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AN EXPLORATORY STUDY OF *SENDERO LUMINOSO'S* DYNAMICS

by

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Any insurgency is a complex and dynamic phenomenon, as is the process of developing a good strategy to counter it. Understanding such types of dynamic complexity demands that strategists expand the boundaries of their mental models. A good strategy does not rely exclusively on a strategist's talent; it is conditioned on a holistic understanding of causal relationships encompassed in the problem and interactions among variables. This thesis analyzes the Peruvian insurgency of *Sendero Luminoso* through the lens of System Dynamics. This study explores eight fundamental concepts in System Dynamics in relation to the Peruvian insurgency: system parameters, system pattern of behavior, loop dominance, causal relationships, system's feedback structure, system's physical structure, decision-making process, and attributes of tangible quantities.

It is demonstrated that useful strategic insight can be obtained from System Dynamics models and subsequent simulations. Furthermore, this work may help to illuminate a few of the factors involved in the defeat of Sendero Luminoso, and might assist policy makers and military strategists to craft efficient counterinsurgency strategies in the future. Finally, this thesis constitutes the initial step for the development of a formal and complete System Dynamics Model of the Peruvian insurgency.

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AN EXPLORATORY STUDY OF *SENDERO LUMINOSO'S* DYNAMICS

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LIST OF ACRONYMS AND ABBREVIATIONS

CAD	Self Defense Committee
CRC	Regional Committee Center of *Sendero Luminoso*
CLD	Causal Loop Diagram
COIN	Counter Insurgency
CRP	Regional Committee “Principal” of *Sender Luminoso*
EGP	People’s Guerrilla Amy
FB-EGP	Base Force of People’s Guerrilla Army
FL-EGP	Local Force of People’s Guerrilla Army
FP-EGP	Main Force of People’s Guerrilla Army
FS	Feedback Structure
METRO	Metropolitan Committee of *Sendero Luminoso*
MRTA	Revolutionary Movement “Tupac Amaru”
MU-EGP	Urban Militia of People’s Guerrilla Army
OF	Operational Factor
OP	Operational Performance
PCP	Peruvian Communist Party
PCP-SL	Peruvian Communist Party–*Sendero Luminoso*
PD-EGP	Popular Detachment of People’s Guerrilla Army
ROC	Rate of Change
SD	System Dynamics
SDM	System Dynamics Model/Modeling
SD-EGP	Special Detachment of People’s Guerrilla Army
SFS	Stock and Flow Structure
SFD	Stock and Flow Diagram
SL	*Sendero Luminoso*
VRAE	Valley of Aprurimac and Ene Rivers

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I. INTRODUCTION

Between 1980 and 1996, Peru was the victim of the *Sendero Luminoso* insurgency (*Sendero*). This organization, which adhered to the most radical lines of thought of Marx, Lenin, and Mao, engaged in a deadly campaign that took the lives of more than 69,000 Peruvians and had a devastating economic impact that still has not been accurately quantified. After nearly two decades of counterinsurgency, Sendero was defeated, although at a great social cost. The bills of this social upheaval are still being paid by Peruvians.

In spite of the turmoil caused by Sendero, evidence recently been made public indicates that the organization itself was actually relatively small and weak. Following its founding in early 1970, when it split from the Peruvian Communist Party (PCP), Sendero was able to recruit only 2,700 militants (communists) and around 70,000 sympathizers.[1] Over that same period, the insurgency managed to obtain few weapons and explosives: approximately 2,000 small caliber guns and around 66,000 cartridges of dynamite.[2] However, regardless of its small size, limited resources and lack of external support, there is no doubt that Sendero was able to hamper the State's ability to progress and accelerated the Peruvian political and economic crisis of the late 1980s. From these facts, some fundamental questions arise: How, being so few and relatively poorly armed, could Sendero bring the State to the brink of collapse? How could the organization persist for nearly two decades? How, with a radical and absolutist ideology, could it find relative acceptance by the population at a time when communism was in full retreat on the world scene?

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[1] "Informe Final de la Comisión de la Verdad y Reconcialiación" [Truth and reconcialiation commission—final report] Comisión de la Verdad y Reconciliación Nacional. 2003. http://www.cverdad.org.pe/ingles/pagina01.php.

[2] "Informe Final de la Comisión de la Verdad y Reconcialiación" [Truth and reconcialiation commission—final report] Comisión de la Verdad y Reconciliación Nacional. 2003. http://www.cverdad.org.pe/ingles/pagina01.php.

It becomes clear that, in counterinsurgency, neither the State's advantage of force nor its superior technologies determine the results of the conflict. In a conventional war, force is used to influence the adversary's decision makers and to engage large military formations. However, in a counterinsurgency context, force has little or no effect; rather, it is the state's capacity to influence the population that will define the outcome of the conflict. Popular support is what ultimately will determine the fate of insurgent organizations.

Readers should bear in mind that Sendero was a diffuse adversary of little visibility, which operated in dispersed small units capable of converging in time and space to attack, and then circumventing the actions of the State's forces to reemerge in another time or space. They were a "fluid" enemy acting under confusion, with no rules of engagement, and often, without respect for human rights. Likewise, as with many other insurgencies, Sendero was deeply embedded in society, coexisting and interacting with and nurtured by the population. From the people, the organization obtained resources, protection, and especially, information that empowered it. With the advantage in information, Sendero enjoyed freedom of decision making to act or not act according to the circumstances. Furthermore, it is not only the adversary who is more complex and dynamic than any regular opponent, but also the society in which insurgents are imbedded that is complex and dynamic in nature. As Forrester asserts, social systems are extremely complex, belonging to the class called multi-loop nonlinear feedback systems.[3]

Social complexity and dynamic insurgencies require statesmen and military planners to face great uncertainty and ambiguity in deciphering the intentions, capabilities and prospect of the insurgency. This kind of scenario will demand multi-agency cooperation in conjunction with several military capabilities and resources, which need to be allocated in the right space and time in order to maximize their effects. In other words, if both the insurgency and society are

[3] Jay W. Forrester. "Counterintuitive Behavior of Social Systems," *Theory and Decision* 2, no.2 (December 1971): 109–140, doi: 10.1007/BF00148991.

complex and dynamic, crafting an effective counterinsurgency strategy has its own complex dynamics. For instance, one question that should be addressed through strategic thinking with proper analysis tools is this: How could our actions have inadvertently fostered the progress of the insurgency and how could our efforts hamper other efforts to defeat the insurgency?

In this regard, strategy as a discipline of thinking deals with large, complex and dynamic problems in which decisions have to be made in environments of high uncertainty. These complex problems usually encompass several interdependent variables that interact dynamically, and most of them include agents—people—actively participating and persistently intervening, making systems behave sometimes in counterintuitive and unexpected ways. These simple facts are perfectly evident in social phenomena, especially in one of the most disruptive, complex and dynamic of these: the insurgency.

Therefore, understanding such types of complexity requires strategists to think beyond their traditional mental models and develop tools to understand how the structure of complex systems creates complex behaviors.[4] Summing up, a good strategy does not rely exclusively on the strategist's talent; it is conditioned on the strategist's holistic understanding of all forces that affect the problem that he wants to solve. Unfortunately, reference systems to foster such holistic understanding of counterinsurgency are scarce. Furthermore, in the particular case of the Peruvian insurgency, only limited information is currently available about the ways in which Sendero Luminoso conducted its campaign, which provides only limited insights for politicians, decision makers, military planners, and scholars. Therefore, an effort to develop system models should be made. From these models, the strategic insights derived from systemic and holistic analysis of the insurgency could contribute to a better understanding of this social phenomena and will assist in crafting future counterinsurgency strategy if it is ever needed.

[4] John D. Sterman, *Business Dynamics: System Thinking and Modeling for a Complex World* (New York, NY: McGraw-Hill, 2000), vii.

A. PURPOSE AND SCOPE OF RESEARCH

This thesis analyzes the Peruvian insurgency of Sendero Luminoso under the optics of System Dynamics (SD) and builds an initial System Dynamics Model (SDM) of the Peruvian insurgency. These models, although presented as a graphical representation of the network of interdependent variables encompassed in the structure of a system, have rigorous mathematical foundations grounded in control theory and nonlinear dynamics.[5] Such combinations of graphical visualization and mathematics will contribute to the development of intuition and conceptual understanding of complex and dynamic systems, without sacrificing the rigor of scientific method.[6] Hence, SD's set of tools can be extremely useful to assist strategic decision making.

In connection with this, this work addresses the question: How can SD assist strategists to better understand complex systems? In addition, this thesis explores through a case study the dynamics of the Peruvian insurgency, addressing the following question: What factors affected the Operational Performance of Sendero between 1980 and 1996? Furthermore, this work also proposes an alternative method of analysis without running a simulation in SDM, based on the pattern analysis of loop dominance and structural analysis. Both methods combined are a heuristic method, but the heuristic analysis is sufficient to answer some important questions with regard to complex dynamics when complete data is not available to run a simulation.

In the case study, this research covers both rural and urban areas in Peru in an attempt to capture not only localized dynamics, but also general interdependencies across the country. This research emphasizes the events in the south-central highland and in metropolitan Lima, the epicenter of Sendero and its ultimate objective, respectively. This selection is the most representative

[5] Sterman. *Business Dynamics*, x.

[6] Sterman, *Business Dynamics*, x.

of the dynamics in rural and urban environments affected by the insurgency phenomenon.

Finally, like many other models, the original model proposed in this work does not pretend to be complete and might contain inaccuracies. Further improvements in the model will require the participation of a multidisciplinary team. This research will serve as a "proof of principle" that important insights can be attained from these models as well as a measure of the impact of key variables. The ultimate goal is to provide an initial SDM of the Peruvian insurgency as a way to encourage strategic and systemic thinking in counterinsurgency.

B. METHODOLOGY OVERVIEW

This thesis will use System Dynamics (SD) to analyze the Peruvian insurgency in order to demonstrate the value of SD in strategic thinking and determine some of the factors that could have contributed to the defeat of Sendero in the early 1990s. This study contains several System Dynamics Models with which to demonstrate how SD can assist strategic thinking and to highlight some of the most relevant aspects that could have had a negative impact on the Operational Performance of the Peruvian insurgency.

Chapter II contains a full description of the basic tools to build an SDM such as Feedback Structure (FS) and Stock and Flow Structures (SFS) of the system, and the corresponding rules to properly modeling complex dynamics. In this chapter are explanations of eight fundamental concepts in System Dynamics: system parameters, system pattern of behavior, loop dominance, causal relationships, system's feedback structure, system's physical structure, decision-making process, and attributes of tangible quantities.

In order to explore the potential of SD tools in prospective research, Chapter III contains a hypothetical counterinsurgency SDM. The results of that simulation are presented, along with a pattern of behavior analysis based on the concept of loop dominance.

In order to explore the dynamics of Sendero Luminoso and the advantage of SD tools in retrospective analysis, Chapter IV contains four SDMs runs utilizing factors that were considered pernicious to the Peruvian insurgency. This work builds these models based on inverse problem process (IPP), which means drawing inferences from a set of observable variables in the system with regard to the causal factors that lead changes in that system. These changes reveal themselves in the sequence of the states of one or several parameters observed over time. In other words, the behavior of the variables under investigation will allow inferring the structure and the general dynamic of the system.

Finally, Chapter V contains the conclusions from these SDMs, which contribute to a better understanding of the insurgency and will assist in crafting future counterinsurgency strategy if it will be needed.

C. LITERATURE REVIEW

This thesis is based on a literature review of the most relevant writings and official reports that address the phenomenon of Sendero Luminoso. However, none of this literature holistically approaches the phenomenon of insurgency in Peru from the standpoint of system dynamics. Though this section represents a brief summary of the resources used as the basis of this research, the researcher has reviewed a number of other resources that encompass different approaches to and aspects of the Peruvian insurgency. The span of this body of knowledge runs from economies and politics to the accounts of personal experiences of people who interacted with the insurgency, and even documents from Sendero Luminoso itself. Likewise, SDM of other insurgencies have been reviewed in order to assist the model development of this research. However, none of these addressed Sendero's insurgency. Finally, two analytical methods for causal relations have been reviewed as references.

1. Sendero Luminoso

Much analysis has been done regarding the conditions and circumstances that led to the rise and development of Sendero Luminoso. This insurgent

movement decided to take up weapons against the state at the time when Peru was returning to democracy after a period of military rule. Although some can associate the lack of democracy—or the consequences of it—with the emergence of insurgencies, the general conditions in Peru in this period of transition did not allow the government to foresee the incoming threat.

The consensus appears to be that the national context in the early 1980s diverged from what could be thought of as a revolutionary situation. According to Gustavo Gorriti, after twelve years of military junta, the nation "emerged more robust, more complex and more capable."[7] Even more, "an increase in exports and the economic recovery accomplished under the junta, prompted some qualified observers to speculate that under a democratic government the economy was sure to perform beyond expectations."[8] Under these conditions, politicians and intelligence experts had little information on hand to anticipate the emergence of Sendero.

Furthermore, the military junta had also initiated a process of modernization in the countryside. For instance, in Ayacucho—the epicenter of Sendero Luminoso—the Government had invested in expanding the utilities infrastructure (lighting, telecommunications, etc.), building new roads, reinforcing the educational system, and implementing land reform. In spite of this, Sendero's growth was nurtured by the people of this region.

A closer look into the social dynamics in the rural areas of Peru shows what appear to be the anthropological and sociological roots of the emergence and the rise of the insurgency occurring in Peru's countryside. From both an anthropological and a sociological standpoint, the process of modernization implies transculturation: in this case, traditional Andean culture merging imperfectly with occidental culture. This anthropological phenomenon appears to have created a vacuum of identity among the Andean population, especially

[7] Gustavo Gorriti, *The Shining Path: A History of the Millenarian War in Peru* (Chapel Hill, NC: The University of North Carolina Press, 1999), 7.

[8] Gorriti, *The Shining Path, 7.*

among young peasantry. Youth in the south Andes became trapped between a traditional Andean world with its own myths, rites and customs that had been weakening for several years, and the Western culture (the world of the cities) that marginalized them because they were from the countryside, lived in the mountains and spoke Quechua.[9] Sendero exploited this lack of identity, providing the peasantry, and especially the youth, with an organization and a new identity.[10]

The process of modernization brought bureaucratic capitalism closer to the rural communities. This was seen through agrarian reform, which supplanted more traditional economic forms. Although this measure improved the relationship between state and peasants, the economic improvement in the countryside still seemed to be precarious. This shortcoming served as raw material for insurgent discourse, allowing Sendero to ideologically attack the "new" economic model.[11]

Definitively, poverty and poor human development in the south Andes of Peru circa 1980 played an important role in the distribution of loyalties. To many, Sendero appeared as an expeditious means for economic improvement and social mobility. The impoverished peasantry was convinced and attracted—at least at the beginning—by Sendero's narrative of equality and welfare. However, the initial success of the insurgency was fostered by the actions of the state. As David Palmer put it,

> although Sendero had taken severe blows, and was at least temporarily marginalized as a major force in Peru's complex social-political-economic matrix, […] measures taken by the incumbent government at that time reduced local government capacity to control issues most important to neighborhoods and communities,

[9] Carlos I. Degregori, "¿Por qué Apareció Sendero Luminoso en Ayacucho? El Desarrollo de la Educación y la Generación del 69 en Ayacucho y Huanta" [Why appeared shining path in Ayacucho?: The development of education and the generation of 69 in Ayacucho and Huanta], Historicizing the Living Past of Latin America, 2007, http://www.historizarelpasadovivo.cl/downloads/degregori.pdf, 166.

[10] Degregori, "¿Por qué Apareció Sendero Luminoso en Ayacucho?," 166.

[11] Degregori, "¿Por qué Apareció Sendero Luminoso en Ayacucho?," 158–159.

> as well as limiting the role of the traditional [political] parties to channel popular concerns within the system.[12]

Gordon McCormick suggests that the degrading conditions in Peru around 1990 were the result of the confluence of three factors: the economic collapse of Peru, the slow radicalization of Peruvian politics, and the increasing threat of Sendero Luminoso.[13] The insurgents seemed to have augmented their range of operations and developed a new ability to appeal to traditional elements of the legal left, while the State show an apparent inability to contain the spread of the insurgency. Sendero's adaptability seem to be favored by a complacent political environment in the second half of the 1980s.

In the early 1990s, Carlos Degregori[14] predicted three possible scenarios for Peru. The first, and worst, scenario was that the conflict would turn into a genocide. The state's inability to counter the insurgents, the de-legitimization of political parties, and the erosion of social organizations could all contribute to this outcome. The second scenario was a combination of economic liberalism and militarization. In this context, the rural population, in forming self-defense committees, would be linked more with the Armed Forces, generating an authoritarian climate that contradicted the process of democratization. Finally, the third and, according to Degregori, most difficult, scenario would be the implementation of a democratic pacification strategy. In this sense, Degregori suggested that the fight against Sendero should be put in the hands of civil authorities and social organizations. This implies the reorientation of the economic program, the consolidation of the political system, the renewal and recovery of political parties, and the forging of a national consensus on pacification.

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[12] David Scott Palmer, *The Shining Path of Peru*, ed. David Scott Palmer (New York, NY: Saint Martin's Press, 1992), 273.

[13] Gordon H. McCormick, *The Shining Path and the Future of Peru* (Santa Monica, CA: RAND, March 1990).

[14] Carlos I. Degregori, "Sociedad Rural y Violencia Política: Los Nuevos Escenarios" [Rural society and political violence: The new scenario] *Debate Agrario* (Centro Peruano de Estudios Sociales – CEPES, 13, 1992): 165–174.

In early 1987, McCormick made an accurate, although partial, diagnosis of the insurgency, concluding that Sendero had begun to confront limits on its range of operations, its ability to endure, and its effectiveness, and therefore will eventually be defeated.[15] McCormick based his argument on five characteristics of the Peruvian insurgency.

First, Sendero was an isolated extremist organization unable to create a common front with other leftist groups in opposition to the regime. Second, the organization had avoided relationships with external sponsors, which denied the organization the material support and prestige that could be gained by having foreign patronage. Third, Sendero employed terrorism indiscriminately, and although the organization might have been able to achieve the support of the population in the short term through violent coercion, its survival would depend on its active cooperation with the population. Fourth, insurgents faced technical constraints as a result of their narrow thinking, which restricted their targets and limited the tactics and technologies that the organization had at its disposal. Finally, Sendero faced organizational limits, derived from its divisional structure, its leaders' difficulty in exercising operational control, and the restrictions on its ability to drive coordinated operations nationwide.[16]

According to McCormick, Sendero had a decentralized structure that made it difficult to contain and defeat; he suggested that the eventual death or capture of Guzman probably would not imply the end of the organization.[17] However, there was no consensus among scholars and intelligence analysts regarding this observation. In fact, Oscar Oliva asserted that Sendero was a centralized and hierarchical organization, so the capture of Guzman would be a fundamental step in defeating the Peruvian insurgency.[18]

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[15] Gordon H. McCormick, "The Shining Path and Peruvian Terrorism," *Journal of Strategic Studies* 10, no. 2 (1987): 123. doi: 10.1080/01402398708437317.

[16] McCormick, "The Shining Path and Peruvian Terrorism," 119–123.

[17] McCormick, "The Shining Path and Peruvian Terrorism," 124.

[18] Oscar Oliva, "Targeting Terrorist Leaders: The Peruvian Untouchables Experience" (master's thesis, Naval Postgraduate School, 2005).

What scholars and the military agree on is that the peasant response against Sendero Luminoso early in 1983 set the limits for the insurgent progress in the countryside.[19] Degregori and other authors highlight the contradictions arising from Sendero's atypical and confrontational relationship with the peasantry, for whom everyday life is greatly influenced by an almost ancestral traditional culture, as opposed to the insurgent project, which was highly exclusive and concerned about the purity of communist militancy.[20] In the anthology entitled *Harvesting Storms: Peasant Rondas and the Defeat of Sendero Luminoso in Ayacucho*, Cecilia Blondet and Enrique Gonzales synthetized the complexity of the problem in the countryside, stating that "the Army, terrorists, Rondas [Self-Defense Committees], evangelists, coca producers, and drugs traffickers created a social dynamic of alliances and betrayal that ultimately defeat Sendero Luminoso."[21]

Most academics agree that, among the actors listed by Blondet and Gonzales, it was the actions of the Self-Defense Committees that were the main factor in the defeat of Sendero. The activity of these state-sponsored peasants' groups forced Sendero to prematurely move from the countryside to the city, containing the activities of the terrorist organization in the rural sphere.[22] Unfortunately, such social dynamics, and especially the "unexpected and

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[19] Carlos I. Degregori, "Ayacucho 1980–1983: Jóvenes y Campesinos Ante la Violencia Política" [Ayacucho 1980–1983: Youth and peasantry in front of political violence], *Nueva Sociedad* no. 114 (1991): 16–24, http://nuso.org/media/articles/downloads/2007_1.pdf.

[20] Carlos I. Degregori, "Sociedad Rural y Violencia Política: Los Nuevos Escenarios" [Rural society and political violence: The new scenarios], *Debate Agrario* no. 13 (1992): 171, http://www.cepes.org.pe/debate/debate13/09_articulo.pdf.

[21] Cecilia Blondet and Enrique Gonazales, Introduction to *Cosechando Tempestades: Las Rondas Campesinas y la derrota de Sendero Luminoso en Ayacucho* [Harvesting storms: Peasant Rondas and the defeat of Sendero Luminoso in Ayacucho], ed. Carlos I. Degregori, (Lima, PE: Instituto de Estudios Peruanos IEP, 1996) 11.

[22] Sergio Giampietri and John Stone, "A Counterinsurgency Study: An Analysis of Local Defense" (master's thesis, Naval Postgraduate School, 2004).

aggressive response of the Self-Defense Committees to Sendero sparked the daily terror in the Peruvian Andes.[23]

With regard to Sendero's urban campaign, there is no consensus about what specifically set limits on Sendero in the capital. In his 1989 book, *The Other Path: The Economic Answer to Terrorism,* Hernando, De Soto classified Peruvian society according to economic principles and associated it with the phenomenon of political violence. Among other interesting things, he concluded that violence led to a "country of people desperate for solutions but caught between terrorist violence and impractical exhortation of progressives," and a country of informality, which arose as an "alternative to subversive and criminal violence because it replaces the energy squandered on resentment and destruction with energy well invested in economic and social progress."[24]

From another perspective, after analyzing Sendero's urban campaign, McCormick stated that success for Sendero would not occur by "taking Lima," but by creating the conditions for the political disintegration of the Peruvian government.[25] McCormick expressed the difficulty of determining precisely when and under what conditions the insurgency would be able to establish itself in the capital, and that the success or failure of it depended on the organization itself rather than on the government's responses.

In recent years, Ben Connable and Martin C. Libicki asserted that the fact that

> terror affects public opinion differently in various regions and among various groups is not surprising. This gradation does, however, pose problems for the insurgent who must shape information operations to address varying local concerns and

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[23] Ponciano Del Pino, "Familia, Cultura y Revolución: Vida cotidiana en Sendero Luminoso" [Family, culture and revolution: Daily life in Sendero Luminoso] in *Los Senderos Insólitos del Perú: Guerra y Sociedad, 1980–1995*, edited by Steve J. Stern (Lima, PE: IEP, 1999).

[24] Hernando de Soto, *The Other Path: The Economic Answer to Terrorism* (New York, NY: Basic Books, 1989), 258.

[25] Gordon H. McCormick, *From the Sierra to the City: The Urban Campaign of Sendero Luminoso* (Santa Monica, CA: RAND, 1992).

> perspectives. Guzmán, who became increasingly dogmatic as Shining Path gained strength, proved incapable of reaching urban slum dwellers put off by his unbending Marxist propaganda. However, it was primarily his reliance on indiscriminate terror that undermined his efforts to create an urban insurrection.[26]

The authors offered an interesting graph explaining the effect of terror tactics and the end of what they call the "First Shining Path insurgency," which is depicted in Figures 1 and 2.

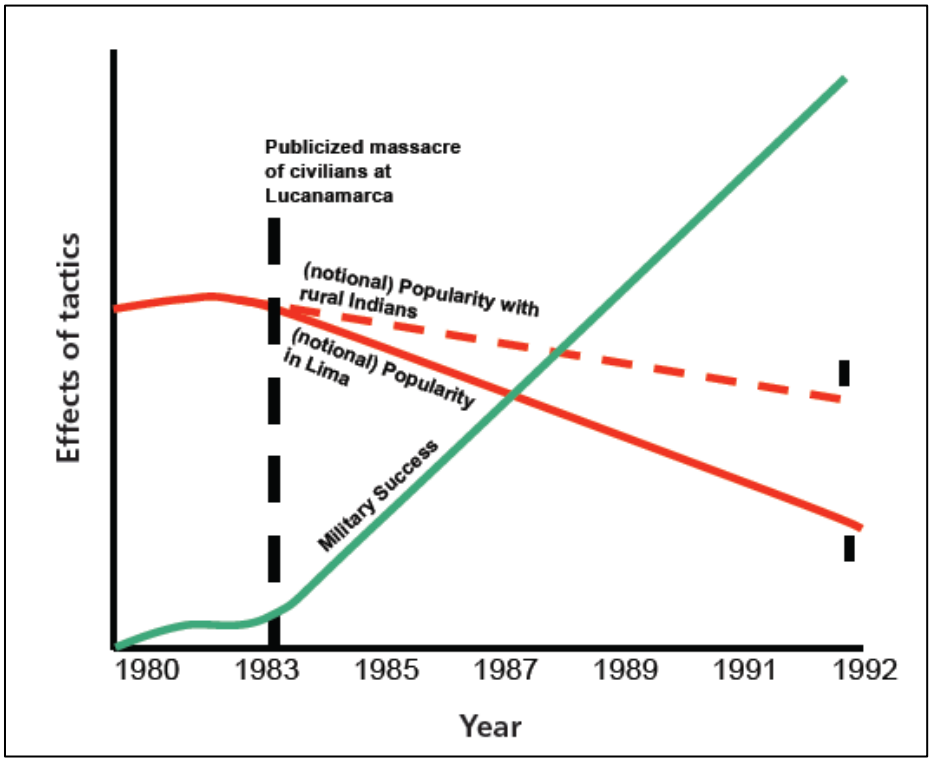

Figure 1. Connable's and Libicki's Assessment of the Effect of Sendero's Terror Tactics.[27]

[26] Ben Connable and Martin C. Libicki, *How Insurgencies End* (Santa Monica, CA: RAND, 2010), 107.

