drastically different behavioral responses to similar exogenous stimuli (Sterman 2000). In essence then, one system dynamics model—properly validated—might be able to provide insight into many different particular insurgencies by varying a small number of demographic, psycho-political, fiscal, and geographical parameters.

However, in recent years a final complication to applying system dynamics to insurgency management has arisen. Until late in the last century, insurgencies were essentially won or lost in isolation from one another. Currently, however, a developing interlinkage between insurgencies in geographically (and even ideologically) dispersed locations is beginning to emerge (Kaplan 2005, Jinnett 2006). Hence, once the general model for the evolution of an isolated insurrection is developed, it will soon become necessary to network a number of such

models together in order to represent the evolving global reality of interlinked and interdependent insurgencies that will characterize the twenty-first century.

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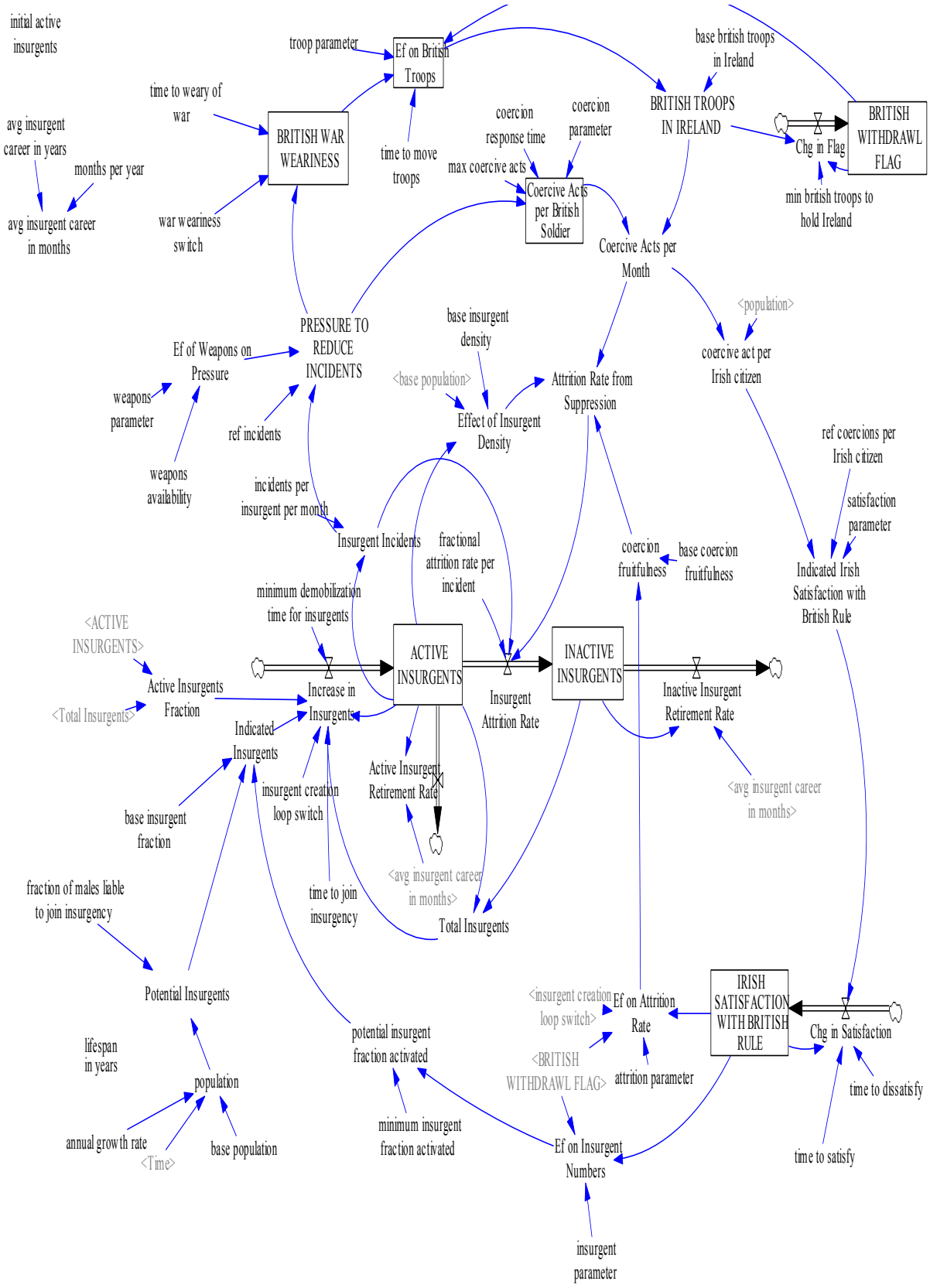
Appendix: Model Diagram and Listing



Equations

```
Active Insurgent Retirement Rate=
               ACTIVE INSURGENTS/(avg insurgent career in months)
        Units: people/Month

ACTIVE INSURGENTS= INTEG (
        Increase in Insurgents-Insurgent Attrition Rate-Active Insurgent Retirement Rate
,
               initial active insurgents)
Units: people

Active Insurgents Fraction=
        xidz(ACTIVE INSURGENTS,Total Insurgents,1)
Units: dmnl
What fraction of the insurgents are active?

annual growth rate=
        0.03
Units: dmnl/year

attrition parameter=
        1
Units: dmnl

Attrition Rate from Suppression=
        Coercive Acts per Month*Effect of Insurgent Density*coercion fruitfulness
Units: people/Month
The fractional attrition rate from coercive acts.

avg insurgent career in months=
        avg insurgent career in years*months per year
Units: months

avg insurgent career in years=
        10
Units: years
The number of years an insurgent will be active assuming that he is
               not captured.

base british troops in Ireland=
        20000
Units: troops

base coercion fruitfulness=
        0.1
Units: people/act
This modifies how many insurgents will be captured per coercive act
               in the base case

base insurgent density=
        0.0005
Units: dmnl

base insurgent fraction= INITIAL(
        1000/Potential Insurgents)
Units: dmnl
This is the base fraction of the population that will be attracted to
               insurgent activities

base population=
        3e+006
Units: people

BRITISH TROOPS IN IRELAND=
        base british troops in Ireland*Ef on British Troops
Units: people
Note that this variable also includes the number of auxilliary troops
               used in the war such as the Royal Irish Constabulary.

BRITISH WAR WEARINESS=
        smoothi(PRESSURE TO REDUCE INCIDENTS*war weariness switch,time to weary of war,
```

```
0)
Units: dmnl
This is the desire of the British to pull out of Ireland due to
               weariness with the insurgency.

BRITISH WITHDRAWL FLAG= INTEG (
       Chg in Flag,
               0)
Units: dmnl
If flag is set, then the British have given up and withdrawn their
               troops from Ireland.

Chg in Flag=
       if then else((BRITISH WITHDRAWL FLAG=0) :AND: (BRITISH TROOPS IN IRELAND<min british
troops to hold Ireland
),1/TIME STEP, 0)
Units: dmnl/Month
This will set the BRITISH WITHDRAWL FLAG once British presence in
               Ireland (as measured by active troops) has fallen below a minimal
               threshold.

Chg in Satisfaction=
       (Indicated Irish Satisfaction with British Rule-IRISH SATISFACTION WITH BRITISH RULE
)/if then else(Indicated Irish Satisfaction with British Rule>IRISH SATISFACTION WITH BRITISH
RULE
,time to satisfy,time to dissatisfy)
Units: dmnl/Month
This measures how quickly Irish satisfaction with British rule
               changes. Note that the time for satisfaction to decrease and to
               increase are different.

coercion fruitfulness=
       base coercion fruitfulness*Ef on Attrition Rate
Units: people/act
This modifies how many insurgents will be captured per coercive act
               in the base case

coercion parameter=
       0.5
Units: dmnl
This causes the coercive acts per British soldier to have diminishing
               returns to the "pressure to reduce incidents". It should be set to be
               less than one.