[27] Connable and Libicki, *How Insurgencies End*, 107.

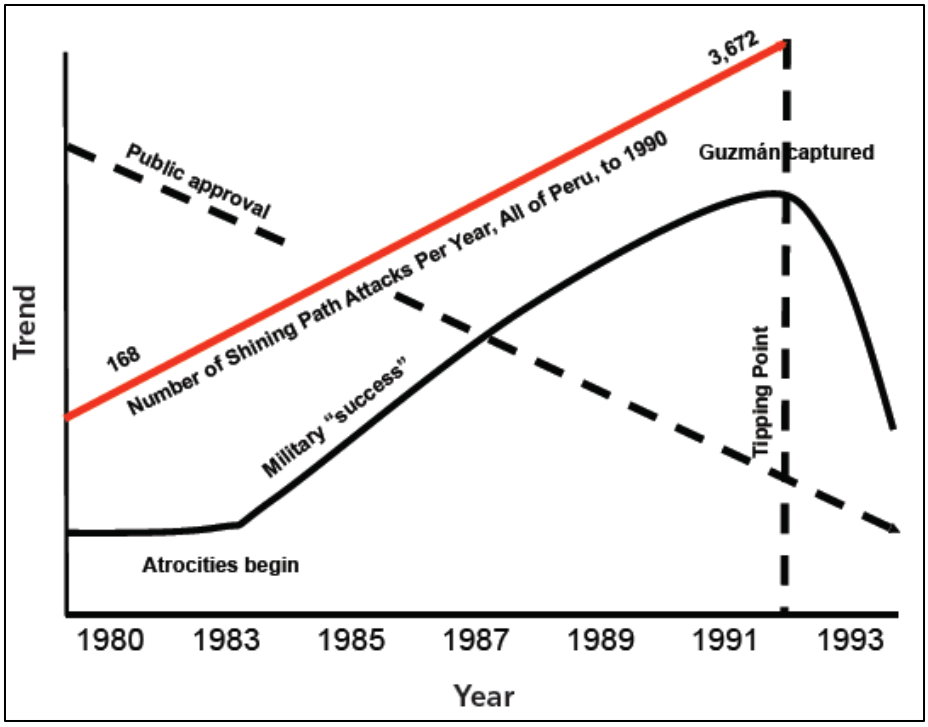

Figure 2. Connable's and Libicki's Assessment of the End of Peruvian Insurgency.[28]

Finally, while some of these works might use different approaches to explain the origin, development, consequences and ultimately the causes of failure of Sendero Luminoso, none of them provides a systemic and holistic framework of the Peruvian insurgency. This brief recount of the vast literature regarding the Peruvian insurgency gives the reader just a glimpse of the complexity of this phenomenon. Likewise, most of this literature focus mainly on anthropology, sociology, politics and military strategy, and none approaches the insurgency using the lenses of system dynamics.

2. System Dynamics Models of Insurgency

In recent years, a few SDMs of insurgency and counterinsurgency have emerged, and they are used as references in this thesis. The advantage of these models is that they provide a systemic view of insurgencies. Using these models

[28] Connable and Libicki, *How Insurgencies End*, 108.

for this thesis is particularly important because they can help to highlight causal relationships that are usually hidden or perceived as disconnected variables within these kinds of complex systems.

In 2006, E. Anderson[29] presented a paper that aimed to prove the value of using SDM to analyze insurgencies. Using as a case study the Anglo-Irish war of 1916–1921, the author focuses on what he considers three "decisive factors" of that conflict and perhaps many other insurgencies. Among these factors two important ones are (1) incident suppression and (2) insurgent creation.[30] From these, the author establishes the causal relationships involved in each and establishes cause-effect sequences, forming two major loops that govern the system under study.

In the first loop, associated with the suppression of incidents, Anderson suggests that, due to increased incidents, because of increases in the insurgent population, the pressure on the government to control these incidents also increased. In Anderson's case study, this pressure was transferred to the British Army, whose soldiers increased their coercive acts, causing increased interference in the Irish civil life but allowing them to neutralize more insurgents. However, while this "coercive policy"[31] could reduce the number of insurgents, this approach seems to have had a pernicious trade-off to the counterinsurgency campaign engendering more insurgents that it removes.

Anderson's second factor—the creation of insurgents—is associated with this increase in coercive acts. He argues that "coercive diplomacy" and persistent interference in society could cause a decline in the satisfaction of the people with the British rule, which eventually produced a greater number of people willing to support the insurgents. This causal chain comprises the second loop within the

[29] Edward G. Anderson Jr., "A Preliminary System Dynamics Model of Insurgency Management: The Anglo-Irish War of 1916–21 as a Case Study" (paper presented at the 24th. International Conference of the System Dynamics Society, Nijmegen, The Netherlands, July 23–27, 2006).

[30] Anderson, ""A Preliminary System Dynamics Model of Insurgency," 4.

[31] Anderson, ""A Preliminary System Dynamics Model of Insurgency," 7.

system analyzed by Anderson and was “thought responsible for a tremendous expansion in size of the Irish volunteers and their offspring.”[32]

In another study, Anderson develops an SDM with the purpose of examining how the relationship between the insurgents and the population behaves due to the intervention of counterinsurgency (COIN) forces.[33] Based on the US. Army and Marine Counterinsurgency Manual (FM 3–24), Anderson develops a complex model that contains up to seven causal loops. Included among these are the (1) suppression loop, (2) escalation loop, (3) blowback loop and (4) intelligence loop.

The suppression loop, which according to the author restricts the growth of the insurgency, is a causal sequence that originates in an increase in the number of insurgent incidents, which increased pressure on the government to counter these incidents. This translates into a greater number of COIN operations that neutralize more active insurgents.[34] However, Anderson notes that the increased COIN operations generated an escalation of violence evidenced by a greater number of insurgent incidents, representing an increase in the rate of “incidents per active insurgent.”[35]

The third loop—the blowback loop—is considered by the author to be the “prime growth engine for insurgencies [...] and creates a tremendous paradox.”[36] This is based on the fact that combat operations undertaken as part of COIN often interfere harmfully in the everyday life of society, causing collateral damage and violations of the law.[37] Because of this, part of the population will feel victimized by the State’s repression and will therefore be identified with the

[32] Anderson, ““A Preliminary System Dynamics Model of Insurgency,” 8.

[33] Edward G. Anderson Jr., “Modeling Insurgencies and Counterinsurgencies” (paper presented at the 27th. International Conference of the System Dynamics Society, Albuquerque, New Mexico, July 26–31, 2009).

[34] Anderson, abstract of “Modeling Insurgencies and Counterinsurgencies,” 7.

[35] Anderson, abstract of “Modeling Insurgencies and Counterinsurgencies,” 9.

[36] Anderson, abstract of “Modeling Insurgencies and Counterinsurgencies,” 10.

[37] Anderson, abstract of “Modeling Insurgencies and Counterinsurgencies,” 10.

insurgency. Consequently, government forces found less willingness from population to support COIN operations, especially to provide information. The latter causes a decay in the efficiency of COIN operations, which reduces the government's ability to neutralize insurgents[38] and comprises what Anderson named the intelligence loop. The latter is based on the positive relationship between intelligence and efficiency of COIN, better intelligence translate to effective operations against insurgency.

Finally, Anderson suggests that his work could improve the outcomes of COIN operations in a number of different ways: improving popular support by redressing some of the popular demands that fuel the insurgency; influencing people by making known the relative merits of supporting the State instead of supporting the insurgency; achieving an appropriate balance between combat operations and intelligence activities, with emphasis on the latter; and finally, noting that in COIN, it is necessary know the expected results before acting in order to avoid the pernicious blowback.[39]

In 2011, Anderson expanded upon his previous work, developing a dynamic model of counterinsurgency policy, including the effects of intelligence, public security, popular support and insurgent experience.[40] What is interesting about this work, unlike Anderson's previous models, is that the author includes an aging chain model that describes an age segmentation of the population.[41] With this, the author emphasizes the fact that only a fraction of the population is "potentially sympathetic to the insurgency,"[42] and this portion depends on certain attributes (e.g., age and sex).

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[38] Anderson, abstract of "Modeling Insurgencies and Counterinsurgencies," 11–12.

[39] Anderson, abstract of "Modeling Insurgencies and Counterinsurgencies," 28.

[40] Edward G. Anderson Jr., "A Dynamic Model of Counterinsurgency Policy including the Effects of Intelligence, Public Security, Popular Support, and Insurgent Experience," *System Dynamics Review* 27, no. 2 (April-June 2011), doi: 10.1002/sdr.443.

[41] Anderson, "A Dynamic Model of Counterinsurgency Policy," 116.

[42] Anderson, "A Dynamic Model of Counterinsurgency Policy," 115.

Choucri et al. developed an SDM of State stability "to represent the nature and dynamics of the 'loads' generated by insurgency activities, the core features of state resilience and its 'capacity to withstand these loads."[43] When trying to decipher the enigma of State stability, these authors developed an interesting segmentation. They divide the system under investigation into several sub-systems, considering (1) population growth, (2) regime resilience, (3) anti-regime recruitment, (4) regime opposition, (5) reduction in open opposition, and (6) communications and mobilization.[44] Furthermore, the authors used as a basis for their proposed model a Stock and Flow structure (SFS) representing the fact that a fraction of the population becomes dissenting, a fraction of these dissenters radicalize and become insurgents, and a fraction of these insurgents are finally neutralized.[45] This SFS, in conjunction with variables that make up each of the segments of the SDM, provides a good basis for deeper analysis of the insurgency.

Tarek K. Abdel-Hamid has used System Dynamics to analyze the conflict in Iraq. The author segments the SDM into three subsystems called (1) insurgency, (2) U.S. military operations, and (3) civil war/ethno-sectarian violence.[46] Abdel-Hamid used as a base a model of diffusion usually used in medicine or biology to represent the spread of disease. In this work, the author takes a parallel assuming a "social contagion" of radical ideas; in other words, the "pathogen is an idea rather than a biological agent."[47] Although the author

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[43] Nazli Choucri, et al., Abstract of "Using System Dynamics to Model and Better Understand State Stability," Working Paper CISL# 2007–03 (Composite Information Systems Laboratory, Sloan School of Management, Massachusetts Institute of Technology, 2007), http://web.mit.edu/smadnick/www/wp/2007-03.pdf.

[44] Choucri, et al. "Using System Dynamics to Model and Better Understand State Stability," 8.

[45] Choucri, et al. "Using System Dynamics to Model and Better Understand State Stability," 9–10.

[46] Tarek K. Abdel-Hamid, "A System Dynamics Modeling Perspective of Iraq's Conflicts," in *Three Circles of War,* ed. Heather S. Gregg, Hy S. Rothstein, and John Arquilla. (Washington, DC: Potomac Books Inc. 2010), 121.

[47] Abdel-Hamid, "A System Dynamics Modeling Perspective of Iraq's Conflicts," 121.

uses one of the simplest models of transmission, where the population of interest is divided only into two cohorts, susceptible (S) and infected (I), it is sufficient to highlight important aspects of the insurgency, such as that the level of " infectivity" varies in direct relation to the level of the population's grievances.[48] In summary, Abdel-Hamid's work provides a different approach to analyze insurgencies that can supply this thesis with new ideas.

In 2012, Giorgio Gallo pointed out the complexity of conflicts and made an effort to capture these dynamics in SDM, using an insurgency context as a case study.[49] In this study, Gallo focuses on domestic instability caused by factors such as unemployment, inequalities, the level of democracy, GDP per capita, and access to information technologies. In particular, the author argues that "the level of democracy and GPD per capita play an important role in the country´s resilience, that is, its capacity to provide adaptation mechanism"[50] to avoid domestic conflicts. Gallo´s insights might provide an overview of the aspects other than military that occur in domestic conflicts.

Erik Pruyt and Jan Kwakkel use SDM to explore and analyze uncertain dynamic issues such as radicalization and de-radicalization processes in insurgent groups.[51] One of the contributions of this work to the development of the SDM of this thesis lies in the SFS that the authors suggested. This structure is composed of five cohorts showing a sequence of radicalization. The authors argue that some of the citizens who are exposed to the message (both explicit and tacit) of the insurgents are "persuaded" and become supporters, from which

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[48] Abdel-Hamid, "A System Dynamics Modeling Perspective of Iraq's Conflicts," 125.

[49] Giorgio Gallo, "Conflict Theory, Complexity and Systems Approach," *Systems Research and Behavioral Science* 30 no. 2 (March/April 2013): 156–175, http://www.di.unipi.it/~gallo/Papers/Conflicts%26Systems.pdf.

[50] Gallo, "Conflict Theory, Complexity and Systems Approach."

[51] Erik Pruyt and Jan Kwakkel, "To Radicalize or to Deradicalize? Is that the Question?" (Proceedings of the 29th International Conference of the System Dynamics Society, Washington, DC, July 24–28 2011).

a portion become activists, another fraction become extremists, and finally, some become terrorists.[52]

Although this distinction is not an academic or professional consensus, it is useful to make a classification based on the level of commitment and radicalization of people who are convinced by the insurgents' rhetoric. However, this first work presented by Pruyt and Kwakkel only represented a radicalization process. Because of this, the authors extended their work to include citizens who had been convinced but were then de-radicalized through a process of "dissuasion."[53]

None of the sources in this brief but interesting recount of recent SDMs of insurgency used the Peruvian insurgency as a case study. However, all models listed in this chapter and other works contribute in some way to the development of the SDM of the Peruvian insurgency, since some of the facts reported by various researchers seem to be replicated in the case of Sendero Luminoso.

3. Analytical Methods for Causal Relations

In complex systems governed by multi-loop structures, identifying dominant loops is an essential task to reveal the most important factors that regulate the behavior of the system. There are a few researchers working on this matter. Their work can be grouped in at least three approaches to identify loop dominance: behavioral perspective, eigenvalue and eigenvector elasticity, and Bayesian network analysis. Among them, the eigenvalue elasticity analysis is perhaps the most promising technique to identify dominant loops, although it is still a work in progress.

David Ford resorted to a behavioral perspective to define loop dominance as "the feedback loop [that] dominates the behavior of a variable during a time

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[52] Pruyt and Kwakkel, "To Radicalize or to Deradicalize?" 14.

[53] Erik Pruyt and Jan Kwakkel, "Radicalization Under Deep Uncertainty: A Multi-Model Exploration of Activism, Extremism, and Terrorism," *System Dynamics Review* 30, no. 1–2 (January – June 2014): 1–28, http://onlinelibrary.wiley.com/doi/10.1002/sdr.1510/full.

interval in a given structure and set of system conditions when the loop determines the atomic pattern of that variable."[54] Likewise, based on this definition, the author suggests a method for determining the dominant loop. This eight-step process is based on the analysis of the pattern of behavior of the variable of interest in a defined period and the loop to be evaluated is selected. Then a variable control is created (or selected) that lets one to change the contribution of the loop to the system under analysis or completely disable it. After handling the control variable, the resulting patterns are compared with those from the variable of interest. If there is variation between these patterns, it is assumed that the loop dominates the system under investigation.[55] Although not conclusive, Ford's method sought to improve SDM analysis of loop dominance and provided a useful technique for identifying dominant feedback.[56]

Burak Güneralpa argued that "conventional model analysis relies heavily on a time-consuming experimental iterative process."[57] In consequence, he developed a loop dominance analysis approach that is based on eigenvalue elasticity analysis (EEA). However, this method is complex and is perhaps reserved for those researchers and professionals with an advanced knowledge of mathematics. Likewise, Güneralpa concludes that the "EEA apparently failed to produce meaningful insights when the model was in a chaotic region. On the other hand, the EEA faced computational challenges in its application to large-scale higher-order models."[58]

To cope with these limitations, resorting to Bayesian networks might be an alternative method of identifying essential causal relations and reducing

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[54] David N. Ford, "A Behavioral Approach to Feedback Loop Dominance Analysis," *System Dynamics Review* 15, no. 1 (1999): 9, http://onlinelibrary.wiley.com/doi/10.1002/(SICI)1099-1727(199921)15:1%3C3::AID-SDR159%3E3.0.CO;2-P/pdf.

[55] Ford, "A Behavioral Approach to Feedback Loop Dominance Analysis," 10–11.

[56] Ford, "A Behavioral Approach to Feedback Loop Dominance Analysis."

[57] Burak Güneralpa, "Towards Coherent Loop Dominance Analysis: Progress in Eigenvalue Elasticity Analysis," *System Dynamics Review* 22 no. 3 (2006): 263–289, http://onlinelibrary.wiley.com/doi/10.1002/sdr.343/pdf.

[58] Güneralpa, "Towards Coherent Loop Dominance," 286.

complexity in causal networks. The Bayesian network's method provides a means of drawing some inferences of the effect of causal relationships in complex systems. This method has been employed in several fields, especially in the realm of biology and economy and marketing. Bayesian networks represent statistical dependencies in a "graph-based model of joint multivariate probabilities distribution that captures properties of conditional interdependence between variables".[59]

However, Bayesian networks require an acyclic structure of variables.[60] Hence, Bayesian networks cannot manage causal loops structures, which are the very basis of SDM and the main responsible for the dynamic behavior of systems. Although there is a method to transform cyclic networks into acyclic Bayes' type networks, thereby eliminating circular relations,[61] it demands transforming causal loops into causal pathways. The extend and complexity of this method place it beyond the scope on this work and so it should be reserved for future research based on the basic model suggested in this thesis.

[59] Nir Friedman, Michal Linial, Iftach Nachman, and Dana Pe'er, "Using Bayesian Networks to Analyze Expression Data," *Journal of Computational Biology* 7, no. 3–4 (2000): 601, http://oncinfo.org/file/view/Friedman2000.pdf.

[60] Sucheta Nadkarni and Prakash P. Shenoy, "A Causal Mapping Approach to Constructing Bayesian Networks," *Decision Support Systems* 38, no.2 (2004): 267, https://libprddspap.lib.ku.edu/bitstream/handle/1808/150/DSS04.pdf?sequence=1&isAllowed=y.

[61] Sucheta Nadkarni and Prakash P. Shenoy, "A Bayesian Network Approach to Making Inferences in Causal Maps," *European Journal of Operational Research* 128 (2001): 488, http://libprddspap.lib.ku.edu/bitstream/handle/1808/164/EJOR01.pdf?sequence=1&isAllowed=y.

II. BUILDING SYSTEM DYNAMICS MODELS

> Effective decision making and learning in a world of dynamic complexity requires us to become system thinkers—to expand the boundaries of our mental models and develop tools to understand how the structure of complex systems creates their behavior.
>
> —John D. Sterman[62]

This chapter contains the methodology involved in the development of System Dynamics Models (SDM) and the analytical method used to evaluate the results. This chapter encompass eight fundamental concepts in system dynamics modeling: system parameters, causal relationships, a system's feedback structure, a system's physical structure, decision-making process, attributes of tangible quantities, a system's pattern of behavior, and loop dominance. These concepts are ordered under the four fundamental steps to build a SDM: 1) identify causal relationships and build a Feedback Structure (FS), 2) integrate FS with Stock and Flow Structures (SFS), 3) develop the model's equations, and 4) run a simulation.

SDM captures the patterns of variables that can describe, with a certain degree of accuracy, the behavior of complex systems. This complexity means that the system may have several variables interacting dynamically. Nonetheless, despite the complexity of these systems a set of just a few variables—which are called the parameters of the system—can be used to fully describe them. Some of these parameters are intangible entities that can only be inferred through observable quantities. This kind of parameter represents latent variables of systems, in which its existence is assumed from manifest or observable variables. For instance, consider how the sense of security in society is altered by criminal activity. In this case, criminal events can trigger a decrease in the sense of security. Hence, it is reasonable to infer an indirect relationship between

62 John D. Sterman, *Business Dynamics: System Thinking and Modeling for a Complex World* (New York, NY: McGraw-Hill, 2000), viii.

the number of crimes and society's sense of security—as crimes increases, the sense of security decreases—even though the "intangible" sense of security cannot be directly observed.

Logically, events will produce changes in the parameters of the system. Over time, these changes describe patterns of behavior. That behavior is governed by the structure of the system, both FS and SFS. Additionally, such behavior reveals the outcome of the interaction between the system's structure (FS and SFS) and the decision making process of agents acting within the system.[63] Large models can include several variables and may demand vast amount of information to run a simulation. However, once the models have been built and reasonable completeness has been ensured, conducting a simple analysis of the pattern of behavior of the system's parameters and its inferred structure can be sufficient to answer important questions in strategic matters.

Simplifying complexity by resorting to these graphical representations allows researchers to investigate and understand complex systems in a simple way that follows a rigorous mathematical process. This simplicity and certainty make System Dynamics a useful tool for strategic issues. Moreover, in spite of the fact that those who intervene in order to correct unintended behavior in the system must do so in an environment of high uncertainty, SDM provides a cognitive process of discovery and constant learning.

A. SYSTEM DYNAMICS MODEL BUILDING

System Dynamics Modeling has four fundamental steps. First, the researcher identifies causal relationships among the system's parameters, identifying feedback loops that associated with the dynamic behavior of the system. Second, the researcher integrates feedback structures with stock and flow structures. Third, the researcher develops the series of model equations, which must capture the proportions and ratios of change among causal, auxiliary and exogenous variables. Finally, the researcher runs a simulation and contrasts

[63]Sterman, *Business Dynamics,* 107.

SDM results with real world data, if it is available.[64] Figure 3 depicts the four steps in SDM.

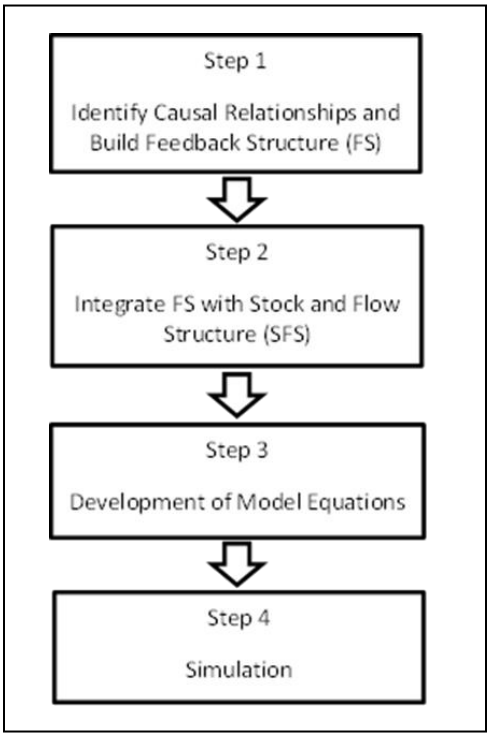

Figure 3. Four Steps to Develop an SDM.

1. Causal Relationships and Feedback Structures (FS)

Feedback Structures are responsible, to a significant degree, for the behavior of the system. They capture the dynamics of a network of interconnected and interdependent variables. FS capture only cause-effect relationships; therefore, correlations must not be included. These variables and relationships are depicted in a Causal Loop Diagram (CLD), in which variables are represented as simple words or statements, and relationships are represented by arrows that connect variables and show the direction of dependency. These relationships can be either positive (+) or negative (-). A

[64] John D. Sterman, "System Dynamics Modeling: Tools for Leaerning in a Complex World," *California Management Review* 43, no. 4 (Summer 2001): 18–19, doi: 10.2307/41166098.

positive relationship means that an increase in variable (*x*) leads to an increase in variable (*y*). Conversely, a negative relationship means that an increase in variable (*x*) leads to a decrease in variable (*y*).

Some systems are simple, governed by a single feedback loop that is either positive or negative. Others are complex systems, which are governed by a combination of positive and negative loops and commonly called Multi-Loop Systems (MLS). An MLS must have at least one reinforcing loop (R) driving the growth and at least one balancing loop (B) constraining the growth of system parameters.[65] In other words, an MLS's parameters are affected by both types of loops, in which many factors can converge, reinforcing or suppressing synergistically the behavior of the variable in question.

The order of the system represents the number of parameters under investigation in the system. As an example, consider the first-order system in Figure 4, in which population is considered the parameter of the system. It clearly indicates that increasing the population increases the rate of birth, thus adding more people to the world.

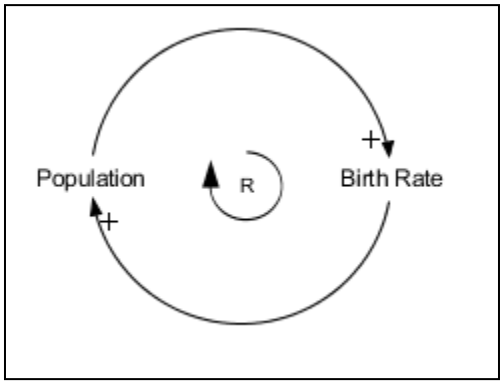

Figure 4. Example of a First-Order Single Loop System

[65] Donella H. Meadows, *Thinking in Systems: A Primer* (White River Junction, VT: Chelsea Green Publishing, 2008), 59.

An example of a CLD representing a second-order system with a single loop can be found in Lanchester's Square Law. This law was developed by English mathematician Frederick William Lanchester in 1916 during the First World War and it is one of two author's mathematical formulas that describe the relative strength of two military forces, Blue and Red. Figure 5 depicts the CLD of Lanchester's Square Law, in which becomes evident that the strength of the Blue force causes attrition in the Red force. By the same token, the strength of the Red force causes attrition in the Blue force.