coercion response time=
       1
Units: months

coercive act per Irish citizen=
       Coercive Acts per Month/population
Units: acts/person/Month
How much is the average Irish citizen aware of coercive acts by the
               British Government?

Coercive Acts per British Soldier=
       smoothi(1-exp(-coercion parameter*PRESSURE TO REDUCE INCIDENTS),coercion response time
,0)*max coercive acts
Units: acts/person/Month
Acts of house searching, detainment, etc. that may lead to arrest of
               an insurgent. It is an increasing function of the pressure to reduce
               incidents with diminishing returns. It also saturates at "max
               coercive acts"

Coercive Acts per Month=
       BRITISH TROOPS IN IRELAND*Coercive Acts per British Soldier*incident suppression loop sw
Units: acts/Month
Total coercive acts by all British troops and paramilitaries in
               Ireland. Includes house searches, etc.

Ef of Weapons on Pressure=
       1-exp(-weapons availability*weapons parameter)
Units: dmnl
This is an increasing function with a max at one.
```

```
Ef on Attrition Rate=
        if then else( insurgent creation loop switch=1,IRISH SATISFACTION WITH BRITISH RULE
^attrition parameter,1)*(1-BRITISH WITHDRAWL FLAG)
Units: dmnl
This is a multiplier that affects coercive fruitfulness depending on
                Irish satisfaction with British rule. If the Irish are highly
                dissatisfied, they will make it diffiucult for the British coercive
                acts to result in capturing an insurgent.

Ef on British Troops=
        smoothi(exp(-BRITISH WAR WEARINESS*troop parameter)*(1-BRITISH WITHDRAWL FLAG),
time to move troops, 1)
Units: dmnl
The wearier the British public is with the war, the less troops they
                maintain in Ireland. Once British Troops have completely pulled out,
                however, they never come back.

Ef on Insurgent Numbers=
        xidz(1,IRISH SATISFACTION WITH BRITISH RULE,1)^insurgent parameter*(1-BRITISH WITHDRAWL
FLAG
)
Units: dmnl
Effect of Irish Satisfaction (or lack thereof) on Irish insurgents

Effect of Insurgent Density=
        (ACTIVE INSURGENTS/base population)/base insurgent density
Units: dmnl
What is the effect of insurgent density on finding an insurgent

FINAL TIME  = 120
Units: Month
The final time for the simulation.

fraction of males liable to join insurgency= INITIAL(
        avg insurgent career in years/lifespan in years/2)
Units: dmnl
Males are half of population. We assume males between ages of 15 and
                30 will want to become insurgents.

fractional attrition rate per incident=
        0.01
Units: persons/incident
How many insurgents are captured/killled per incident.

Inactive Insurgent Retirement Rate=
        INACTIVE INSURGENTS/avg insurgent career in months
Units: people/Month
Lifespan of insurgents before "retiring" is assumed to be finite.

INACTIVE INSURGENTS= INTEG (
        Insurgent Attrition Rate-Inactive Insurgent Retirement Rate,
                0)
Units: people
The number of captured and dead insurgents who would have remained
                active if they had been able to.

incident suppression loop sw=
        1
Units: dmnl
0 = No Incident Suppression Loop; 1 = Incident Suppression Loop on

incidents per insurgent per month=
        0.01
Units: incidents/Month/person

Increase in Insurgents=
        max(if then else (Indicated Insurgents<Total Insurgents,1,Active Insurgents Fraction
)*(Indicated Insurgents-Total Insurgents
        )/time to join insurgency,
        -ACTIVE INSURGENTS/minimum demobilization time for insurgents)*insurgent creation loop
switch
Units: people/Month
```

```
This drives the number of active insurgents to what their indicated
               level should be based on Irish satisfaction with British Rule.
               However, there is also a maximum rate at which they leave to prevent
               the active insurgent stock from going negative. This would represent
               the tendency of some fraction of the insurgents to be extremely hard
               line.

Indicated Insurgents=
       base insurgent fraction*potential insurgent fraction activated*Potential Insurgents
Units: people
This is how many insurgents there could be if they could immediately
               "join up" and pick up arms.