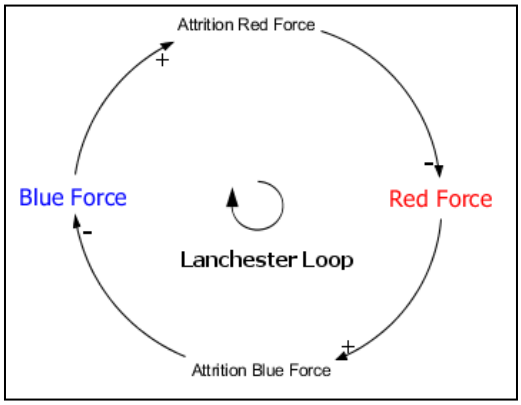

Figure 5. Example of a Second-Order Single Loop System

Figure 6 depicts a second-order multi-loop system. This particular example considers two political parties, Blue and Red, vying for constituencies. The Blue party unfolds an aggressive campaign of recruitment to affiliate more citizens. The Blue affiliation rate would be conditioned not only on the efforts of the Blue party—assuming that recruitment depends upon primary socializations of party members—but also on the number of Red party affiliates. It means that at some point, the rate of affiliation no longer will depend directly on the number of Blue party members. It might be difficult to find and assimilate Red members because their numbers become smaller and smaller over time.

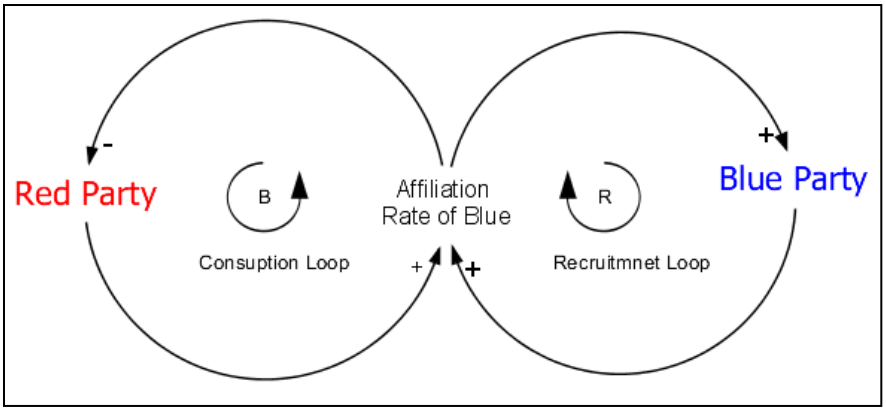

Figure 6. Example of Second-Order Two Loop System

However, not all variables have an immediate impact on their subsequent variable. The effect of one variable on another can be delayed, for instance, due to the gradual adjustment of perceptions or beliefs.[66] In CLD, these delays are depicted as delay marks (//) over the arrow affected by this delay. Figure 7 depicts a simple first-order multi-loop system with delays in the context of insurgency. As shown, the increasing human resources available for the insurgent organization to recruit do not have an immediate impact on their recruitment rate or on their attrition rate.

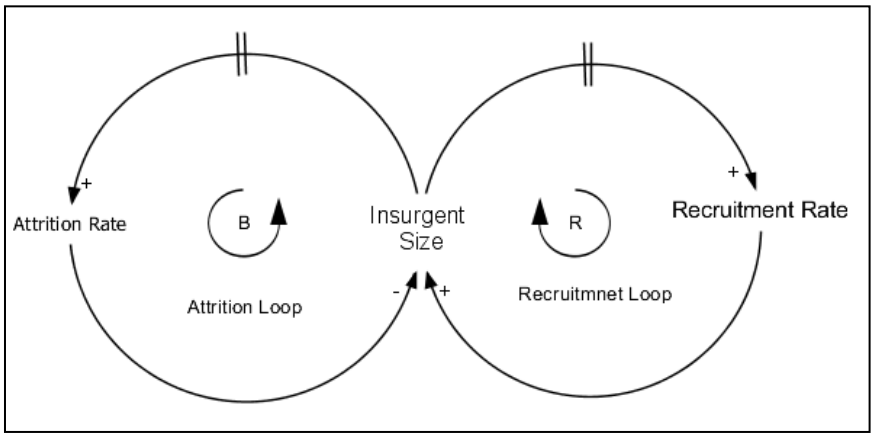

Figure 7. Example of a First-Order Two Loop System with Delays

66 Sterman, *Business Dynamics*, 412–426.

Feedbacks are not necessarily transmitted and returned through the same system's components. These feedbacks may route through multiple intervening components within the system, or potentially return from an external system before returning back to the component where they started.[67]

Variables in the CLD tell researchers nothing about the ratios and proportions of change between variables in the model. For instance, it is difficult to say whether the Blue forces or the Red forces depicted in Figure 5 would be more likely to win the battle. The success or failure of these forces is conditioned on the initial values (soldiers) of both forces and on their effectiveness in combat (attrition coefficient). Hence, to communicate more effectively, Causal Loop Diagrams must be complemented with initial values and some other constant and variables, which are considered auxiliary or intermediate variables of the system.

Finally, one limitation of CLDs is their inability to capture the Stock and Flow Structure (SFS) of the system,[68] which captures the dynamic flow and accumulation of both tangible and intangible variables. For instance, the number of troops in the Blue and Red forces would be an example of tangible quantities in stock. Hence, the CLD requires improvements to capture with more precision a real world system, which demands the connection of feedback structures with SFS.

2. Physical Structure or Stock and Flow Structure (SFS)

In system dynamics, Stock and Flow Structures, represented as Stock and Flow Diagrams (SFD), consist of networks of stocks and flows linked by information feedback from the stocks, constants, and exogenous variables to the rates.[69] Stocks can represent tangible quantities such as people or material, or

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[67] Virginia Anderson and Lauren Johnson, *Systems Thinking Basics: From Concepts to Causal Loops* (Westford, MA: Pegasus Communication Inc., 1997), 5.

[68] Sterman, *Business Dynamics*, 191.

[69] Sterman, *Business Dynamics*, 202.

intangible variables such as physiological states, perceptions, expectations, or even morale.[70] Figure 8 depicts a generic SFS.

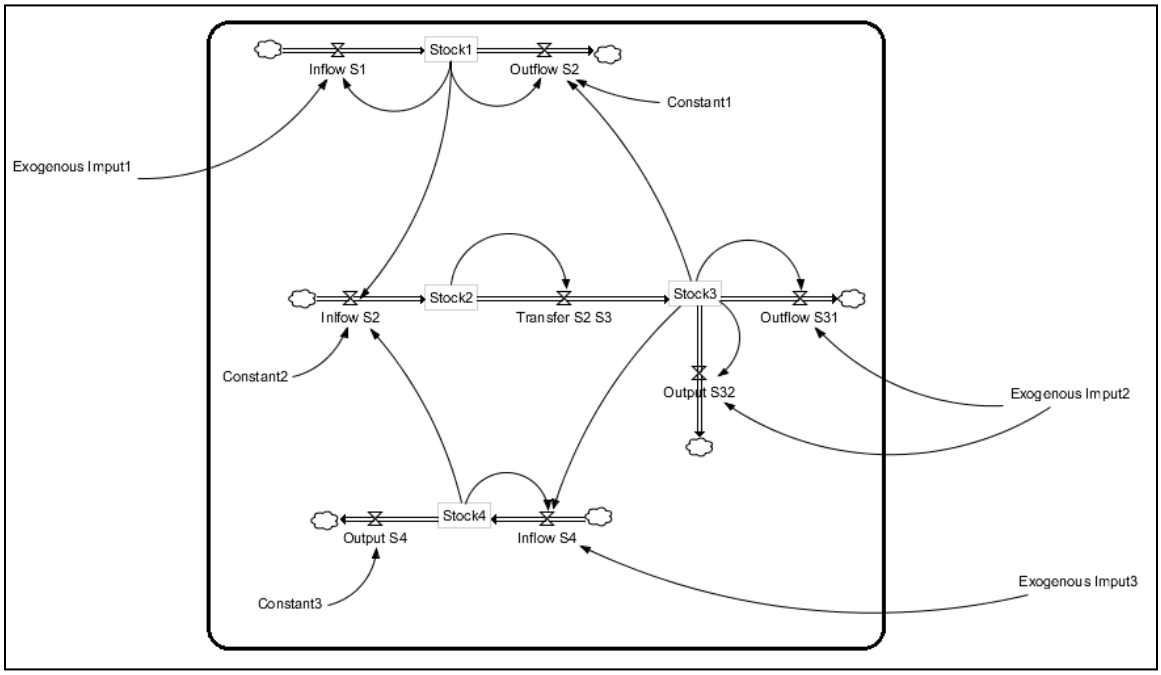

Figure 8. Generic Stock and Flow Structure SFS.[71]

Stock and Flow Structures provide the basis for action and are critical in the dynamics of the system. Additionally, stocks provide inertia, memory and cause delays and create disequilibrium dynamics.[72]

SFS has a precise and unambiguous mathematical meaning. Its graphical representation, the Stock and Flow Diagrams, “replaces” writing mathematical formulas with a graph that simplifies the process of modeling, understanding and communicating.

As John Sterman points out, stocks integrate their flows. They can change only through their rates of flow; therefore there cannot be causal links directed to

[70] Sterman, *Business Dynamics*, 201.

[71] Sterman, *Business Dynamics*, 204.

[72] Sterman, *Business Dynamics*, 195–196.

them, and the net flow into the stock is the rate of change (ROC) of the stock.[73] Formula 2.1, presented by Sterman, defines the integral equation that corresponds to a stock and its flows.

$$Stock_t = \int_{t_0}^{i} [Inflow_{(s)} - Outflow_{(s)}]ds + Stock_{(t_0)} \quad (2.1)$$

where, $Inflow_{(s)}$ represents the value of the inflow at any time (s) between the initial time (t_0) and the current time (t), and $Outflow_{(s)}$ represents the value of the outflow at any time (s) between the initial time (t_0) and the current time (t).

Equivalently, the net Rate of Change (ROC) of any stock, its derivative, is the inflow less the outflow, defining the differential equation, as seen in equation (2.2):

$$\frac{d(Stock)}{dt} = Inflow_{(t)} - Outflow_{(t)} \quad (2.2)$$

In general, the flows will be functions of the stock and other state variables and parameters.[74] The determinants of the rates of inflow and outflow are the stock itself and any other constant or variable affecting the rates. It must be kept in mind that constants can be variables that change so slowly over the time horizon of interest that they are considered constant.

Likewise, SFS can include auxiliary variables. These types of variables, sometimes called intermediate variables, are used in functions of the stocks, constants, or exogenous variables. The latter are considered stocks that have been chosen not to model explicitly and so are drawn outside the model boundary.[75] Auxiliary variables contribute to the model's clarity and ability to communicate,[76] and to defining the proportion and ratios of change among variables. For instance, Lanchester's Square Law depicted in Figure 9 shows the

[73] Sterman, *Business Dynamics*, 204.

[74] Sterman, *Business Dynamics*, 194.

[75] Sterman, *Business Dynamics*, 202.

[76] Sterman, *Business Dynamics*, 202.

correspondent SFS with attrition coefficients (Blue and Red) as auxiliary variables.

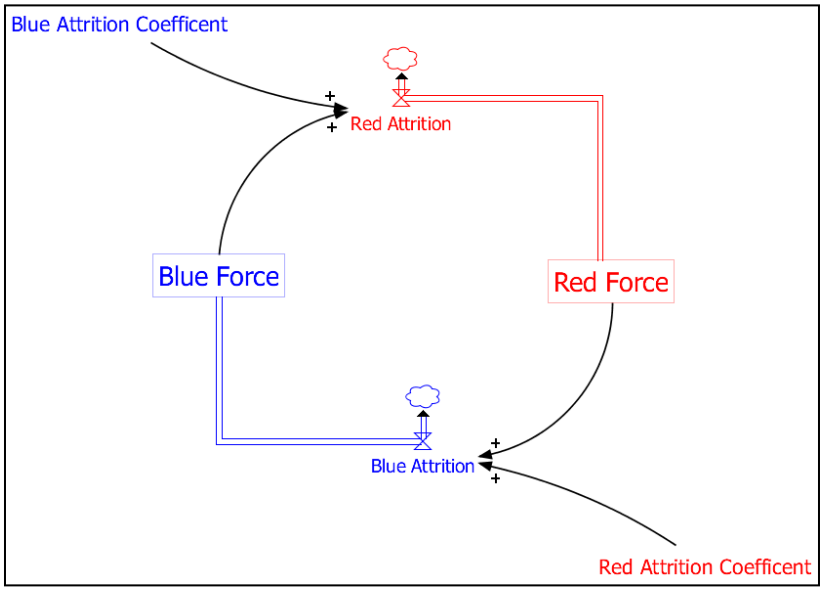

Figure 9. Lanchester's Square Law SFD.

Additionally, the level of aggregation of variables and the model boundaries are two other important aspects that should be considered when building a model. The level of aggregation (or disaggregation) refers to the number of internal categories or stock represented, while model boundaries refer basically to the scope of the model.[77] Outside the boundary of one system can be other systems in connection with the model of interest, and these links will be considered exogenous variables. Figure 10 depicts the concepts of aggregation and model boundaries.

[77] Sterman, *Business Dynamics*, 213.

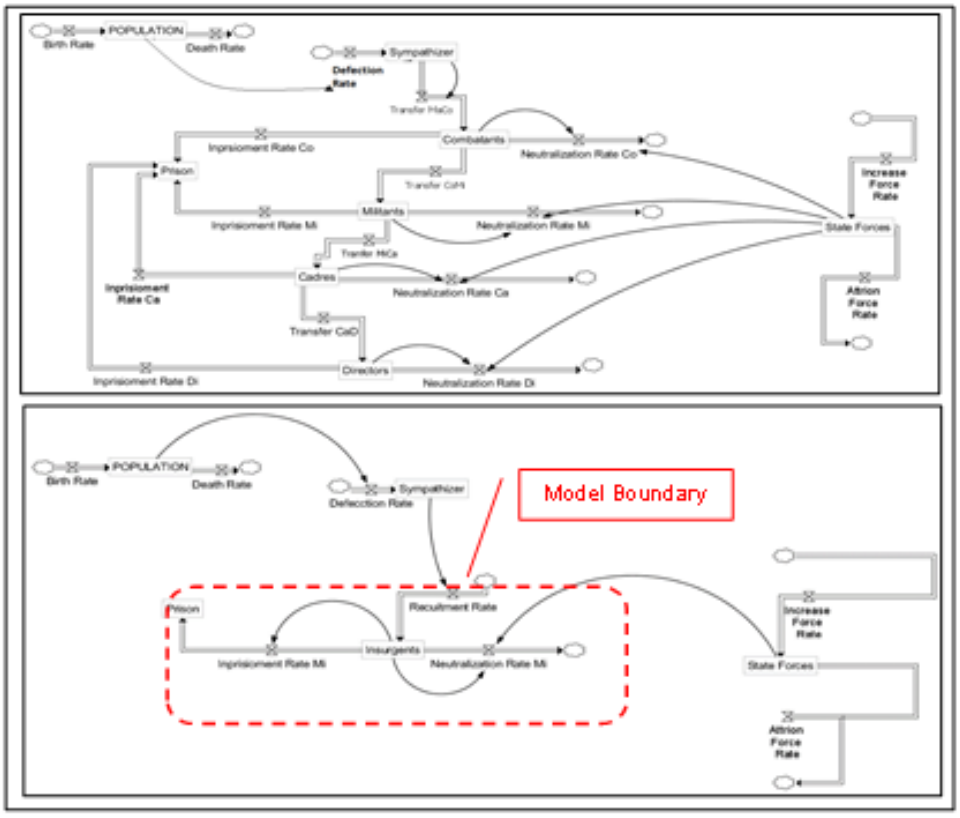

Figure 10. Example of Variable Aggregation and Model Boundary.

a. Decision Making Process.

Likewise, an SFS can include the decision-making processes of agents (e.g., actors or intelligent entities within the system) acting within the system. These decision-making processes can only govern the rates of flow of a stock into the system, which will be determined by decision rules that shape the behavior of the agents in the system. Decisions rules are the protocols and policies specifying how decision makers process available information. Hence, modeling decision making requires the researcher to detect and represent "the guiding policy" that yields the stream of decisions,[78] and only should include the information available to agents as the inputs in the decision-making process. Figure 11 depicts a generic decision making process model.

[78] Sterman, *Business Dynamics*, 514–515.

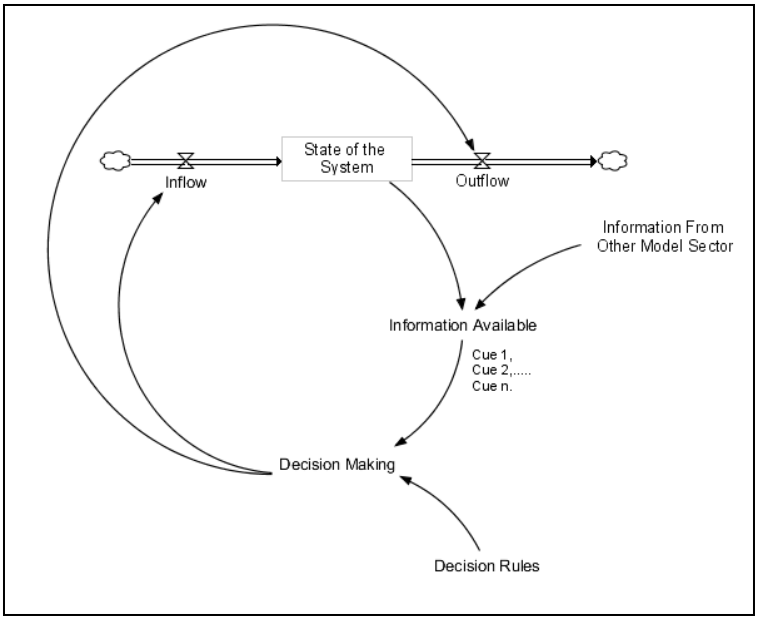

Figure 11. Generic Decision Making Process.

b. Coflow and Intangible Attributes

Stock and Flow Structures also can capture intangible attributes of the tangible variables in the system. While Stock and Flow Diagrams are commonly used to analyze systems capturing total quantities of "material" that flow in the system, coflows are used to account for attributes of items flowing through stock and flow networks.[79] Also, most of coflows can describe as conserved quantities, in which the total level of the attribute can only change in direct relation to the size of the main stock. However, it is common for stock to change without any change in the main stock.[80] The general structure of a coflow is depicted in Figure 12, in which tangible quantities and their attributes are shown as two separate diagrams. Figure 13 depicts an example of a coflow of a high-order system. In these cases, stocks can be aggregate and the average attribute must be calculated.

[79] Sterman, *Business Dynamics*, 469.

[80] Sterman, *Business Dynamics*, 505.

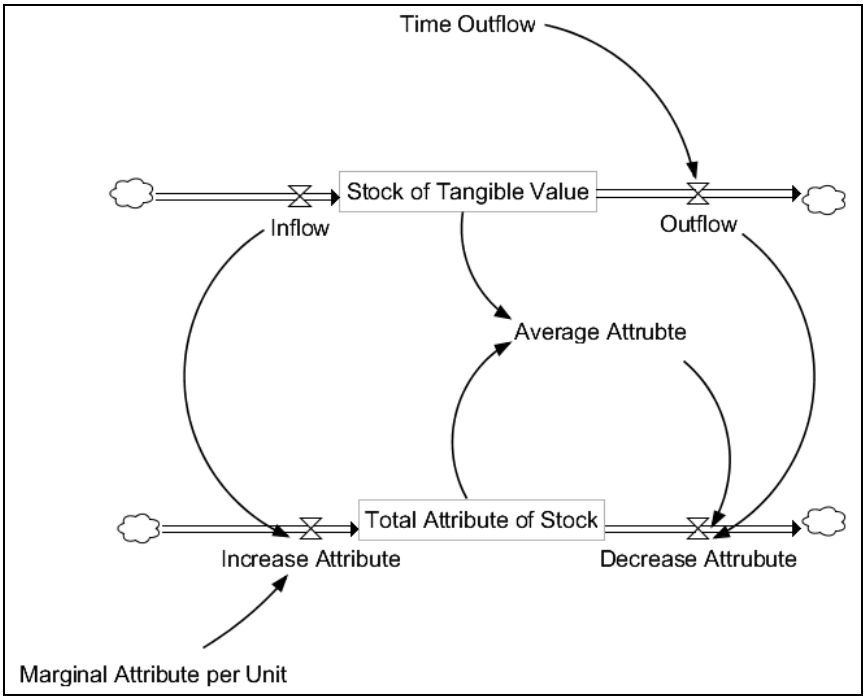

Figure 12. Generic Coflow Structure

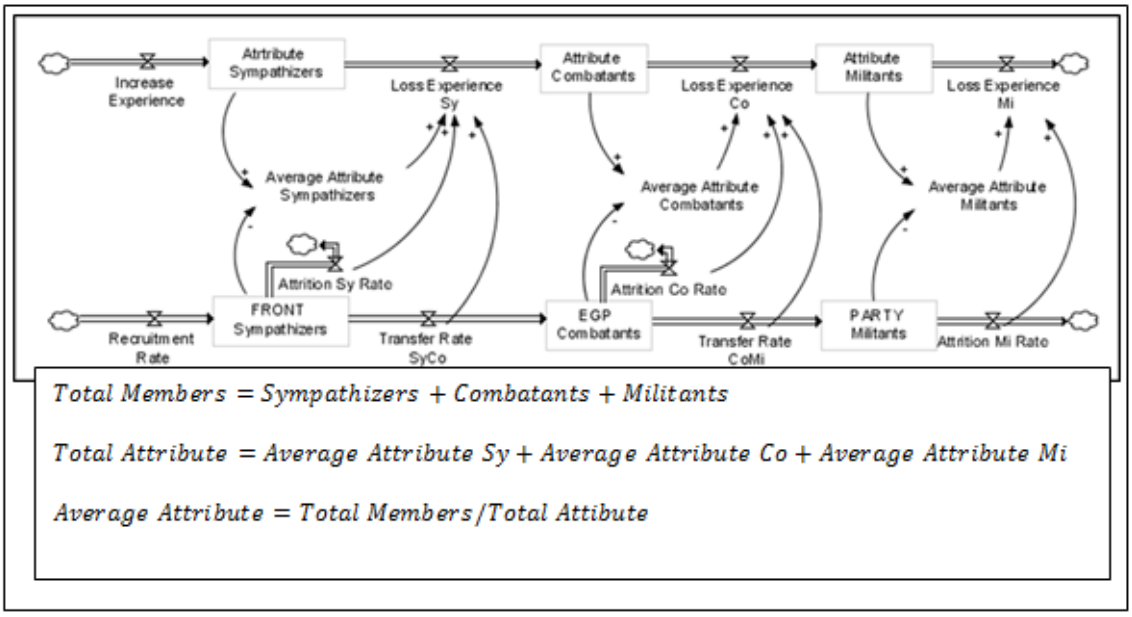

Figure 13. Coflow of a High-Order System and Average Attribute

Finally, from the causal relationships of the FS, an SFS integrates intermediary or auxiliary variables, decision processes, attributes of stocks,

constants, and model boundaries. In other words, SFSs are what give the full sense to a model and capture not only causal relationships but also important variables to determine the dynamics of the system. Once the SFS is determined, the researcher can move to writing the model equations that provide the ratios and proportions of change between sets interdependent variables, and finally, run a simulation.

3. Model Equations and Simulation

One of the advantages of System Dynamics Models is to provide a graphical interpretation of a system without losing the rigor of mathematics. Hence, the model will not be complete until the model equations are properly described and validated. Using as an example Lanchester's Square Law, the original equations of the battle of two armies, Blue and Red, are showed in the system of equation 2.3

$$\begin{cases} dB/dt = -\rho R \\ dR/dt = -\beta B \end{cases} \tag{2.3}$$

where $\rho > 0$ is the attrition coefficient (or fighting effectiveness coefficient) of the Red forces, $\beta > 0$ is the attrition coefficient of Blue forces, and B_0, R_0 are the initial troop strengths.[81]

For the Lanchester's Square Law SFD (depicted in Figure 9), the mathematics are "simplified" to the following equations:

$$Blue\ Force = -Blue\ Attrition \tag{2.4}$$

$$Red\ Force = -Red\ Attrition \tag{2.5}$$

$$Blue\ Attrition = Red\ Force * Red\ Attrition\ Coefficent \tag{2.6}$$

$$Red\ Attrition = Blue\ Force * Blue\ Attrition\ Coefficent \tag{2.7}$$

[81] See as reference Joyner, "An Introduction to Systems of Differential Equations: Lanchester's Equations for Battle," U.S. Naval Academy (March 2007), http://www.usna.edu/Users/math/wdj/_files/documents/teach/sm212/DiffyQ/de-lanchesters-eqns.pdf.

After model equations have been written, the System Dynamics Model is complete and all that remains is to define the initial values, the parameters and constants of the model. For example, assume that two armies are in close combat, with the Blue force having an initial value of 10,000 soldiers and the Red force an initial value of 8,500 soldiers. Then the Blue forces have a coefficient of attrition of 0.018 and Red forces, with a slightly better performance in combat, a coefficient of attrition of 0.025. Tables 1 and 2 contain the initial values and constants, respectively.

Table 1. Initial Values, Lanchester's Square Law

Definition	Symbol	Value
Blue Force	B_0	10,000
Red Force	R_0	8,500

Table 2. Parameters and Constants, Lanchester's Square Law

Definition	Symbol	Value
Blue Force Attrition Coefficient	β	0.018
Red Force Attrition Coefficient	ρ	0.025

Then, after running a simulation, the results are depicted in Figure 14. This result suggests that, although the Blue forces began the battle with the advantage of size of force and delivered significant losses to the Red forces, after about 107 minutes (the time has been assumed to be in minutes) the Red forces offset the Blue forces, based upon their better combat effectiveness. After almost three hours of battle, the Blue forces are finally defeated, with only 463 Red soldiers surviving.

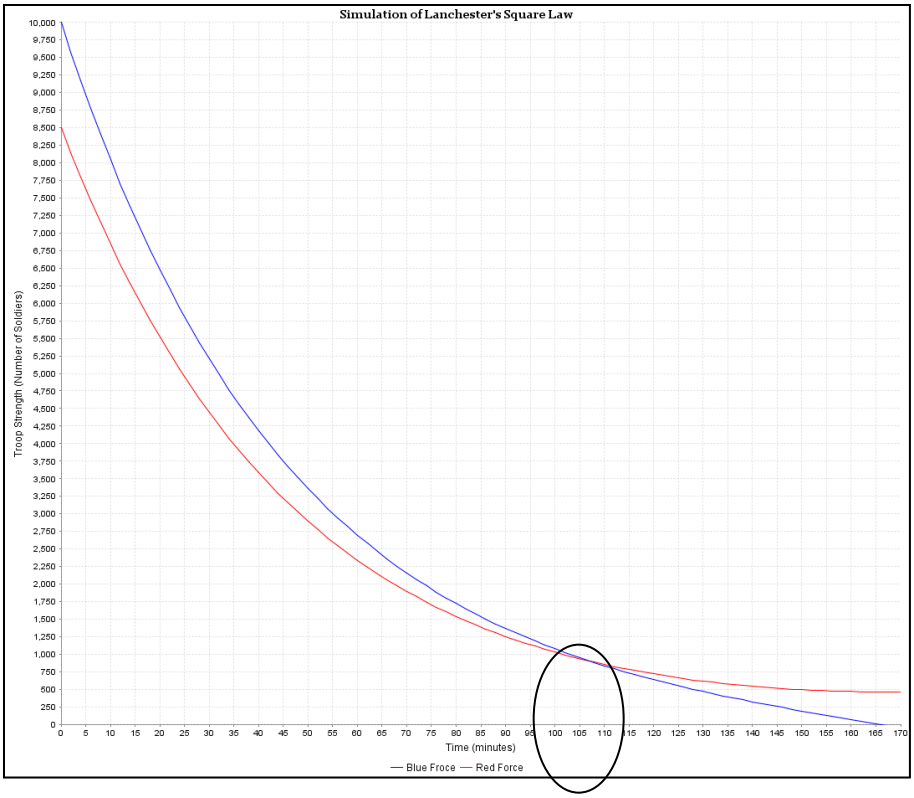

Figure 14. Lanchester's Square Law Simulation Sample.

B. PARAMETER, PATTERN ANALYSIS, AND LOOP DOMINANCE

System Dynamics Models provide a holistic view of the structure of the systems that is assumed to be responsible for the behavior of the system. However, accurate simulations demand a vast amount of information regarding the proportions, ratios of change and relations among variables. As an alternative, observing how the parameters change over time—their pattern of behavior—can help to reveal the structure of the system that produces the changes in the variables of interest. As was mentioned earlier, in System Dynamics the behavior of the variables is governed by both FS and SFS and depends on the type of relationship—linear or nonlinear—between the variables that form the system's structures.

Discrete dynamical systems are the simplest, because their exact solutions are known.[82] They can produce three types of behavior: exponential growth, equilibrium, and exponential decay. In first order linear systems, a positive feedback loop creates exponential growth; a negative feedback loops creates exponential decay; when loops offset one another, they create equilibrium.[83] In linear multi-loop systems, shifts in dominance of different feedback loops do not occur.[84]

Nonlinear relationships can produce a pattern of behavior that forms a logistic type curve, or "S" shape. Nonlinearities are far more complex than linear systems, because it is difficult to capture with precision the proportions and ratios of cause-effect among variables. However, most real world complex systems are governed by nonlinearities. In multi-loop nonlinear systems, the combination of both types of loops can lead to the system exhibiting such logistic growth, or "S" shape growth, because loop dominance shifts as the system evolves.[85] Figure 15 depicts the four patterns of behavior derived from linear and nonlinear relationships.

[82] Sterman, *Business Dynamics*, 551.

[83] Sterman, *Business Dynamics*, 291.

[84] Sterman, *Business Dynamics*, 284.

[85] Sterman, *Business Dynamics*, 291.

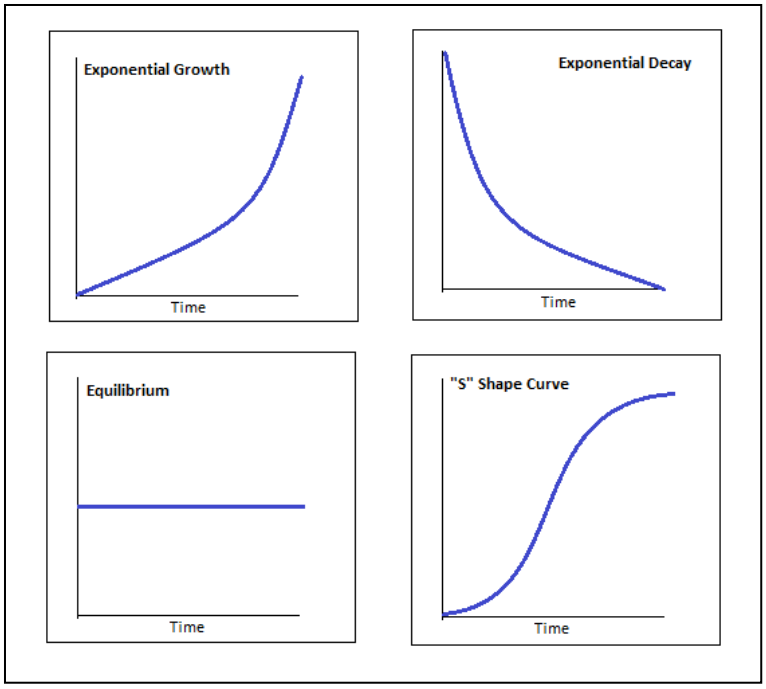

Figure 15. Four Patterns of Behavior

As a corollary, when the pattern of behavior of a variable is known, loop dominance can tell which loop (either positive or negative) dominates the system in a specific period. The formal definition of loop dominance for a first-order (single state variable) system is shown in the following equations:

$$\frac{\partial \dot{S}}{S} > 0 \Rightarrow Positive\ Feedback\ Dominates \tag{2.8}$$

$$\frac{\partial \dot{S}}{S} = 0 \Rightarrow Feedback\ Offset \tag{2.9}$$

$$\frac{\partial \dot{S}}{S} < 0 \Rightarrow Negative\ Feedback\ Dominates \tag{2.10}$$

where $\dot{S} = \frac{dS}{dT}$[86]

Positive feedback or reinforcing loops (R) dominate whenever the Rate of Change of the variable is increasing, that is, as long as the slope of the net ROC as function of the state variable is positive. Negative feedback or balancing loops

[86] Sterman, *Business Dynamics*, 289.

(B) dominate whenever the net ROC is decreasing in the state variable, that is, as long as the slope of the net rate is negative.[87] An inspection for dominant loops in the pattern of a system's parameters allows the structure of the system that drives such behavior to be inferred. This is what is known as inverse problem process, which means drawing inferences about the causal factors that lead the system to that state, from a set of observable states.[88] This kind of inverse problem process is a fundamental tool for retrospective research.

To summarize, knowing the behavior of the system's parameters allows the performance of the entire system to be inferred. A parameter's patterns of behavior and loop dominance unveil the presence or absence of both negative and positive feedback loops. For instance, an exponential growth suggests the absence of negative feedback loops and only positive loops dominate. In the patterns showing an "S" shaped curve, a shift in loop dominance must be assumed. Hence, having built with reasonable completeness the structure of a system, the researcher can draw inferences regarding which loops prevail over others looking up in the pattern of behavior of the system's parameters within the time horizon of the investigation.

[87] Sterman, *Business Dynamics*, 289.

[88] Albert Tarantola, *Inverse Problem Theory: Methods for Data Fitting and Model Parameter Estimation* (New York, NY: Elsevier 1987).

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III. HYPOTHETICAL COUNTERINSURGENCY SYSTEM: AN EXAMPLE OF PROSPECTIVE RESEARCH USING SYSTEM DYNAMICS

In order to show the use of System Dynamics Models in prospective research, this chapter contains a hypothetical counterinsurgency SDM that explores the dynamics between two sub-systems: the insurgency and the population. From a simple narrative based on the interaction of these two sub-systems, a CLD is constructed, in which the reinforcing loops and balancing loops are identified. Then, this FS is integrated with intermediary variables, three exogenous constants (COIN forces, COIN operational effectiveness, and victimization coefficient), and two exogenous variables (Information Operations [IO] Effectiveness and Intelligence Level). Using this SFS as guide, the model equations are formulated and a simulation run to assess the impact of changing the levels of intelligence and IO effectiveness in COIN operations. Finally, in order to complement the simulation, the results are analyzed under the optics of loop dominance.

A. HYPOTHETICAL COUNTERINSURGENCY SYSTEM—FEEDBACK STRUCTURE

Insurgencies generally begin small. They require first and foremost an increase in their size and strength. Being small, insurgencies resort to terrorism, among other things, in order to increase their size. Although the connection between an insurgency's attacks and its recruitment rate may not be evident, there is a mechanism associated with it. Insurgent attacks, if properly managed, can trigger a chain of events that can result in an increase in insurgent numbers, which allows insurgents to conduct more attacks, creating a self-reinforced loop. McCormick and Giordano call this the "provocation effect." Insurgent violence can provoke the State's forces "into engaging in excessive counter-measures, applying repression indiscriminately, and striking out at targets that they cannot

see [collateral damage]. In consequence, State's actions "alienate population and push people into the arms of the insurgency."[89]

In an ideal scenario for insurgency growth, if insurgents manage to operate with low visibility the State's forces will not be able to neutralize them at the same rate that they can recruit new members. Therefore, the insurgency continues to grow up to a point in where the organization will reach a significant size, and therefore increase its signature. Then, State's forces will be able to improve their situational awareness and can target more insurgents.[90] This creates an attrition loop that balances the size of insurgency.

Insurgent size can have a negative impact on the recruitment rate. It is evident that the neutralization rate reduces the number of insurgents. What is not so evident, but happens nonetheless, is that the number of effective COIN operations is perceived as a sign of a State's capacity and willingness to control an insurgency. As McCormick and Giordano assert, counter-actions can reinvigorate popular estimates of a State's ability and willingness to carry the war to the insurgency.[91] Thus, people become satisfied with the State's performance, which, in turn, reduces the number of dissidents, which ultimately has an impact on the insurgency's recruitment rate.

B. HYPOTHETICAL COUNTERINSURGENCY SYSTEM—STOCK AND FLOW STRUCTURE

Although the aforementioned narrative is not sufficient to capture the entire complexity of counterinsurgency dynamics, it does allow one to develop a basic Casual Loop Diagram as shown in Figure 16. This feedback structure includes three loops: a reinforcing loop called "Provocation Loop," a balancing loop called "Attrition Loop," and a balancing loop called "State Capacity Loop."

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89 Gordon H. McCormick and Frank Giordano, "Things Come Together: Symbolic Violence and Guerilla Mobilization," *Third World Quarterly*, 28 no. 2 (2007): 308, http://www.jstor.org/stable/4017701.

90 Alan Washburn and Moshe Kress, *Combat Modeling* (New York, NY: Springer, 2009).

91 McCormick and Giordano, "Things Come Together," 311.

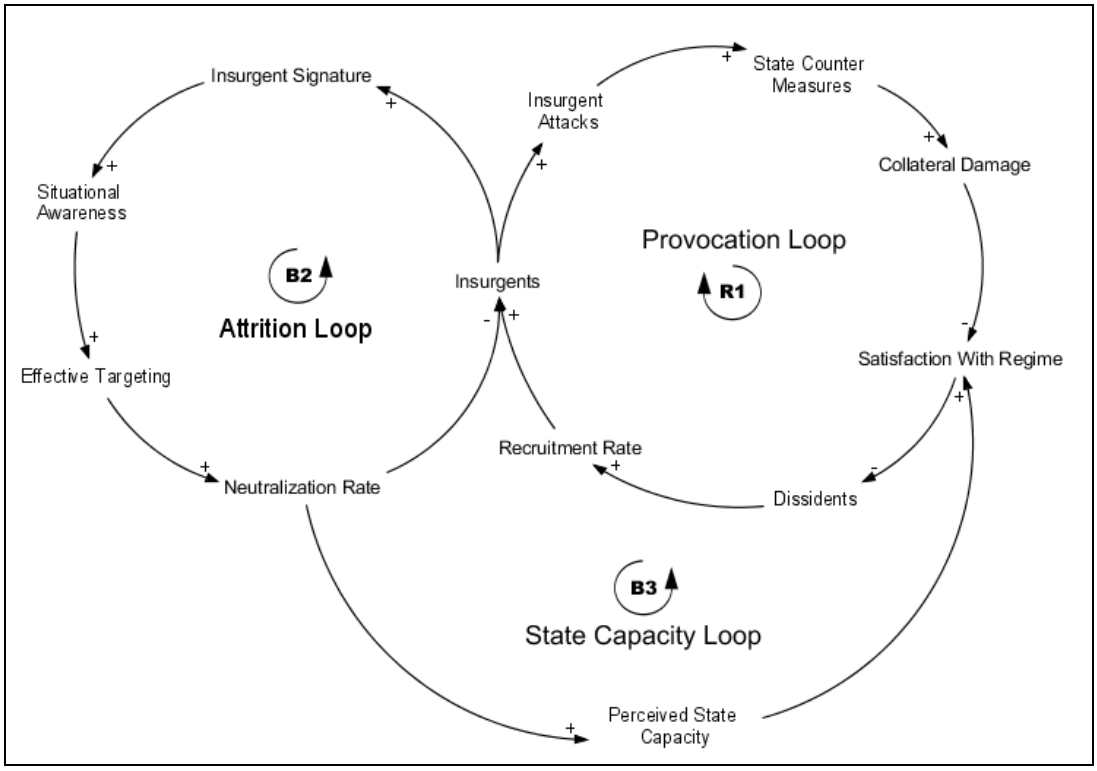


Figure 16. Hypothetical Counterinsurgency System—Causal Loop Diagram.

From the causal relationships depicted in Figure 16, a Stock and Flow Diagram is created adding intermediary variables, decision process, exogenous variables and constants. These variables and constants included in the systems are those which have been assumed by the author are important to determine the proportions and ratios among variables. These variables are: Population, Intelligence level, COIN Operational Effectiveness, Insurgent's operational factor, victimization coefficient, transition coefficient and IO operations effectiveness. These parameters will be explained in full detail in the next section of this chapter. Figure 17 depicts the SFD of the basic counterinsurgency system.

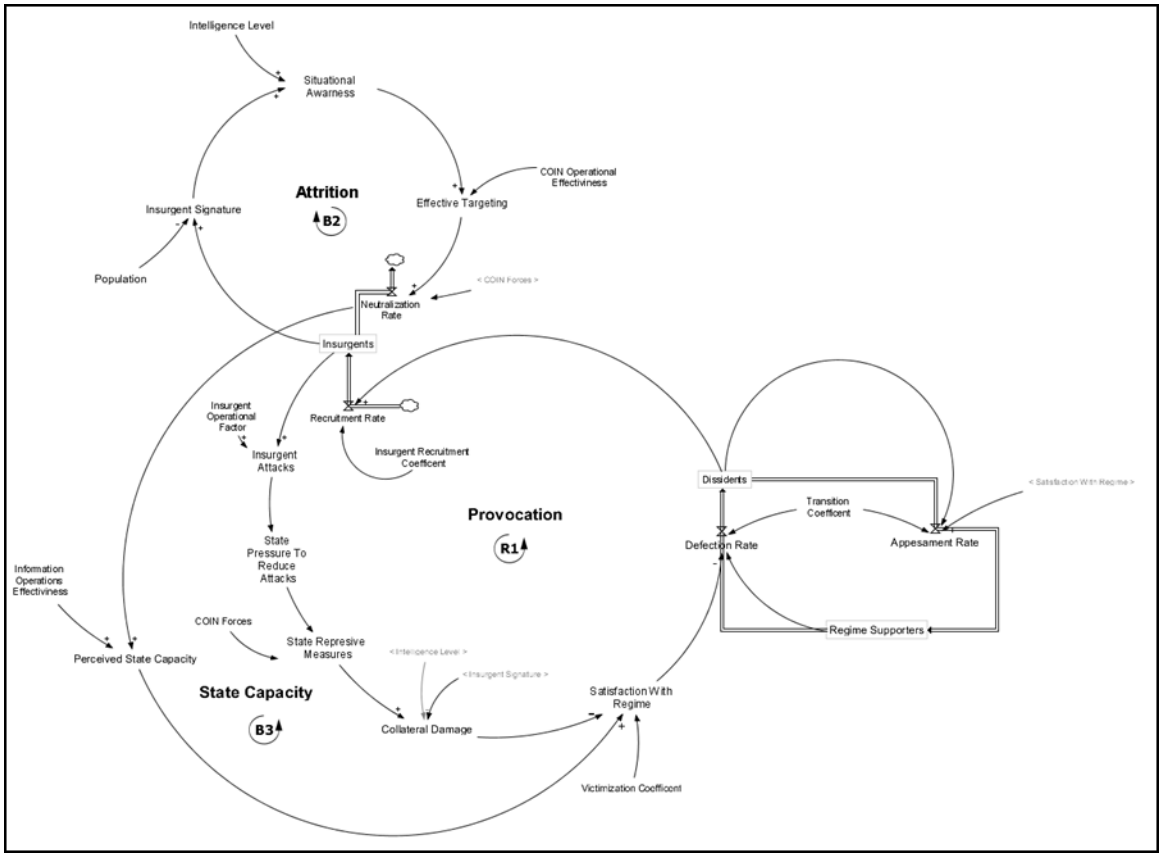


Figure 17. Hypothetical Counterinsurgency System—Stock and Flow Diagram

C. HYPOTHETICAL COUNTERINSURGENCY SYSTEM—MODEL EQUATIONS

This model explores the dynamics between two subsystems: the population and the insurgents. Both are components of a system called the Counterinsurgency System. It has been assumed for this example that the system's parameter that represents the state of the system is the insurgent size *(I).* This represents the number of insurgents actively participating in the insurgency, and it is a function of the Recruitment Rate and Neutralization Rate. Hence, the dynamics of this parameter are represented by the following ordinary differential equation, which represents the change of the number of insurgents over time:

$$\frac{dI}{dt} = Recruitment\ Rate_{(t)} - Neutralization\ Rate_{(t)} \quad (3.1)$$

Likewise, it has been assumed that recruitment rate represents the fraction of dissidents that radicalize and become insurgents per unit of time. This fraction results from the number of dissidents *(D)* multiplied by a constant recruitment coefficient *(Γ).* Hence, we define the recruitment rate as follows:

$$Recruitment\ Rate = D * \Gamma \quad (3.2)$$

The number of dissidents increases as the regime supporters *defect* and become dissident. The rate at which the number of insurgents changes is called the *defection rate*. Conversely, the number of dissidents decreases as the dissidents decide to support the state. This is called the *appeasement rate*. Hence,

$$\frac{dD}{dt} = Defection\ Rate_{(t)} — Appeasement\ Rate_{(t)} \quad (3.3)$$

Both the defection rate and appeasement rate are functions of the level of *satisfaction with the regime (β).* When $\beta < 0$, people flow from *RS* to *D*, and when $\beta > 0$, people flow from *D* to *RS.* It is assumed that the fraction of *D* and *RS* that flow in and out are both equal and constant, and they are represented by a correspondent *coefficient of transition (RS* $\rightarrow$ *D =* τ *RS* ; *D* $\rightarrow$ *RS =* τ *D).* Hence, defection rate and appeasement rate are given by the following formulas:

$$Defection\ Rate = -MinSatisfaction\ with\ Regime, 0 * \tau\ RS * RS \quad (3.4)$$

$$Appeasement\ Rate = MaxSatisfaction\ with\ Regime, 0 * \tau\ D * D \quad (3.5)$$

It is assumed that the variable *satisfaction with regime*, which represents the population's attitude toward the regime, is a decision-making process governed by a function based on available information that the population has regarding the progress of the conflict. It is the weighted difference between the perceived attrition to the insurgency caused by the regime, and the collateral damage in the population generated by the regime's actions against the insurgency. The weight parameter υ, or *victimization coefficient,* represents the

population's cognitive trade-off between insurgency and collateral damage. The larger the value of υ, the more sensitive the population is to its own casualties.[92] Hence,

$$Satisf.w/Regime = Perc.State\ Capacity — (Collateral\ Damage * \upsilon) \quad (3.6)$$

Perceived State Capacity is evidently associated with COIN Forces' relative success in neutralizing insurgents. However, the population will perceive only a fraction of the information available regarding the progress of the counterinsurgency campaign. Such perception has been assumed to be conditioned by the *effectiveness of information operations (Φ)* to convey the proper message to the population. Therefore,

$$Perceived\ State\ Capacity = Neutralization\ Rate * \Phi\ Effectiveness \quad (3.7)$$

where IO effectiveness is assumed to be a parameter constrained to $0 \leq \Phi \geq 1$.

As insurgents are embedded in societies, the measure of their signature is I/P, which represents the probability that a person randomly selected from society is an insurgent. We define this as

$$Insurgent\ Signature = I/P \quad (3.8)$$

From this insurgent signature, the State's forces' situational awareness, represents the fraction of this insurgent signature that can be perceived by the State, based upon available intelligence data. Intelligence level (ι) is a constrained parameter, where 1 indicates that the State's forces have complete intelligence on the insurgents for targeting. Therefore,

$$Situational\ Awareness = \iota + 1 - \iota * Insurgent\ Signature \quad (3.9)$$

In spite of being able to identify the enemy, effective targeting *(θ)* is conditioned to the operational effectiveness of COIN Forces. It is assumed that COIN Forces *(F)* have a constant operational effectiveness *(ε),* interpreted as the

[92] Washburn and Kress, *Combat Modeling,* 230.

fraction of the COIN missions that are successful over every possible interaction with the insurgents. Hence, effective targeting is defined as:

$$Effective\ Targeting, \theta\ =\ Situational\ Awareness * \varepsilon \tag{3.10}$$

Given a constant number of COIN Forces intervening in operations, the resultant neutralization rate *(ν)* caused by the State's forces is defined as

$$Neutralization\ Rate, \nu\ =\ \theta * F \tag{3.11}$$

Insurgencies are generally revealed when they unfold their campaign of violence. So often, little is known about these shanty adversaries and their pretentions before the violence erupts. Most insurgencies open their armed campaigns with a small number of insurgents conducting low profile attacks. This is because the number of active insurgents is just a few at the beginning. The scarcity of human resources prevents the insurgents from conducting more attacks. Hence, the number of insurgent attacks *(ψ)* will be a function of the *insurgent size I.* As a consequence, it is assumed that there is a constant *insurgent's operational factor (α)* that represents the number of possible attacks per insurgent *(Attacks/Insurgent).* In other words, only a fraction of insurgents are able to execute attacks at any given time. Therefore,

$$Insurgent\ Attacks\ =\ I * \alpha \tag{3.12}$$

As the number of insurgent attacks increases, the pressure on the government to control the attacks *(ω)* also increases. The pressure on the government can be interpreted as the probability that the State incurs some kind of repressive measures. Although it must be some function of the number of insurgent attacks, it is assumed that it cannot be a linear relation and has its finite limits. Hence,

$$State\ Pressure\ to\ Reduce\ Attacks\ =\ f\ \psi \tag{3.13}$$

For the sake of simplicity, we take into account the nonlinearity of the relationship between insurgent attacks and the State's pressure to reduce

incidents. It has been assumed arbitrarily that the function that commands the increasing or reduction of the pressure on the government is an activation function with a shape of a Gompertz Curve given by the formula,

$$\omega\,(\psi) \;=\; ae— be \;-\; c\psi \tag{3.14}$$

where a is the asymptote and *b* and *c* are constant positive numbers. That function is translated to the model through a graphical lookup table, which is shown in Figure 18.

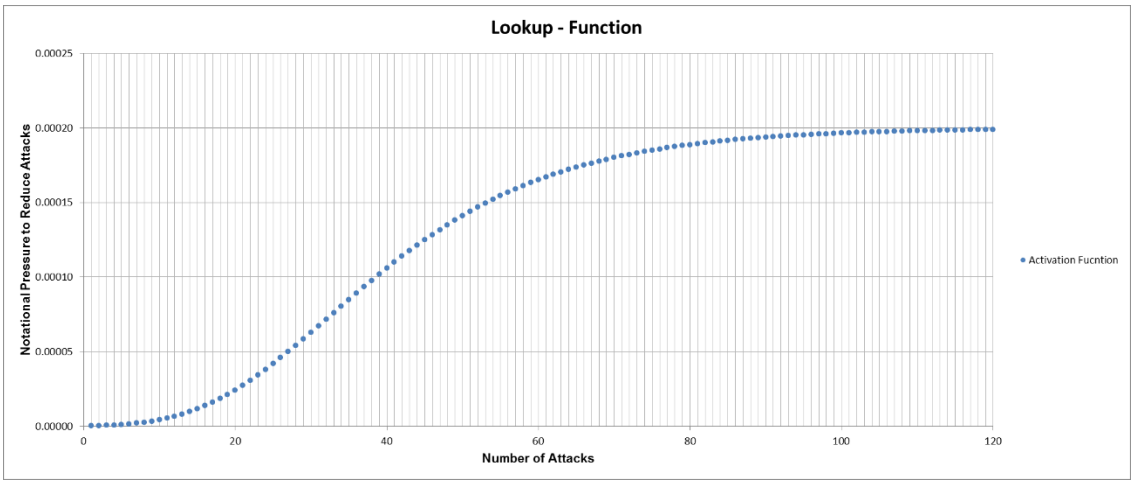


Figure 18. Lookup Function Curve

Given the pressure to reduce the number of incidents, the State's repressive measures can be interpreted as the COIN Forces' ability to inflict collateral damage on the population. It is assumed to be equivalent to the operational effectiveness *(ε)* when COIN Forces interact with insurgents. These can produce undesirable consequences over the population so the model is

$$State\ Repressive\ Measures \;=\; COIN\ Forces * \omega \tag{3.15}$$

Increasing the State's repressive measures has a direct relationship with the amount of collateral damage produced on civilians. It is also influenced by the intelligence level *(ι)* and the fraction of civilians *(1—IP).* Hence,

$$Collateral\ Damage = State\ Repressive\ Measures * 1 - \iota * 1 - \text{IP} \quad (3.16)$$

Given the aforementioned formulas, the Hypothetical Counterinsurgency SDM is now complete and ready to run a simulation.