Indicated Irish Satisfaction with British Rule=
       min(xidz(1,(coercive act per Irish citizen/ref coercions per Irish citizen)^satisfaction
parameter
,1),1)
Units: dmnl
This is how satisfied the Irish would be with British rule absent any
               legacy effects. It's primarily determined by the British interference
               in Irish Civil life through coercive acts.

initial active insurgents=
       1000
Units: people

INITIAL TIME  = 0
Units: Month
The initial time for the simulation.

Insurgent Attrition Rate=
       Insurgent Incidents*fractional attrition rate per incident+Attrition Rate from
Suppression
Units: people/Month
Number of insurgents detained, killed, or going "AWOL" per month.

insurgent creation loop switch=
       1
Units: dmnl
0 = Loop Off; 1 = Loop On

Insurgent Incidents=
       ACTIVE INSURGENTS*incidents per insurgent per month
Units: incidents/Month
How many raids, snipings, bombings etc. are committed in total by all
               insurgents

insurgent parameter=
       2.5
Units: dmnl
Power that modifies the effect of Irish Satisfaction with British
               rule on Insurgent numbers. This power should be greater than 1.

IRISH SATISFACTION WITH BRITISH RULE= INTEG (
       Chg in Satisfaction,
               1)
Units: dmnl
This is an index of how satisfied the Irish are with British rule.
               Note that there is a first-order delay between the indicated
               satisfaction as a function of current British coercive acts and the
               change in perceptions by the Irish people.

lifespan in years=
       50
Units: years

max coercive acts=
       0.2
Units: acts/person/Month
This is a limit on how many coercive acts a British soldier could
               commit per month

min british troops to hold Ireland=
```

```
        2000
Units: troops

minimum demobilization time for insurgents=
        6
Units: months

minimum insurgent fraction activated=
        0.1
Units: dmnl
There are always some discontents in most societies

months per year=
        12
Units: months/year

population=
        base population*(1+annual growth rate/12)^Time
Units: people
The base population increases with time

potential insurgent fraction activated=
        minimum insurgent fraction activated+Ef on Insurgent Numbers
Units: dmnl
What fraction of potential insurgents actually want to take up arms

Potential Insurgents=
        fraction of males liable to join insurgency*population
Units: people
Number of population who could be converted to insurgents if the
                conditions are right.

PRESSURE TO REDUCE INCIDENTS=
        Insurgent Incidents*Ef of Weapons on Pressure/ref incidents
Units: dmnl
This is the effect of incidents on the urgency felt by British govt.
                to do something about it. The effect of this will be lagged in its
                outcomes.

ref coercions per Irish citizen=
        0.0001
Units: acts/Month/person
Scaling factor for Irish Satisfaction

ref incidents=
        5
Units: incidents/Month
Scaling factor for impact of incidents on pressure on the British
                Govt.

satisfaction parameter=
        0.5
Units: dmnl
This should be set to less than one to ensure diminishing returns to
                coercive acts

SAVEPER  =
         TIME STEP
Units: Month
The frequency with which output is stored.

TIME STEP  = 0.25
Units: Month
The time step for the simulation.

time to dissatisfy=
        3
Units: Month
Time needed to upset the Irish

time to join insurgency=
        6
Units: Month
```

```
time to move troops=
        6
Units: months

time to satisfy=
        60
Units: months

time to weary of war=
        24
Units: months

Total Insurgents=
        ACTIVE INSURGENTS+INACTIVE INSURGENTS
Units: people

troop parameter=
        0.75
Units: dmnl
Should be set to less than one to ensure diminishing returns

war weariness switch=
        1
Units: dmnl
0 = War Weariness Loop Off; 1= War Weariness Loop On

weapons availability=
        1
Units: dmnl
This is an variable that accounts for fact that if the insurgents are
                armed, it generally escalate the impact of any incidents.

weapons parameter=
        5
Units: dmnl
Availability of weapons rapidly escalates the effect of any incident
```