D. HYPOTHETICAL COUNTERINSURGENCY SDM SIMULATION

To run a simulation in the hypothetical counterinsurgency system built as an example, initial values of the stocks and values of constants and parameters included in the system have been assumed. Tables 3 and 4 contain these values.

Table 3. Initial Values

Definition	Symbol	Value
Insurgent Size	I	512
Population	P	9,500,000
Dissidents (9% of Population)	D	855,000
Regime Supporters (91% of population)	RS	8,645,000
COIN Forces	$COIN\ Forces$	25,600

Table 4. Parameters and Constants

Definition	Symbol	Value
Intelligence Level	ι	$0 \leq \iota \geq 1$
Insurgent's Operational Factor	α	0.0082
IO Effectiveness	Φ	$0 \leq \Phi \geq 1$
Victimization Coefficient	υ	2
Transition Coefficient	$D \rightarrow RS = \tau_D$ $RS \rightarrow D = \tau_{RS}$	0.001
Insurgent Recruitment Coefficient	Γ	0.00005
COIN Operational Effectiveness Coefficient	ϵ	0.00025

Figures 19 through 24 show the results of the simulation, assuming the time in days. Figure 19 depicts the change of insurgents based on five levels of intelligence (0.5, 0.6, 0.7, 0.8, and 0.9) and a constant value of the IO

effectiveness parameter of 0.5. The results suggest that when IO effectiveness is kept low, the insurgency will grow unless the State can achieve high levels of intelligence (0.8 or 0.9). Likewise, with a level of intelligence of 0.9, the insurgency can be defeated in approximately nine years and six months and can reach a size of around 12,000 members.

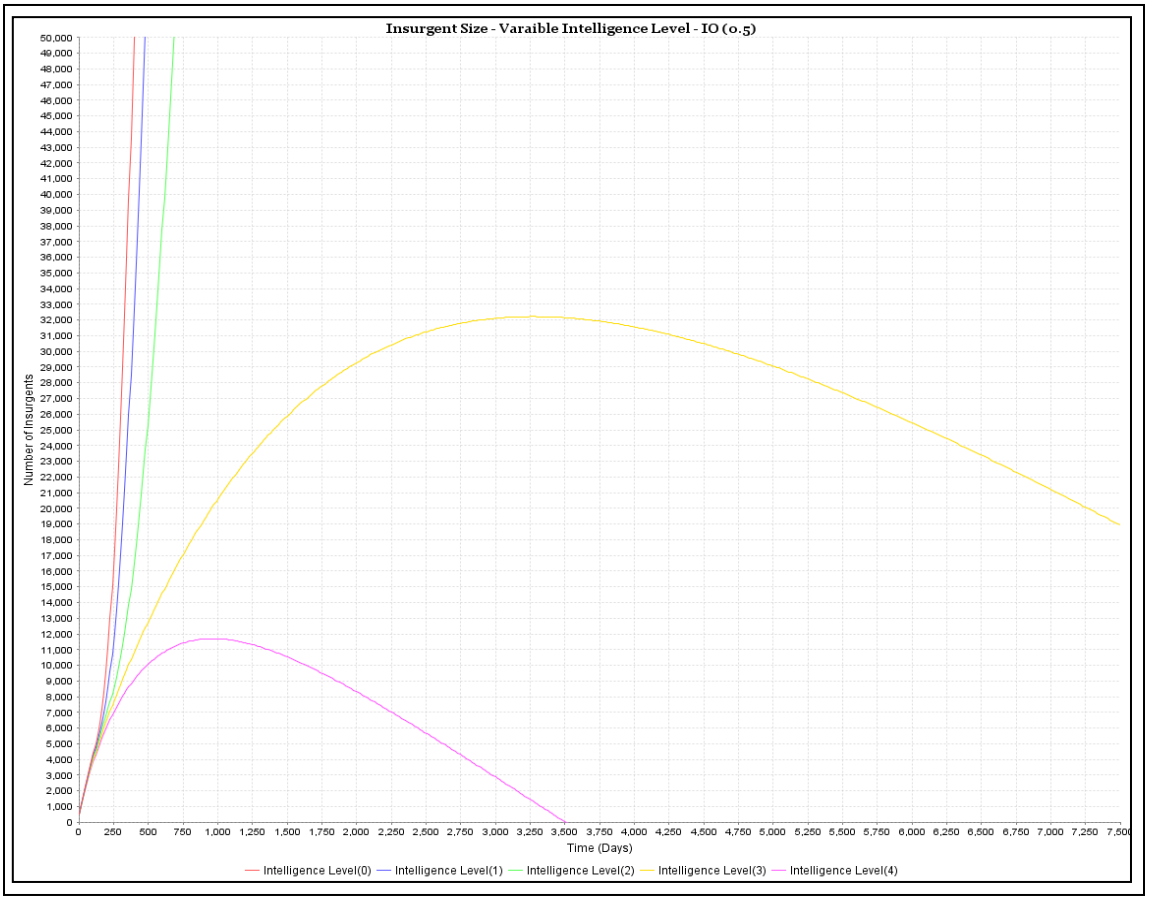


Figure 19. Simulation with Variable Intelligence Levels and 0.5 Level of IO Effectiveness

Figure 20 shows the result of a simulation with the same level of intelligence (0.5), but with the level of IO effectiveness increased to 0.7. The results suggest that when the IO effectiveness level has been increased by 0.2, a relatively effective COIN campaign will require high levels of intelligence. In this case, with a level of intelligence of 0.8, the insurgency can be defeated in

approximately in eleven years and can recruit a maximum of about 12,000 members. With a level of intelligence of 0.9, the insurgency can be defeated in approximately in six years and will reach a size of almost 8,000 members.

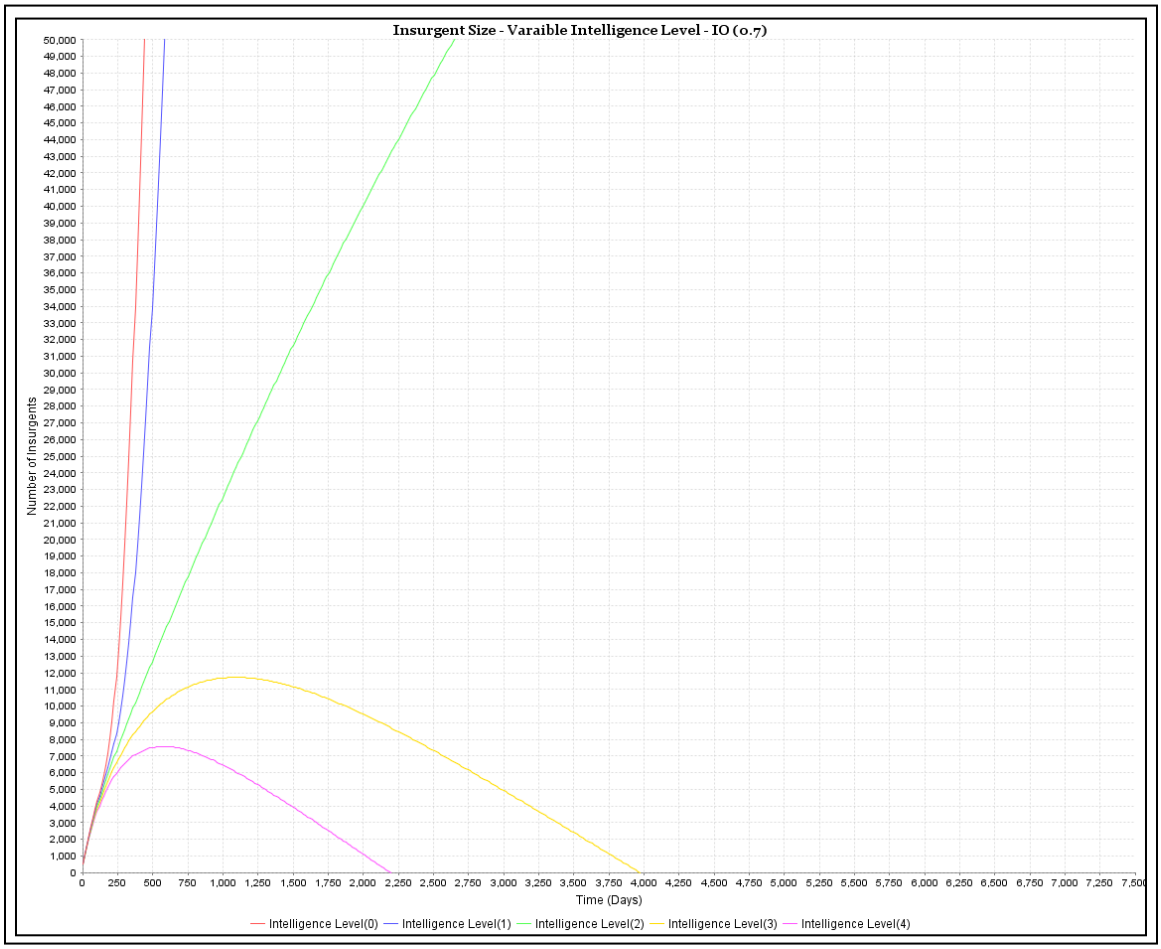


Figure 20. Simulation with Variable Intelligence Levels and 0.7 Level of IO Effectiveness

Figure 21 shows the results of the simulation with the same five levels of intelligence, but with the IO parameter increased to 0.9. It is assumed that this is the maximum level of IO efficiency that can be achieved, taking in account the several constraints and difficulties as found in real world. The results suggest the same pattern demonstrated in the two previous simulations. An effective COIN requires high levels of intelligence, even though the IO level has reach its

maximum. In the best scenario, with an intelligence level of 0.9, the insurgency can be defeated in about four years, and will not surpass 6,000 members.

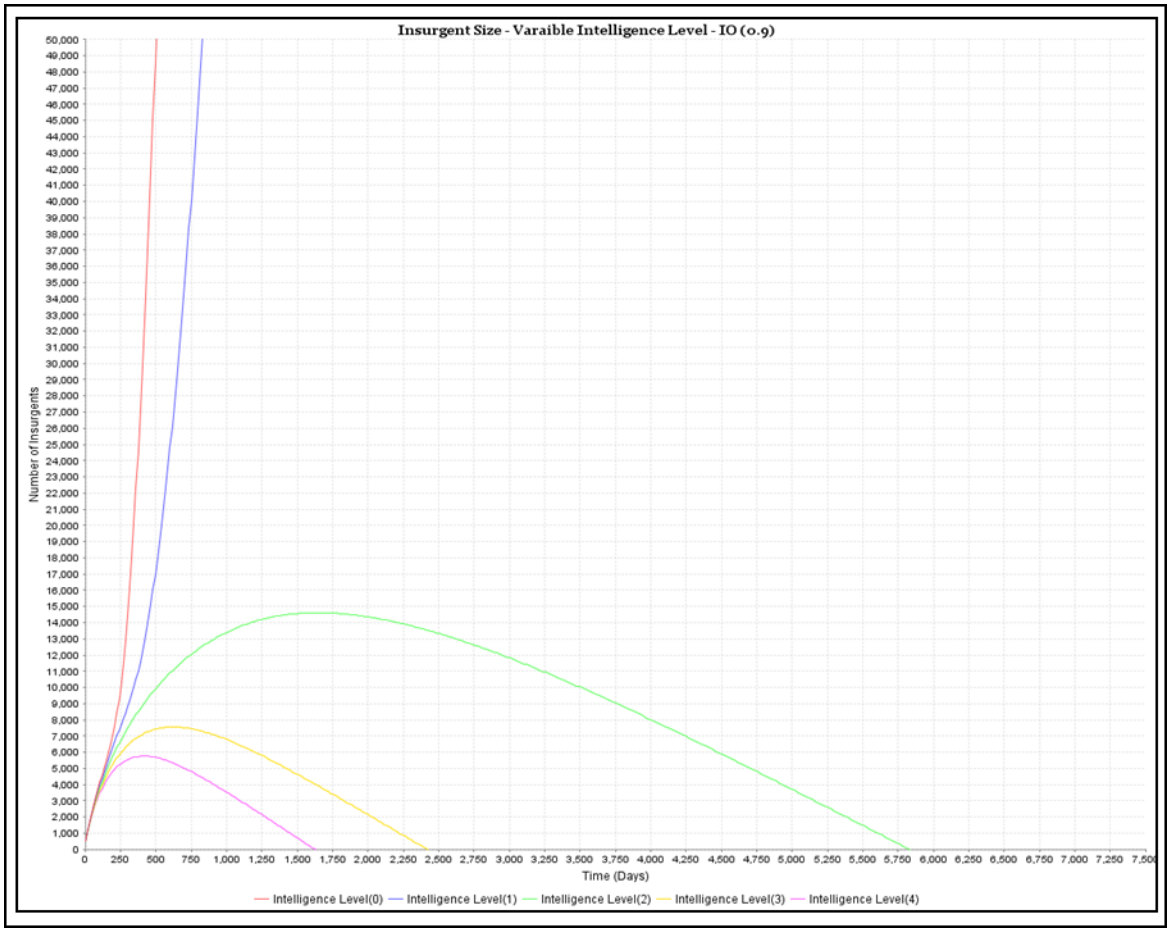


Figure 21. Simulation with Variable Levels of Intelligence and 0.9 Level of IO Effectiveness

Figure 22 shows the results of the simulation based on five levels of IO effectiveness (0.5, 0.6, 0.7, 0.8, and 0.9) and a constant value of the Intelligence Level parameter of 0.5. The results suggest that with low levels of intelligence, the State would be unable to control the insurgency, regardless of the IO efforts.

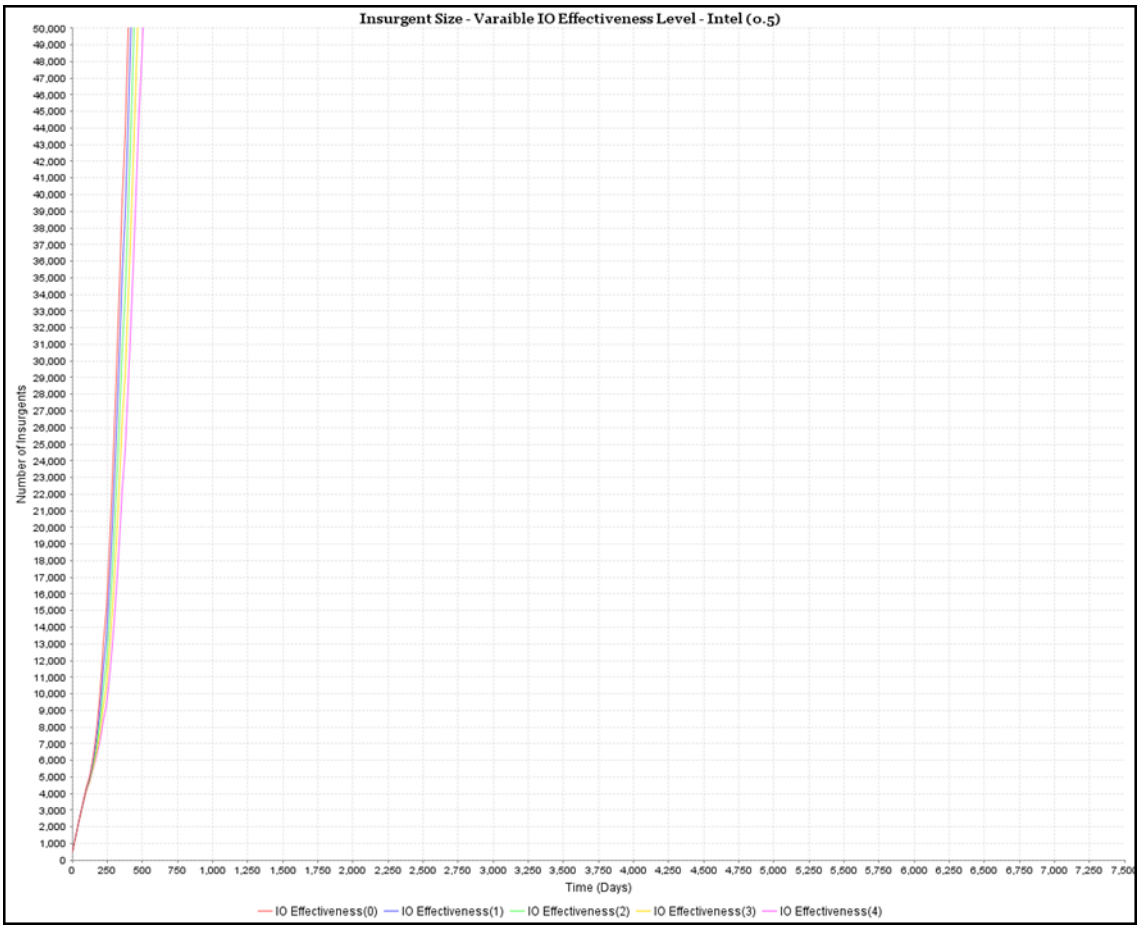


Figure 22. Simulation with Variable Levels of IO Effectiveness and 0.5 Intelligence Level

Figure 23 shows the result of the simulation on the same five levels of IO effectiveness, but with the level of intelligence increased to 0.7. Although this is a good level of intelligence, the State will still require high levels of IO effectiveness. With an IO level of 0.9, the State will require around sixteen years to defeat the insurgency, which will reach a maximum size of roughly 15,000 members. Likewise, if the IO is kept slightly down at 0.8, the insurgency can reach a size of 25,000 members, and defeating it will take the State more than twenty years.

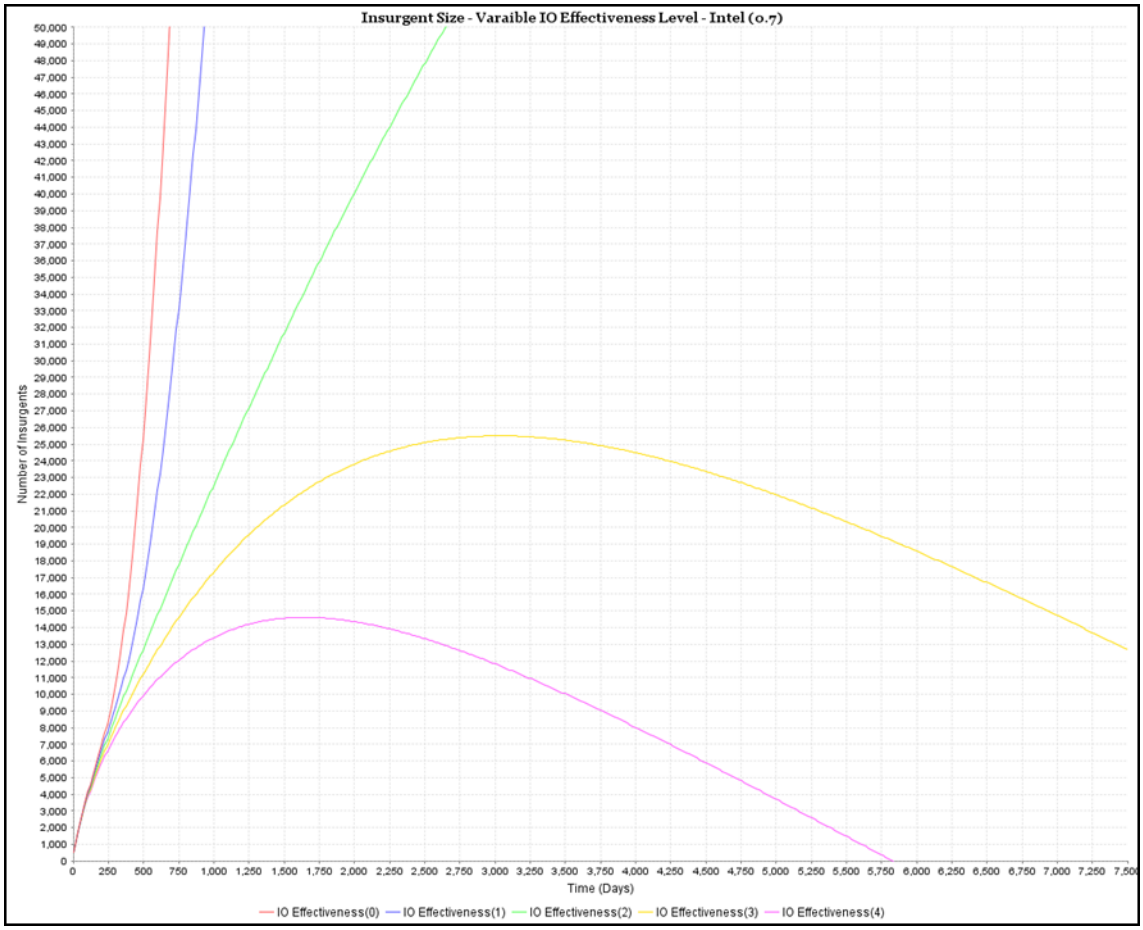


Figure 23. Simulation with Variable Levels of IO Effectiveness and 0.7 Intelligence Level

Finally, Figure 24 shows the results of the simulation when run with the level of intelligence at 0.9. The results suggest that with an optimum level of intelligence, the State can defeat the insurgency more efficiently. This, coupled with different levels of IO, can reduce and ultimately defeat the insurgency. With an IO level of 0.5, the insurgency can reach a size of approximately 12,000 members and it will take to the State almost ten years to neutralize it. With an IO level of 0.6, the number of insurgents will reach a maximum of 9,000, and they will be defeated in around seven years. With an IO level of 0.7, the number of insurgents will reach a maximum of 7,800, and they will be defeated in almost six years. With a level of IO equal to 0.8, the insurgency size will reach its zenith around 6,800 members, and it will survive for almost four and a half years.

Finally, with a 0.9 level of IO and 0.9 level of intelligence, the insurgency will reach a maximum 5,900 and can be defeated in around four years.

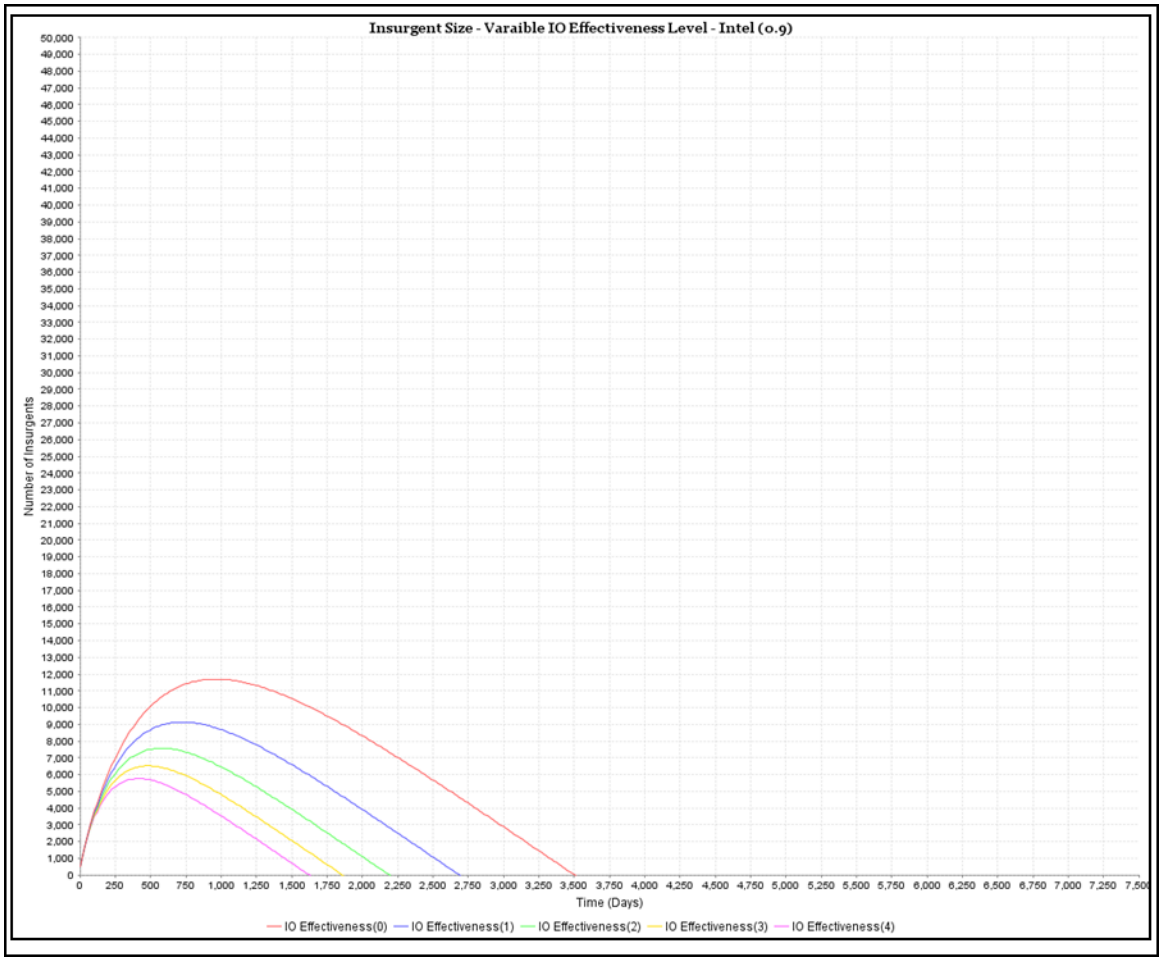


Figure 24. Simulation with Variable Levels of IO Effectiveness and 0.9 Intelligence Level

In summary, the results of the Hypothetical Counterinsurgency SDM used as an example in this thesis suggest that an optimum combination of high levels of intelligence and IO are necessary to control the insurgency in the most efficient way. Both variables have a direct impact on both the size of insurgency and the duration of the conflict. This conclusion is not a surprise and fits perfectly with common sense. However, the basic model of this chapter was not intended to provide a complete and faultless analysis; its purpose was merely to provide a

simple example of how SD tools can be used prospectively to gain some strategic insights regarding complex problems and systems.

One of the main advantages of using these tools lies in fostering the process of thinking with regard to the problem under investigation, rather than arriving at perfect solutions. The process of building models can, by itself, provide strategists with a holistic and systemic view of the dynamics of complex problems. Using basic models, like the one described in this chapter, teams of experts can collaborate to make improvements without losing track of the problem that must to be solved.

E. PATTERN OF BEHAVIOR ANALYSIS AND LOOP DOMINANCE

With the results of the simulation of a SDM, researchers could investigate the behavior of stocks or other important variables in the system. Most of these variables are cumulative, changing only through their inflows and outflows. For instance, from the previous simulation, when the Intelligence Level is at 0.7 and the IO Effectiveness is at 0.9 (as was shown in Figures 21 and 23), the pattern of change of insurgent size is shown independently in Figure 25 along with the cumulative “S” Shape curve.

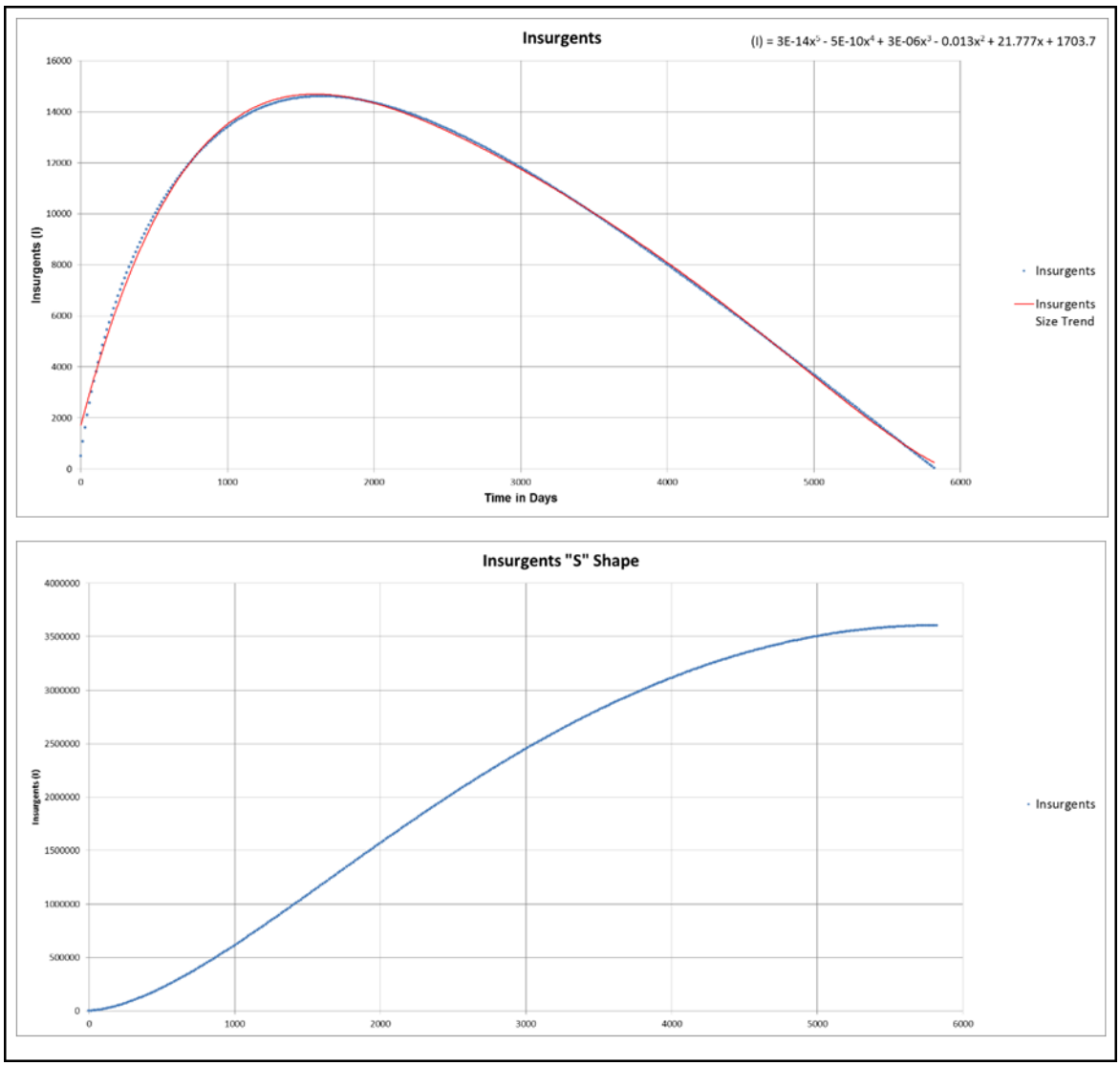


Figure 25. Insurgents' Pattern of Change and Cumulative "S" Shape Curve of the Hypothetical Counterinsurgency System.

Then, Figure 26 depicts the rate of change (ROC) of the insurgent size over time and dominant loops.

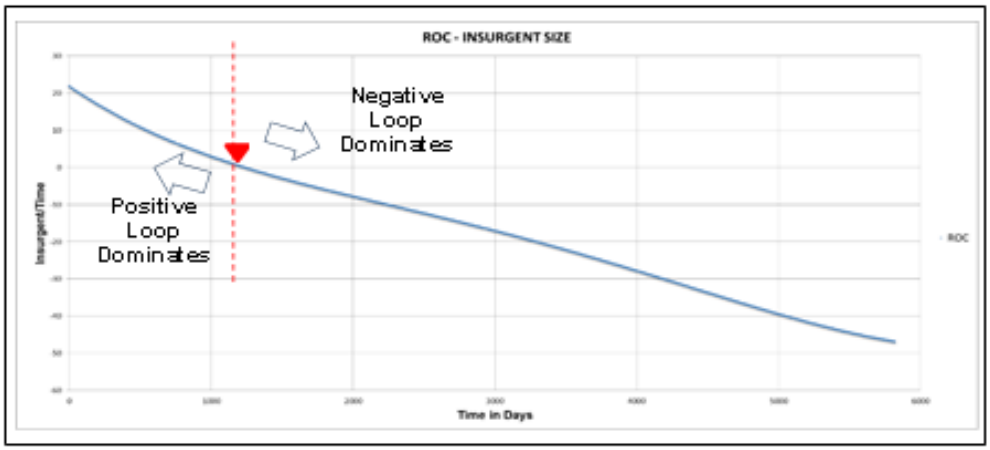


Figure 26. Rate of Change of the Size of the Insurgency in the Hypothetical Counterinsurgency System.

Observing Figure 26, it is possible to infer the initial dominance of the "provocation loop." From day 1 up to about day 1,200, it becomes clear that this loop dominates. In other words, the insurgents were able to recruit more new members through that mechanism than the State's forces could neutralize. From day 1,200 up to the end of the insurgency, clearly the "attrition loop" and "state capacity loop" dominate. Hence, based on the results of the simulation, it could be inferred that the low signature of insurgents makes them difficult to track and neutralize, and, in consequence, the State faces difficulties in containing the insurgency. However, once the size of insurgency grows beyond fourteen thousand members, its signature increases, which, coupled with good intelligence, allows the State to neutralize a significant number of insurgents.

At the same time, the State, with good intelligence, avoids engaging in indiscriminate repression, thus producing less collateral damage, which translates into a smaller portion of the population becoming dissatisfied with the State. Thus, the number of dissidents who feed the insurgency decreases. Equally, as the State is able to track and neutralize more insurgents, the population perceives an increasing state capacity and willingness to control the phenomenon, which also reinforces the population's satisfaction with the regime and consequently reduces the number of people becoming dissidents.

IV. PERUVIAN INSURGENCY SYSTEM: AN EXAMPLE OF RETROSPECTIVE RESEARCH USING SYSTEM DYNAMICS

The previous chapter contains an example of how SD tools can be used to conduct a prospective analysis, and this chapter contains an example of how those tools can be used to conduct a retrospective analysis. So far, this thesis has proven the value of a simulation using System Dynamics tools for modeling complex problems, which can be used to compare the results with actual data sets. Some may argue that the absence of data that can be compared with results from simulations, or even the lack of data regarding initial values and auxiliary variables can hinder the utility of SDMs. However, by resorting to the inverse of the problem process, it is possible to draw some inferences about the structure of the system by analyzing the pattern of behavior of the system's parameters. This does not represent a complete SDM in the strict sense of the word, but inferring the structure of a complex system from a limited and observable data set can be very useful.

In this regard, the inverse problem process using SD tools might begin with an analysis of the pattern of behavior of parameters. Then, all the variables assumed to affect those parameters are brought together in a Physical Structure, or SFS. Finally, this structure of the system can be used to draw some inferences regarding the feedback structure that governs the systems and leads the parameter to behave in the way that has been observed.

A. SENDERO'S OPERATIONAL PERFORMANCE—PATTERN ANALYSIS AND LOOP DOMINANCE

As Donella Meadows asserts, "system behavior revels itself as a series of events over time."[93] In this regard, such a sequence of events can sometimes expose latent or "hidden" parameters of interest, which are assumed be capable of describing the state of the system under investigation. However, in these

[93] Donella H. Meadows, *Thinking in Systems: A Primer*, ed. Diana Wright (White River Junction, VT: Chelsea Green Publishing, 2008): 89.

particular cases, the events must be premeditated and systematically mounted actions with a specific purpose. This could be the case of violence in an insurgency context.

In insurgencies, the use of violence as a catalyst for the revolutionary process is the variable that prevails and the common characteristic of any of insurgent group. Terrorism is the insurgency's method of choice for waging the insurgent war, its unmistakable signature. As has previously been discussed in this thesis, an insurgency's violence is not aimed at degrading the State's forces; instead, it has a subtler purpose.

In the case of Sendero Luminoso, the willingness of Abimael Guzman and other leaders to continue resorting to violence as their main way to achieve their political goals remained constant throughout the internal struggle until Guzman's arrest in late 1992. This argument finds support in the fact that, after almost ten years of violent campaigns, Guzman still believed that Sendero's victory would require more of a "people's war to succeed."[94] Nonetheless, Sendero's initial acts were low- profile nationwide, but rapidly increased in number and lethality. In the first year of struggle, there were fewer than 200 insurgent incidents; by 1984, the State's agencies registered more than 2,000. Figure 27 depicts the evolution of Sendero's attacks between 1980 and 2000 at the regional committee level. For more than a decade after 1980, Sendero gradually increased its armed actions both in intensity and in geographical extent, affecting almost all of Peru, but primarily those marginalized areas of the state's influence.

[94] Entrevista con el Presidente Gonzalo [Interview with President Gonzalo] Peruvian Communist Party— Central Committee, accessed July 2014, 1989. http://www.pagina-libre.org/MPP-A/Textos/PCP1989/Entrevista.html.

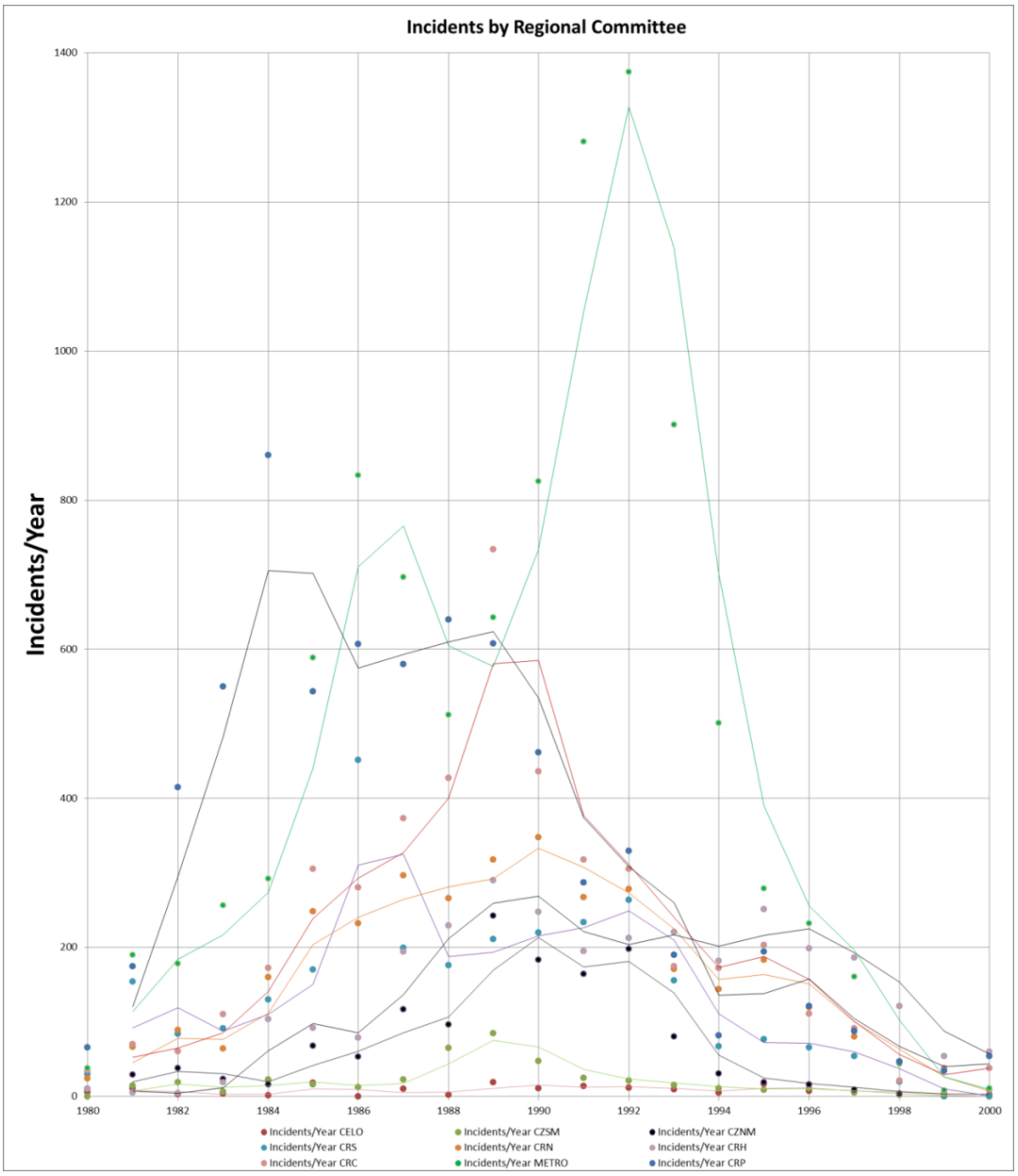


Figure 27. Sendero's Incidents by Regional Committee.[95]

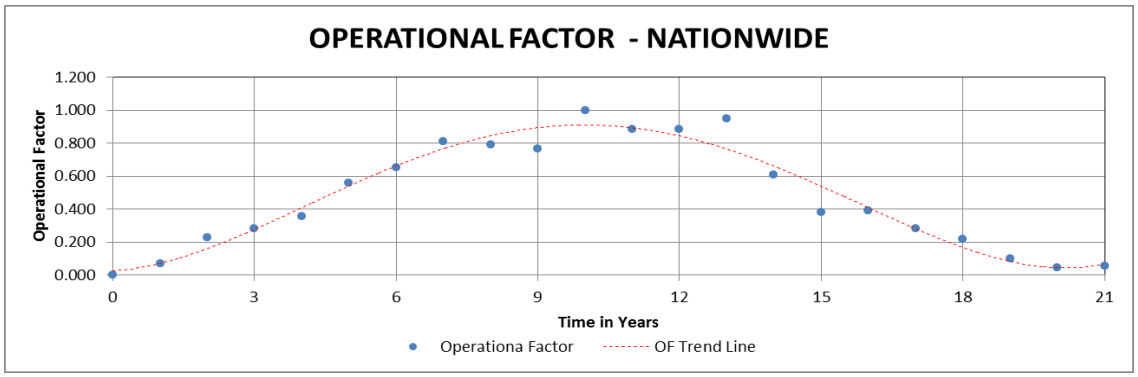
By analyzing the number of insurgent attacks per year, it is possible to identify another key variable, the Operational Factor (OF). The OF results from the number of events each year divided by the maximum number of events in a single year within the time horizon, assuming that the maximum number of

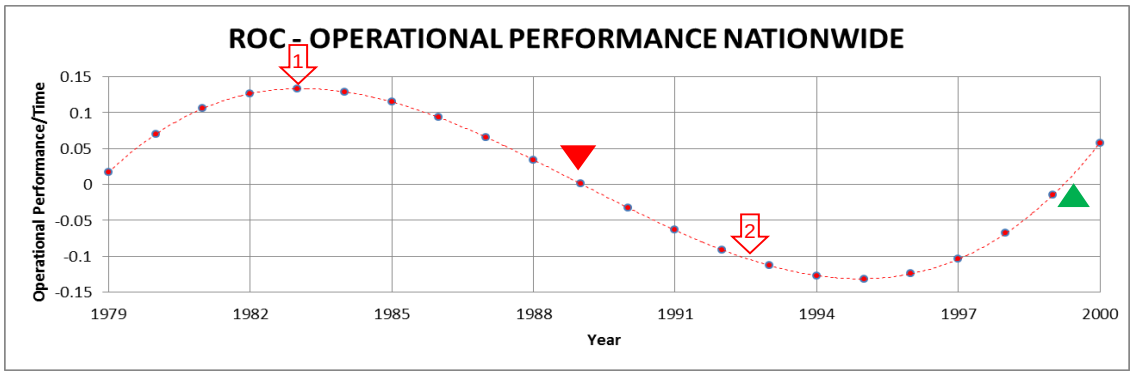
[95] Source: Peruvian National Police (PNP) / Peruvian Statistic and Information National Institute (INEI).

attacks indicates the insurgents' maximum operational capacity. This operational factor is assumed to indicate the presence of a latent variable named the Operational Performance (OP), which with this reasonable assumption can be indirectly observed.

Operational Performance can only be constrained by two things: organizational contingencies, and contingencies in the insurgents' operational environment. In this regard, it is assumed that Sendero suffered two major contingencies during its terror campaign: the beginning of the armed forces' counterinsurgency campaign in January 1983 and the capture of Abimael Guzman in September 1992. These represent contingencies of the operational environment and the organization, respectively. Figure 28 contains the table of attacks per year, the calculated Operational Factor, and the ROC of the assumed nationwide Operational Performance of Sendero Luminoso.

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
ATTACKS	219	715	891	1124	1760	2050	2549	2489	2415	3149	2779	2785	2995	1918	1195	1232	883	681	310	144	175





Loop Shift (Positive Dominates)

Loop Shift (Negative Dominates)

1 1/1983 – Armed Forces engage in COIN

2 9/1992Capture of Guzman

Figure 28. Sendero's Operational Performance: Nationwide

In addition, Figure 28 depicts the rate of change of Sendero's Operational Performance trend nationwide, considering as contingencies for Sendero the engagement of the Armed Forces in COIN and the capture of Guzman. Of these two contingencies, the graph suggests that the intervention of the Armed Forces affected the operational capacity of the insurgents. As shown in the table on the top of Figure 28, Sendero conducted 219 attacks in 1980 and 2,050 attacks in 1985. This means a difference of 1,831 attacks in five years. Over the next five-year period (1985-1989) the difference is 1,099. This demonstrates that at the time when Guzman was captured, Sendero was already having some kind of contingency that affected its Operational Performance.

Nonetheless, it can be seen that circa 1997, Sendero made an attempt to increase its number of armed actions although not at the same magnitude that it had in previous years. This trend was, perhaps, due to the fact that after Guzman's capture in 1992, Oscar Ramirez (third in command) assumed the task of reorganizing Sendero nationwide. It is known that Ramirez flew from Lima and established himself in the Regional Committee Center (CRC), and had contact with remnants of the Committee Principal (CRP) and of the Metropolitan Committee (METRO).

In spite of the efforts of Ramirez, each Committee already had its own constraints. For instance, as depicted in Figure 29, in the Regional Committee Principal (CRP), the insurgents' Operational Performance shows a different pattern than that of the other committees. Sendero's capacity to conduct attacks in that region seems to progress slowly up to 1986, when some kind of balancing loops begin to dominate. By the time of Guzman's capture, the CRP's capacity to perform attacks in Ayacucho has been limited. However, after Guzman's capture, the trend begins to move upward, indicating a slightly recovery of operational capacity, perhaps due to Ramirez's attempt to reorganize the insurgency.

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
ATTACKS	66	174	415	550	861	543	607	580	640	608	461	287	329	190	82	194	121	88	47	34	54

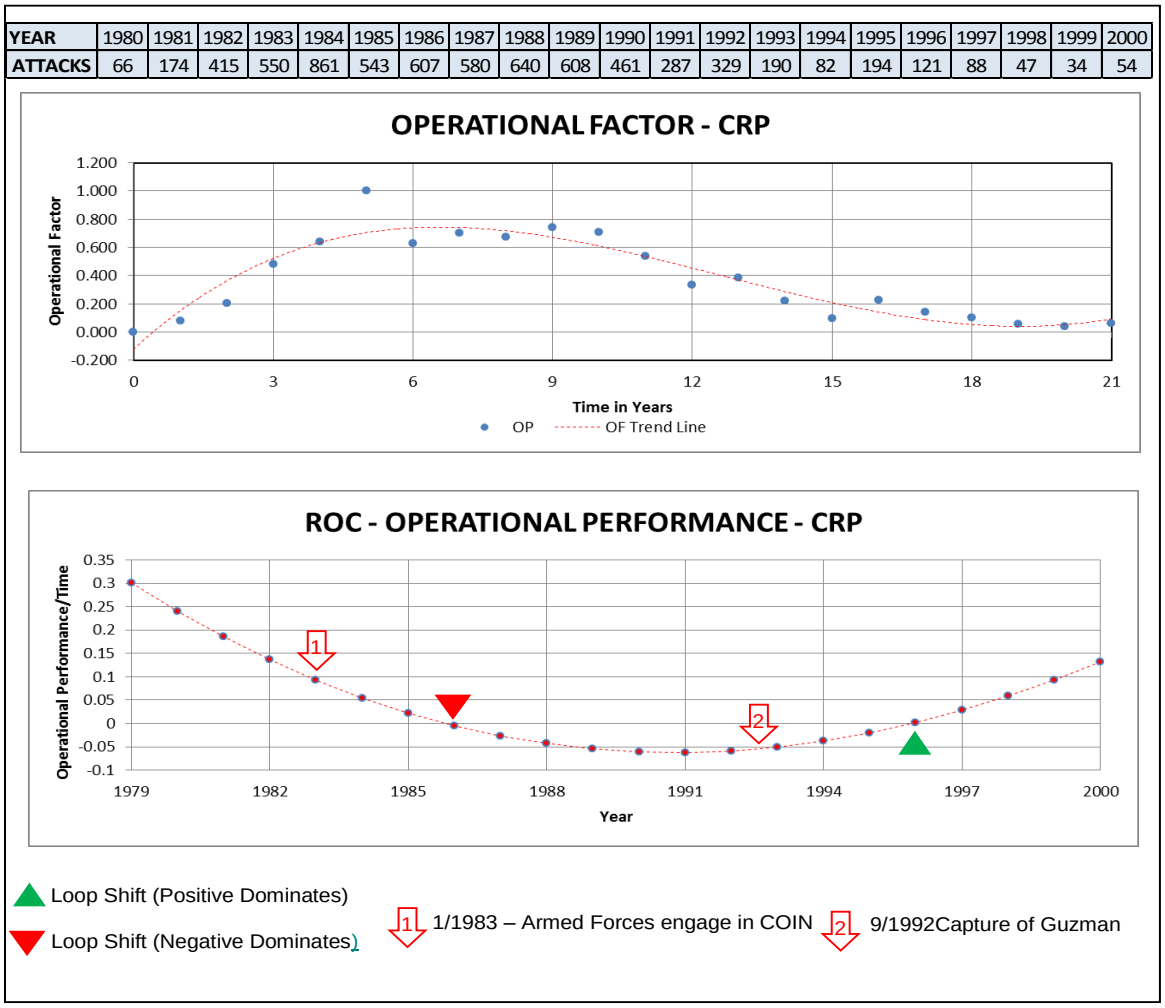
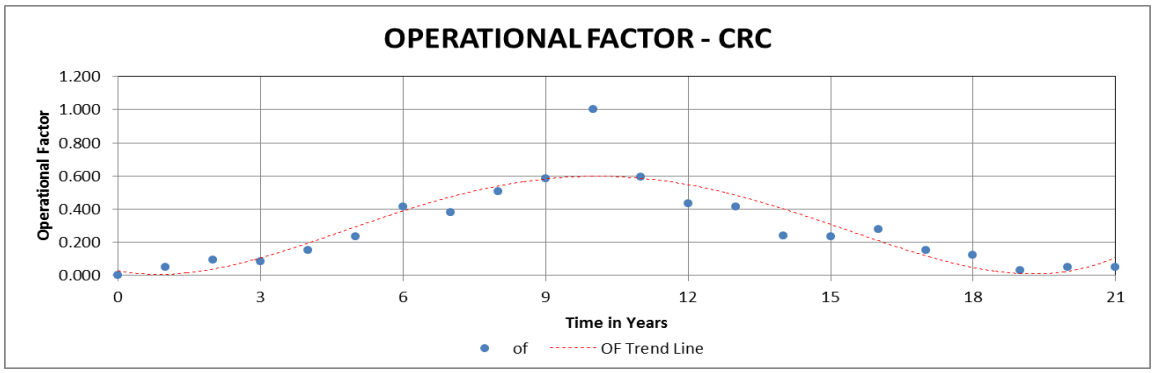


Figure 29. Sendero's Operational Performance: Regional Committee "Principal."

The patterns of Operational Performance behavior for the Regional Committee "Center" (CRC) and the Metropolitan Committee (METRO) have many similarities with each other, in spite of the fact that the Armed Forces were not initially deployed in Lima as they were in the countryside. Both committees were able to sustain their wave of violence for almost ten years until the late 1990s, when some kind of negative loops begins to dominate the scenario. Figures 30 and 31 depict the Operational Performance of CRC and METRO.

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
ATTACKS	35	70	61	110	172	305	280	373	427	734	436	317	305	175	172	203	111	91	21	38	38



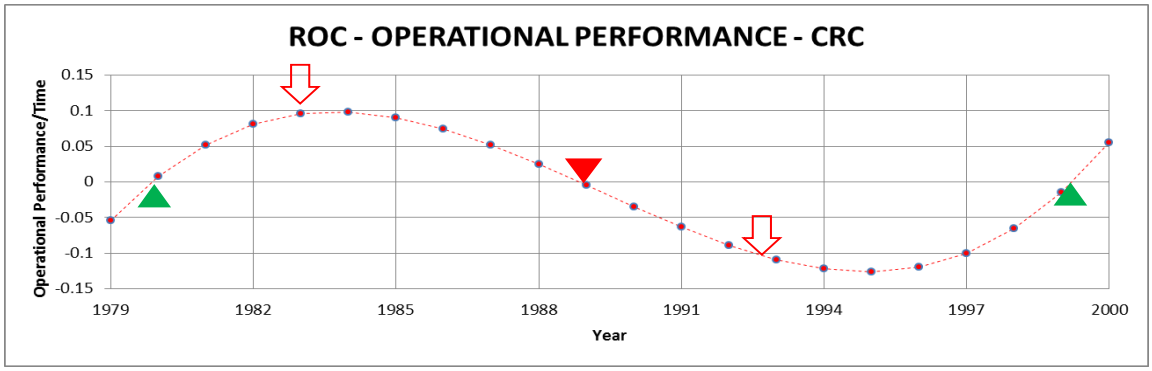


Figure 30. Sendero's Operational Performance: Regional Committee "Center."

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
ATTACKS	38	190	178	256	292	588	834	697	512	642	825	1281	1375	901	501	279	232	161	44	8	11

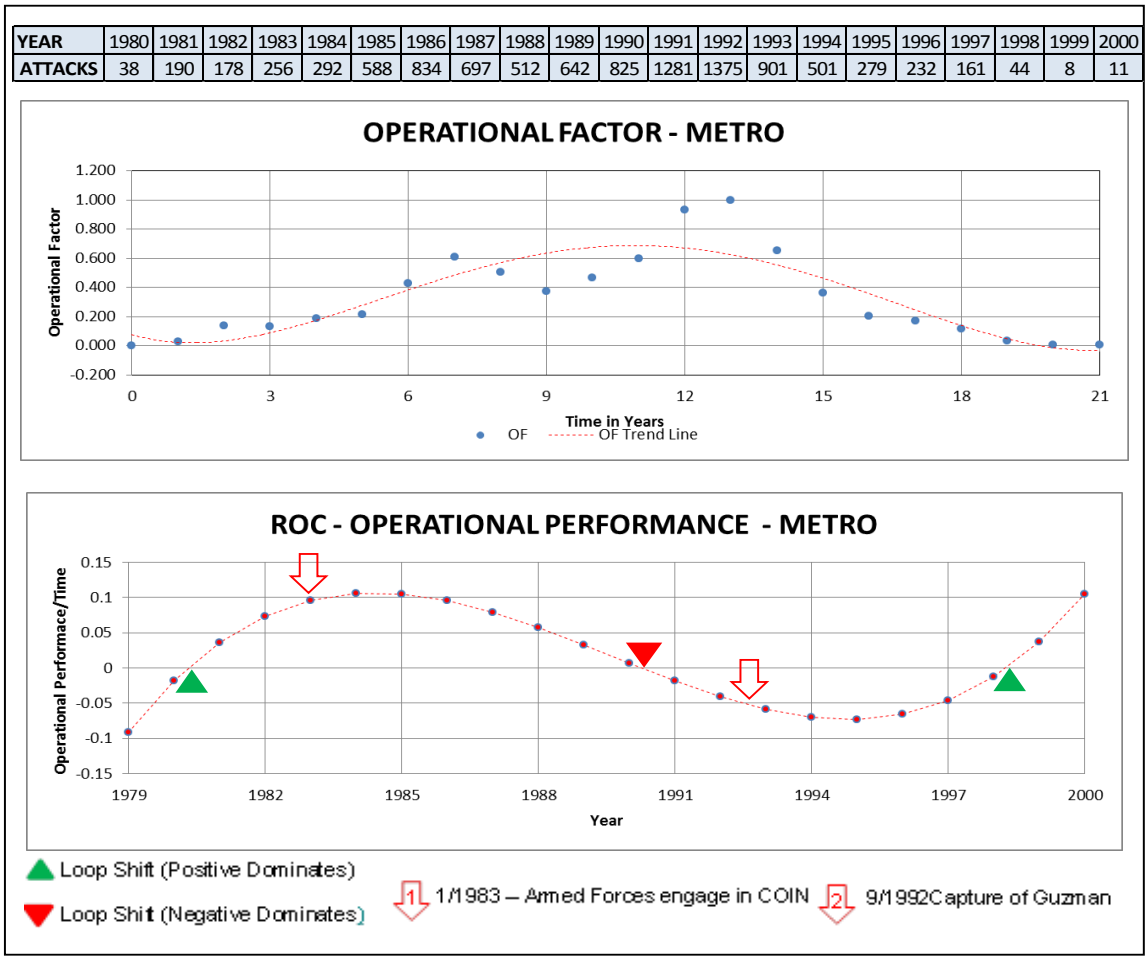


Figure 31. Sendero's Operational Performance: Metropolitan Committee.

More specific inferences can be drawn by analyzing these patterns. For example, in Figure 32, which contrasts the Operational Performance of the CRP, CRC and METRO, it becomes evident that the intervention of the Armed Forces into the conflict did not have a uniform impact on all committees. The METRO was the last of these three committees to lose its operational capacity. As was previously mentioned, Sendero's military end was to take Lima, provoking an insurrection; therefore, it was expected that the last actions would be concentrated in the capital. It also allows inferring that Guzman transferred resources from the countryside to the capital at the end of the 1980s. Of course,

there must be other factors that influenced the Operational Performance of the committees.

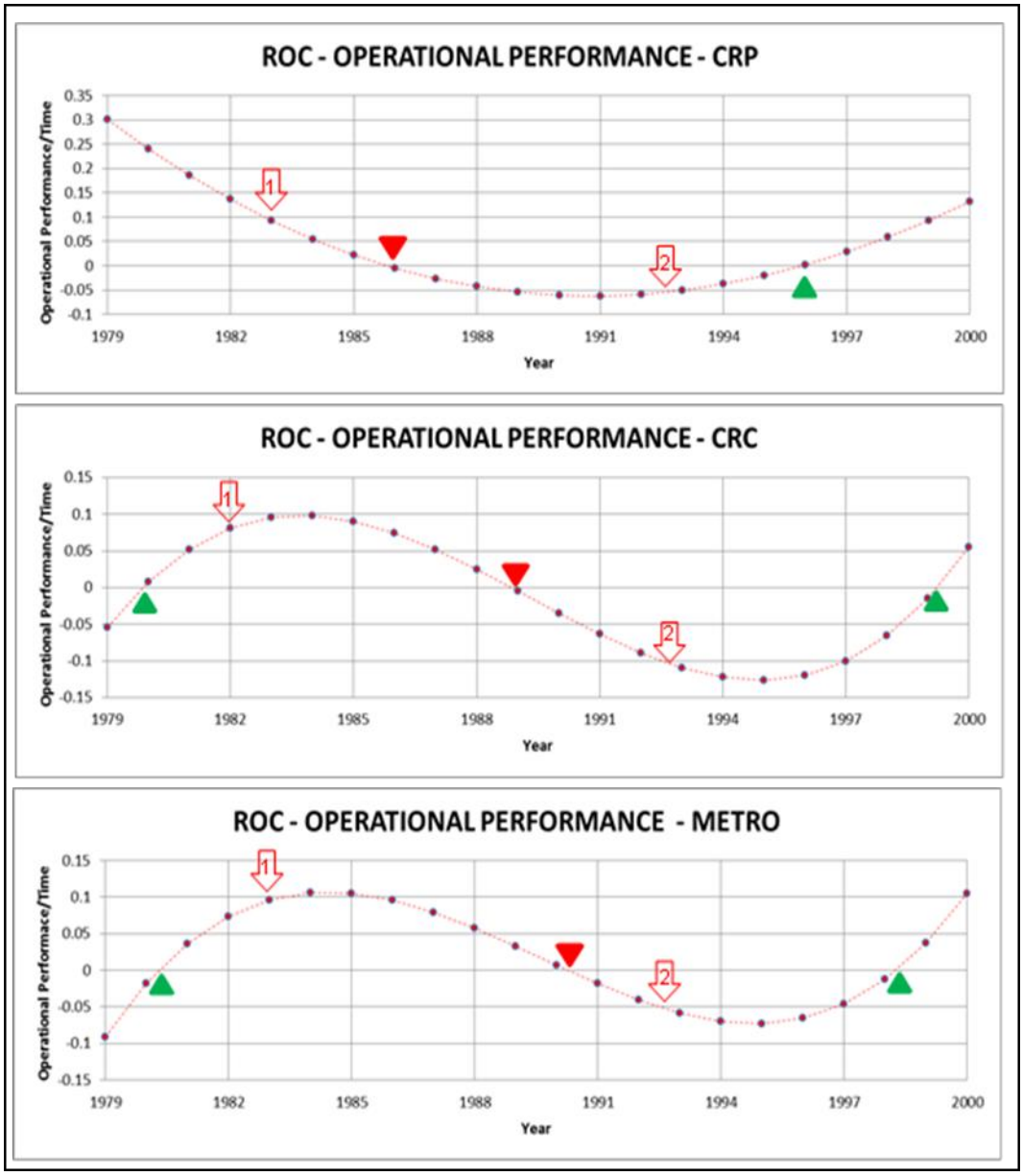


Figure 32. Operational Performance: CRP, CRC, METRO.

Summing up, in spite of useful inferences that can arise from a simple pattern analysis, the results indicate that in very complex systems such as insurgencies, a single factor within a system cannot determine the behavior of

the system. It is the intrinsic dynamic interactions amongst several subsystems, components and variables that lead to system change. Hence, it becomes necessary to build a structure of the systems that is assumed to be able to capture all possible dynamics that lead to the change in the selected variable.

B. PERUVIAN INSURGENCY SYSTEM—STOCK AND FLOW STRUCTURE

Other factors that might have an impact on the Operational Performance of Sendero can be found under Clausewitz's concept of the frictions of war. As stated in the U.S. Marine Corps Doctrinal Publication 1 (MCDP-1) "Warfighting," "friction is the force that resists all action and saps energy; it makes the simple difficult and the difficult seemingly impossible."[96] In more pragmatic terms, frictions may be mental or physical, and may be caused either by external (or environmental) factors, such as enemy actions, weather or terrain, or by intrinsic (or organizational) "factors, such as no defined goal, lack of coordination, unclear or complicated plans, and complex task organizations or command relationships."[97]

Of all possible factors that might generate friction, this section models four of them as a system's components or subsystems. These four factors are (1) *Motivation and Commitment*, which represents an organizational—mental factor, (2) *Expertise*, an organizational—mental factor, (3) *Logistics*, an organizational—physical factor, and (4) *Opposing Civilian Forces*, an environmental—physical factor. These four factors are assumed to be responsible for the reduction of Operational Performance in Sendero.

1. Motivation and Commitment Subsystem.

It is assumed that members of Sendero act rationally. Therefore, potential members of the insurgency will select an alternative that renders better benefits:

96 Department of the Navy, *Warfighting* (MCDP-1) (Washington, DC: United States Marine Corps, 1997), http://www.clausewitz.com/readings/mcdp1.pdf.

97 Department of the Navy, *Warfighting*, 5.

in other words, they will choose the option that best satisfies their expectations. The individual's perception of the potential for satisfaction arises from some kind of utilitarian function that values short-term tangible benefits and long-term expectations based on the probable outcome of the conflict.[98] In this sense, a person's satisfaction with Sendero is influenced by three variables: the popular long-term expectation of Sendero's victory in the conflict, the popular expectation of gaining short-term tangible benefits, and the actual gain of tangible benefits in the short term.

The popular expectation of Sendero's victory is conditioned on the perceived strength of the insurgent organization, the perceived strength of the State, and the State's progress in counterinsurgency. In this regard, the insurgency uses violence to attempt to generate a perception among the population that the insurgency is growing stronger and the State is growing weaker. In the absence of specific information, the population estimate the relative size of the insurgency based on their perception of the operational capacity of the insurgency, which is, in turn, based on the number of violent incidents or attacks. With this in mind, the insurgency seeks to increase the number of people who are willing to support the insurgency in order to show that the revolutionary project is growing and has good prospects.[99]

Popular expectations of gaining short-term tangible benefits is conditioned on two things: people's perception of the insurgency's capacity to provide such short-term tangible benefits, and the organization's ability to convey an explicit message that is able to manipulate people's expectations of social welfare. In other words, if Sendero promises to provide tangible benefits, and people believe that the insurgents will do so, it is likely that the population's expectation of receiving tangible benefits from Sendero will increase.

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[98] See as reference, McCormick and Giordano, "Things Come Together," 309.

[99] McCormick and Giordano, "Things Come Together," 309.

However, popular expectations have an inverse relationship with popular satisfaction. The greater the expectations, the more difficult it becomes to satisfy those expectations. In this regard, Sendero did create a great expectation of improvements in social welfare by promising short-term benefits, but the insurgents were actually unable (or unwilling) to fulfill their promises.

For example, after the insurgents took over a farm in 1981, local commanders mandated that the land be exploited collectively (including the participation of women in the agricultural labor) for the common benefit of the local peasants. This action initially created favorable views of the insurgents among rural communities, and brought compliance based on Sendero's promises. However, shortly thereafter, local commanders ordered that the crops grown on the land become a "contribution" to the revolution, which left almost nothing for the local communities.[100] This caused great discontent among the peasants, and consequently reduced the satisfaction levels of those who were already supporters of the insurgency.

Figure 33 depicts the structure of variables that are related to the people's satisfaction with Sendero Luminoso.

[100] José Coronel, "Violencia Política y Respuestas Campesinas en Huanta" [Political Violence and Peasant Response in Huanta] in *Las Rondas Campesinas y la Derrota de Sendero Luminoso* [The peasant Rondas and the defeat of Sendero Luminoso] (Lima, Perú: IEP,1996), http://archivo.iep.pe/textos/DDT/laderrotadesendero.pdf, 46.

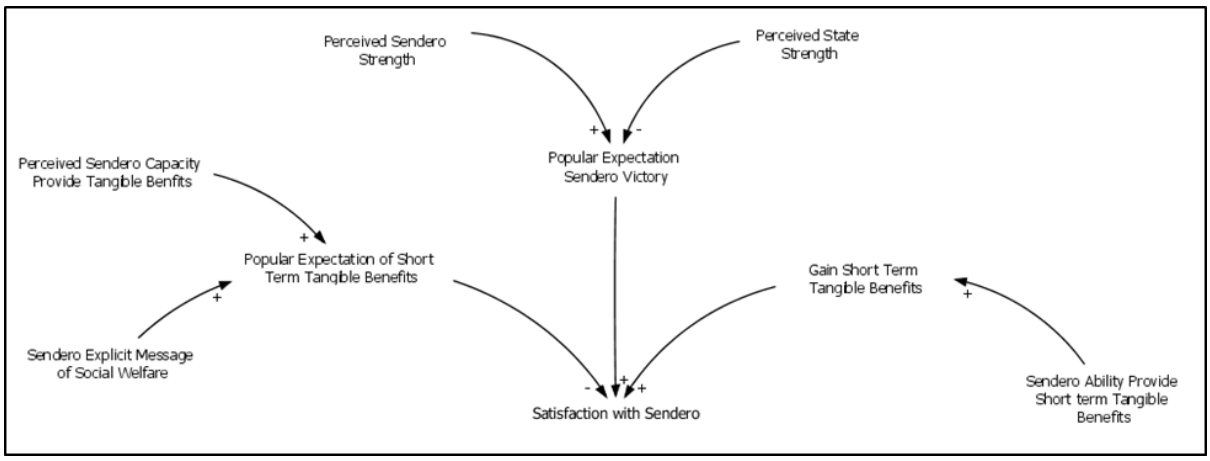

Figure 33. Satisfaction with Sendero—Suggested Variable Structure.

Not all new members who joined the organization arrived with the same motivation and commitment. In fact, some, if not most, were forced by the organization to enlist in its ranks. After 1983, the actions of the Armed Forces forced Sendero Luminoso to recruit young supporters to replenish their lost combatants and hold the support bases that had already been constituted. However, these new recruits had different levels of commitment, from youth who identified with the party and were ready to take up guns for the revolution, to people who were not willing to sacrifice themselves and traditional communities that were innocent of any form of political violence.[101] These newcomers caused a loss in the average level of motivation and commitment throughout the organization.

In consequence, decay in the levels of motivation and commitment of members of Sendero resulted in lower Operational Performance, and members of the organization became more susceptible to demobilization. This increased the rate of attrition (through demobilization), thereby reducing the number of insurgents. With fewer members in their ranks, the insurgents had fewer human resources at their disposal to recruit new members, which reduced the affiliation

[101] Del Pino, “Familia, Cultura y ‘Revolución,’” 165.

rate. Figure 34 depicts the coflow that is suggested to model motivation and commitment as an attribute.

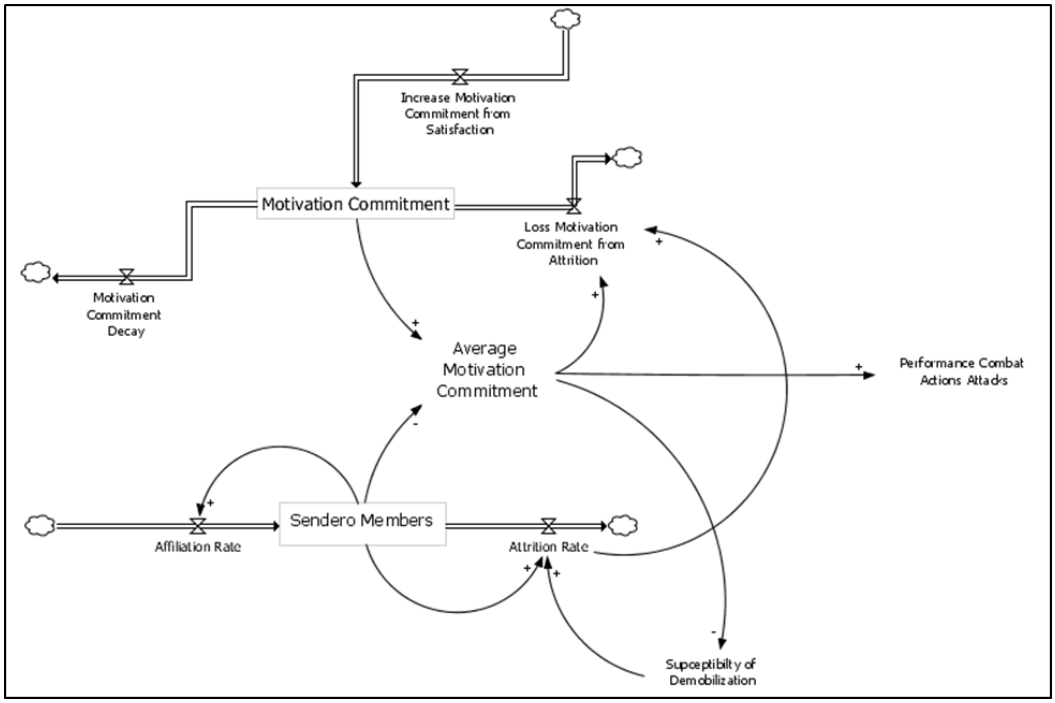

Figure 34. Suggested Coflow that Models Motivation and Commitment as an Attribute.

When Sendero's local commanders perceived a decay in the commitment and motivation of its members, they increased their acts of coercion and abuse in an attempt to control this loss. For instance, while facing daily difficulties, the people made some demands that revealed a level of resistance that had been accumulating for a long time. This led the insurgents to engage in terror and domination in order to strengthen their position.[102] Such abuses caused the population to more clearly perceive the benefits of cooperating with the government rather than moving into the ranks of Sendero, which caused a loss in their level of motivation and commitment.

[102] Del Pino, "Familia, Cultura y 'Revolución,'"197.

This created a coercion loop, an important loop within the motivation and commitment subsystem. When motivation levels among the insurgents decayed, the insurgent leaders' perception of such decay increased. As this perception increased, the leaders of Sendero increased their coercive acts to prevent the defection of members who were not yet well indoctrinated. In consequence, members of Sendero grew less motivated and committed. Figure 35 depicts the coercion loop.

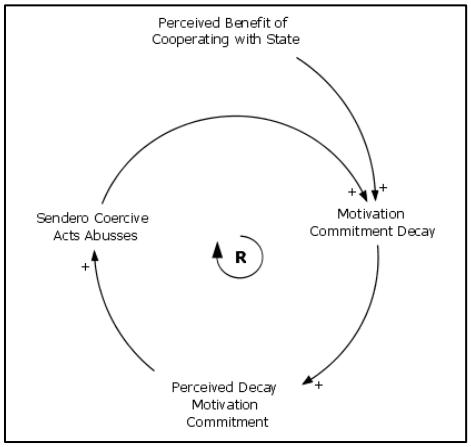

Figure 35. Coercion Loop—Motivation and Commitment Subsystem.

Finally, Figure 36 depicts a Stock and Flow Structure that represents the motivation and commitment subsystem.

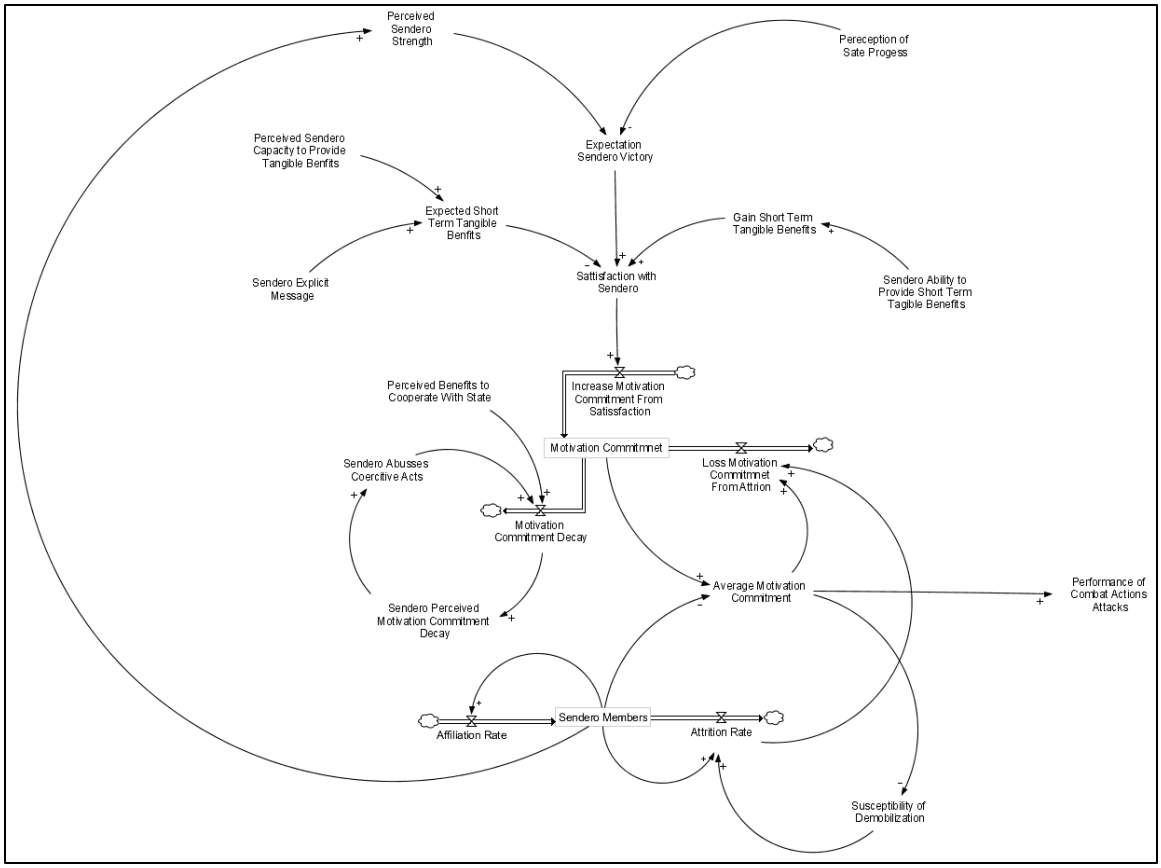

Figure 36. Motivation and Commitment Stock and Flow Structure

2. Expertise Subsystem.

Expertise represents another attribute of an organization. In general terms, members of an organization gain experience by formal training and daily practice and experiences. In the context of insurgencies, new members receive basic military training and their experience increases in direct relation to the number of training opportunities available and the number of actions in which the insurgents take part.

Conversely, a member's experience level decays when the insurgents are forced into inaction due to the State's deterrence measures. When Police and Armed forces increase their operational security and strengthen the potential targets of attacks (e.g., police stations, etc.), an insurgency must invest more time in concentrating its forces and preparing for attacks. Although the

insurgency's local commanders might spend more time thinking and planning for attacks, the operatives enter in a period of standby and alert. In practice, longer periods of inaction mean a decrease in the frequency of the attacks, which in the long run causes a decay in the insurgents' level of experience.

In the specific case of Sendero Luminoso, the insurgents were organized into three classes of combatants. Within the People's Guerrilla Army (EGP), which operated in rural areas, the first of these three classes was the Main Force (FP-EGP), or mobile network. The Main Force was Sendero's only standing and permanent army. It was dedicated to military action and constantly moved between various population centers. Sendero concentrated its most experienced combatants in the Main Force. The second class of combatants in the EGP was the Local Force (FL-EGP), and the third was the Base Force (FB-EGP), both of which were part of Sendero's territorial network. These two forces executed mainly administrative, logistical and indoctrination tasks in their respective communities, and were only sporadically called to perform military actions in support of the FP-EGP.[103]

In urban areas, Sendero kept the same configuration of three forces, but termed them "detachments" rather than "forces." The Special Detachments (DE-EGP) were equivalent to the Main Force, the Popular Detachments (DP-EGP) were equivalent to the Local Force, and the Urban Militia (MU-EGP) were equivalent to the Base Force. The Special Detachments were responsible for selective killings and large-scale attacks such as car bombs. The Popular Detachments and the Urban Militia complemented these actions with small acts of sabotage, armed propaganda and minor actions.[104]

The classification described in the two previous paragraphs leads to a coflow of high order depicted in Figure 37, which allows one to model the

[103] Benedicto Jiménez Baca, *El Inicio, Desarrollo y Ocaso del Terrorismo en el Perú: El ABC de Sendero Luminoso y el MRTA* [The beginning, devlopment and sunset of the terrorism in Peru: The ABC of Sendero Luminoso and MRTA] (Lima, Perú: SANKI, 2000).

[104] Jimenez Baca, *El Inicio, Desarrollo y Ocaso del Terrorismo en el Perú*.

attribute of expertise of the entire organization. Figure 38 depicts the aggregated coflow to Model Organizational Experience.

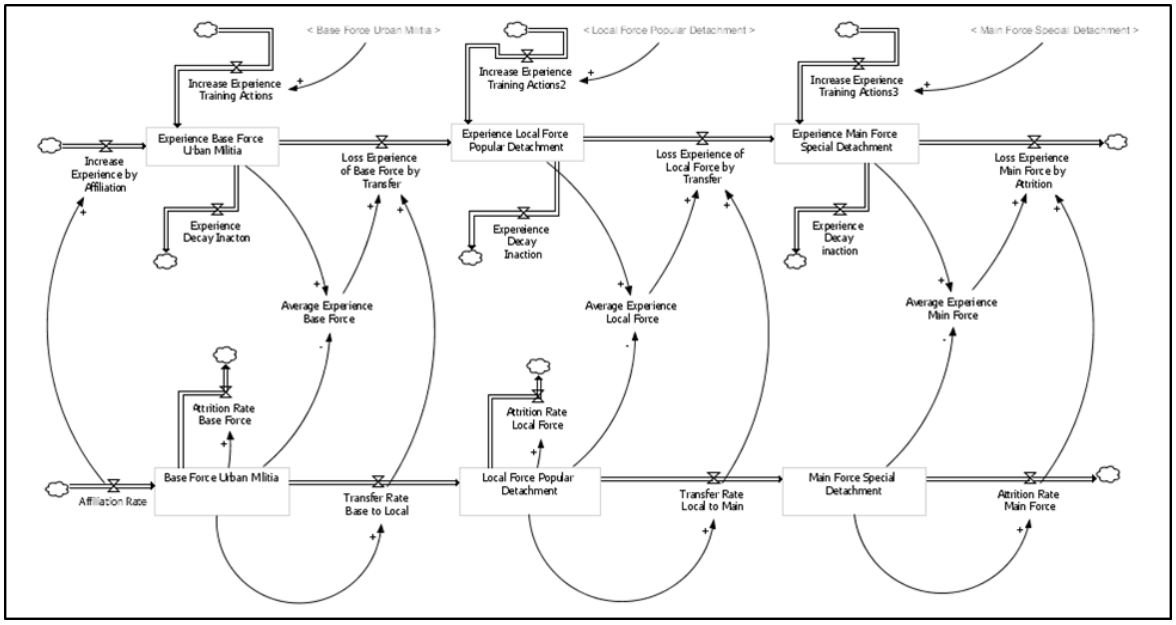

Figure 37. High Order Coflow to Model Organizational Experience.

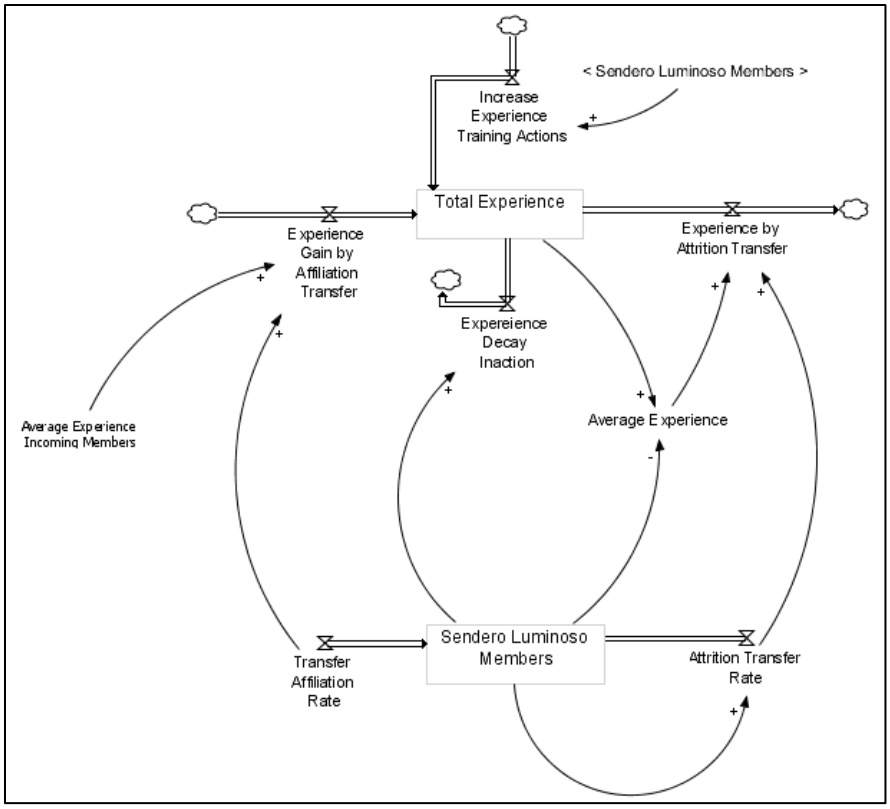

Figure 38. Aggregated Coflow to Model Organizational Experience.

As is evident, losses caused by attrition diminish the total experience of the organization. As more insurgents are neutralized or captured, the organization's level of experience decreases; in consequence, the organization must recruit and train new combatants. Sendero was forced to mix experienced militants with new recruits that had little or no experience. Inexperienced insurgents are more prone to commit errors in action, which reduces the organization's combat performance; this can cause an increase in the attrition rate, which decreases the average experience of the organization. The Stock and Flow Structure depicting the Expertise subsystem is illustrated in Figure 39.

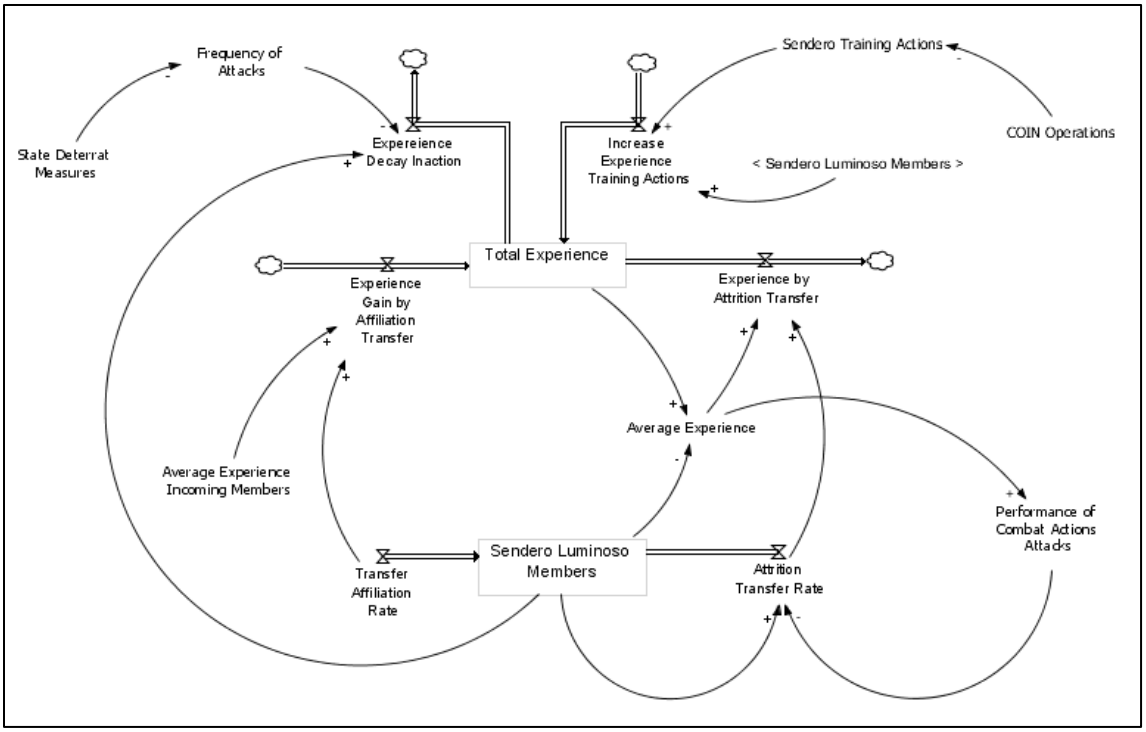

Figure 39. Expertise Stock and Flow Structure.

3. Supply Chain and Logistics Subsystem.

Sendero's doctrine supported a supply chain that was essentially self-sustaining. For instance, the masses were placed in charge of feeding Sendero's forces especially the Main Force, producing food and providing shelter and security to the EGP. Non-agricultural products were purchased with money collected from the "war quotas" and through assaults on merchants and commercial carriers.[105]

Likewise, faithful to the Maoist doctrine, Sendero's main source of weapons and explosives were those stolen from security forces and private institutions, especially private mines, which were the source of most of the dynamite that Sendero used. On occasion, some insurgents would build homemade guns and explosives. This usually occurred in rural communities. In the city, there is no evidence that Sendero ever invested time and resources in

[105] Del Pino, "Familia, Cultura y 'Revolución,'" 170.

building homemade weapons; however, the urban insurgents were able to produce car bombs after 1985.

In Lima and other cities, Sendero created a series of front organizations that were intended to raise funds. The most remarkable examples of these organizations were two pre-university academies named “Cesar Vallejo” and ADUNI. It has been estimated that together, these academies remitted approximately $20,000 USD per month to the Central Committee (directly to Guzman) for different expenses. Likewise, it is speculated that the insurgency received some funding from Communist groups abroad, through international cells operating mainly in Europe.

One particular example was the Regional Committee Huallaga (CRH), where Sendero locally had its own founding system. The CRH, whose area of responsibility included the Upper Huallaga Valley, one of the most fertile coca valleys at that time, received funds from drug firms and cartels. With these resources, Sendero not only could pay a “salary” to some of its members, but also acquired some weapons and other military equipment through intermediaries. By the late 1980s, it is estimated that insurgents were receiving at least $10 million USD a year from the “taxes” paid by the Colombian operators for using “more than one hundred clandestine airstrips in the Upper Huallaga.”[106] With all the variables abovementioned in mind, Figure 40 depicts the Supply Chain and Logistics SFS.

[106] José E. Gonzales, “Guerrilla and Coca in the Upper Huallaga Valley,” in *The Shining Path of Peru*, ed. David Scott Palmer (New York, NY: St. Martin’s Press, 1992).

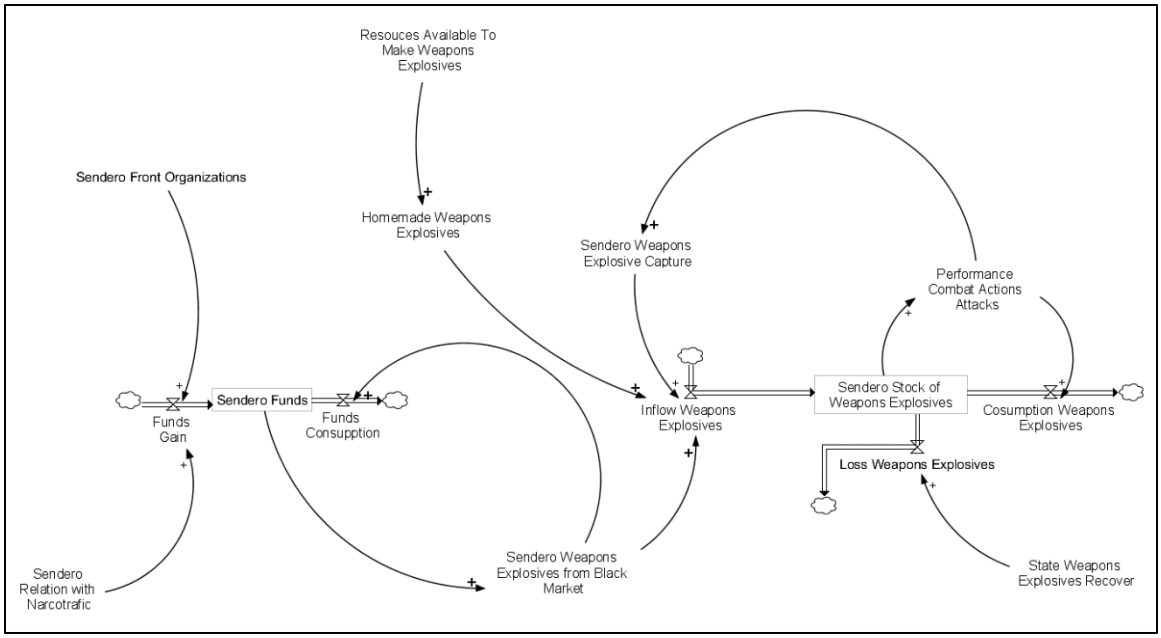

Figure 40. Supply Chain and Logistic Stock and Flow Structure.

4. Opposing Civilian Forces Subsystem.

The primary factor that led to the derailing of Sendero Luminoso and its plans was that civil society organized against it. Beginning in late 1982, some rural communities in the southern highlands (Ayacucho) began to organize self-defense committees (CAD), or “Peasant Rounds.” These first anti-insurgency civil organizations arose from the peasants’ own initiatives in response to the abuses committed by the insurgency, although in 1983, the armed forces began to encourage, organize and support these communal groups. With the backing of the Peruvian State, the CADs multiplied and recovered spaces where Sendero had implanted its Popular Committees.

This active resistance of society against the insurgency represents one of six groups or categories that are suggested to be the components of the physical system of the insurgency. According to Degregori, the rural people coalesced into three categories or groups. The first of these groups consisted of people, mainly peasants, who supported Sendero in exchanged for benefits; in other

words, this group accepted the insurgency for pragmatic reasons.[107] The second category included those people who were exposed to the control of Sendero, whether willingly or unwillingly. Most if not all of these people disagreed with and rejected the insurgents, but had no chance to confront them openly. This category was called adaptation-in-resistance.[108] The third category of rural people consisted of those who were engaged in the active resistance mentioned in the previous paragraph.

The fourth group was that portion of the population that actively supported Sendero Luminoso (e.g., in the so-called Popular Committees). The two remaining groups came from the general population, which was assumed to be divided into those who were dissidents, strongly criticizing and opposing the regime (the fifth group), and those who were State supporters (the sixth group). These six categories are assumed to form the physical structure of the insurgency system. Figure 41 depicts the physical structure of these six groups.

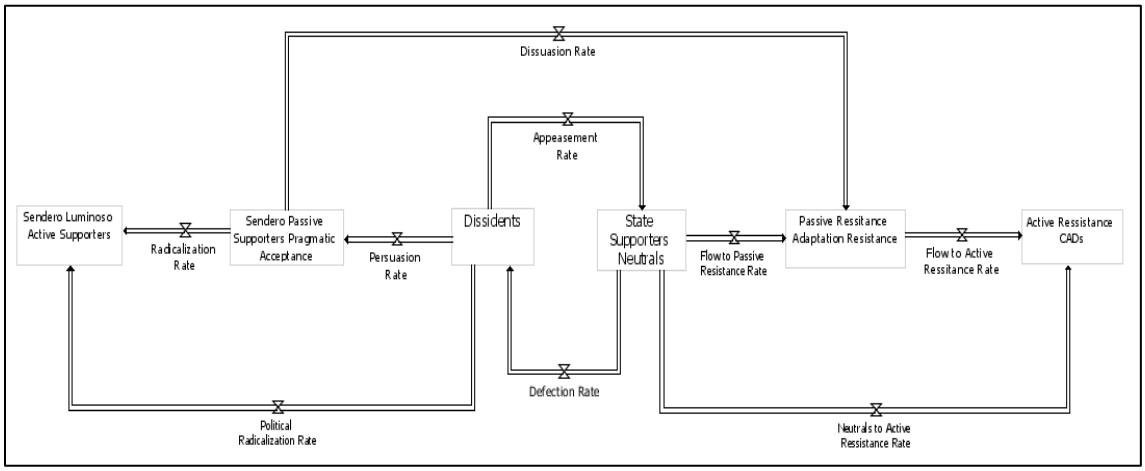

Figure 41. Physical Structure of Proposed Six Groups in Insurgency System.

[107] Carlos I. Degregori, “Ayacucho 1980–1983: Jóvenes y Campesinos ante la Violencia Política” [Ayacucho 1980–1983: Youth and peasants face political violence], *Nueva Sociedad* 114, (Julio-Agosto 1991): 16–24, http://nuso.org/media/articles/downloads/2007_1.pdf.

[108] Degregori, “Ayacucho 1980–1983,” 19.

Using this structure as a base, the dynamics of insurgency in the first two years of armed conflict were characterized by the conversion of dissidents to passive supporters who were attracted by the rhetoric of Sendero Luminoso. The adherents to the insurgency were mainly young peasantry, students, teachers and radical proletarians. However, within months, the insurgents began to lose their capacity to convene more supporters, because their terror practices ended up generating rejection among those who had initially been attracted by the enthusiastic message of the insurgency.

The social and ideological distance between insurgents and peasantry became manifest and widened, generating tensions that alienated the population from the insurgent project. In relation to this, the denial, substitution and assassination of traditional authorities appear to be the primary source of rejection.[109] The denial of local (most traditional) authorities happened when mainly young students, who had been recruited in universities and then went back to their communities, were placed as authorities of the "new" communist republic. This ran counter to the traditional forms of power in rural communities, where elder used to hold the power and authority. Even more, in places where traditional authorities reject Sendero's intentions, the insurgents executed thousands of peasants without distinction and penalized thousands more.

Such infamous practices increased peoples' perceptions that the insurgents represented a physical risk to individuals and private or communal property. The physical punishments and executions imposed by Sendero had a negative impact, especially in rural social networks, which are built based on multiple relationships of kinship, affinity, and participation in civic and religious institutions,[110] and cut across different social layers, linking people of different strata. Consequently, a growing sector of the rural community adopted a

[109] Coronel, "Violencia Política y Respuestas Campesinas en Huanta," 47.

[110] Carlos I. Degregori, "El Fin de la Utopía" [The End of Utopia] in *Sendero Luminoso* [Shining Path] (Lima, Perú: IEP, 1988), 45, http://archivo.iep.pe/textos/DDT/ddt4-6.pdf.

negative attitude towards the insurgency, as people rebelled against the rebels and Sendero increased its indiscriminate violence.

A second cause of dissatisfaction that seems to recur in the literature reviewed, is the perceived risk of losing economic opportunities and the risk of not improving social welfare. According to communist dogma, economic benefits could be achieved only through the collective work organized and supervised by the Party. However, while the proposal for an economically self-sufficient society had a positive impact on the population at the rhetorical level, in practice the demands of people's war and the irrational imposition of control measures by the insurgents had the opposite effect.

For instance, in early 1982, a group of insurgents reached one community in the Valley of Aprurimac and Ene River (VRAE) and held a popular meeting there, during which the insurgents explained to the crowd that, in order to wage war from the countryside against the cities, it would be necessary to "starve the cities" by blowing up bridges and blocking roads. Erroneously, Sendero sought to deprive the cities, especially Lima, of food and farm products, restricting the areas where crops could be grown and prohibiting any form of commerce outside the communities that were controlled by the insurgency. Likewise, in some cases, weekend fairs were banned and the peasants were forced to engage in communal works, making products that were mainly used by the insurgents. These actions ended in the impoverishment of the already depressed areas occupied by Sendero, affecting equally traders, the middle class and poor peasants. Peasants and merchants were unable to sell their products in local markets and cities.[111] It has become clear that the control of the local economy

[111] Ponciano del Pino, "Tiempo de Guerra y Dioses: Ronderos, Evangélicos y Senderistas en el Valle del Río Apurímac" [Time of war and God: Rondas, evangelists and Sendero in the Valley of Apurimac River] in *Las Rondas Campesinas y la Derrota de Sendero Luminoso* [The Peasant Rondas and the Defeat of Sendero Luminoso] (Lima, Perú: Instituto de Estudios Peruanos, 1996), 133.

had more to do with Sendero's strategic conception of waging people's war, rather than the implementation of a utopian autarkic model.[112]

The third cause of popular rejection of the insurgency was the people's perception of risk of social marginalization, discrimination or segregation. In spite of their narrative of inclusion and non-marginalization, Sendero's members carried cultural biases because the insurgents came from different regions of the country than those in which they operated. For instance, after an incursion into Uchurracay, one of the mid-level cadres said: "We swept away those Chutos."[113] "Chutos" is a derogatory term that people from the valley of Huanta use to refer to the inhabitants of the highland of Ayacucho, who are usually Quechan speakers.

The fourth cause of popular rejection was the perception of the risk of deprivation of liberties and rights, when communities began to compare the liberties and rights that they already had with the perceived demands of the insurgency. Insurgent acts were associated with the imposition of limits to personal and collective liberties, and the deprivation of constitutional, local or traditional rights, all of which led to an increase in popular dissatisfaction with Sendero.

These restrictions appear to have been a byproduct of the people's war conditions, when the entry of the Armed Forces into the counter-insurgency campaign generated a kind of collective "paranoia" in Sendero. In that restrictive context, Sendero began to control the entry and exit of people in communities. Even in the popular committees, Sendero's leaders began to behave in a more authoritarian way and several freedoms were suppressed. Members of the communities were meticulously observed and any complaint or criticism against the insurgents was taken as a betrayal. Sendero was forced to exercise more

112 Degregori, "El fin de la Utopía," 45.

113 Del Pino, "Familia, Cultura y 'Revolución.'"

control and surveillance of the communities' activities, while increasing sanctions and coercive measures.[114]

The fifth factor that increased the negative attitude towards Sendero was the perception of risk to individual or social values and norms. For instance, the vast majority of communities in the Andes have deep Catholic roots. In 1990, more than 14 percent of the population was evangelical Christian and most of the rest were Roman Catholic. Conversely, Sendero members were atheists, with no other moral reference than the radical fate of communism. In the VRAE, this caused religious leaders to encourage several communities to join together in self-defense committees, proclaiming the need to face the "antichrist."[115]

It is also important to highlight the role of religion in the collective mind of the population of Lima. More than 80 percent of Lima's population is Catholic, and several Christian, Evangelical, and Pentecostal organizations played important roles in the social structure of the capital. These institutions clearly rejected the use of violence as a means of social change. Since these religious institutions were very close to the most vulnerable population, they were an obstacle to Sendero's plans. In 1990, Sendero assassinated a group of members of an Evangelical Non-Governmental Organization.

The last aspect that generated tensions was the perception of risk of loss of cultural and ethnic identity. In this regard, the gender and age of members of the insurgency appear to be at the root of tensions, especially in the Andean community, where the local culture and traditions are marked by strong stereotypes of authority. Sendero's membership was 46 percent female, and almost 80 percent of the group was between the ages of sixteen and twenty-five; this structure of gender and age influenced the population's acceptance of the group. An observation from a victim of Sendero put it well: "Armed girls led me to

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[114] Del Pino, "Familia, Cultura y 'Revolución,'" 170.

[115] Gustavo Gorriti, "Escrita en Sangre, la História del VRAE" [Written in blood, the history of VRAE], *Caretas* (November 2009).

the square ... yes, girls who not worth it, but as they had guns, we had to obey ... !Nasty this situation! If I had had a weapon, I would stop her."[116]

The perceived risks discussed above altered not only popular intention and behavior, but also the expectation of short- and long-term benefits, the deprivation of volition of those who were directly involved in the conflict, and the personal perception of opportunities for self-defense from undesired impositions, all of which accounted for changes in people's attitudes toward the insurgency. Using the Theory of Planned Behavior (TPB)[117] as reference, one can say that people's intentions to support the insurgency were conditioned on (1) their perception of costs and benefits in the short and long term, (2) their perception about the behavior of other individuals, and (3) their perception about limiting factors to perform specific intentions.

In relation to this, Ajzen asserts that "intentions to perform behaviors of different kinds can be predicted with high accuracy from attitudes toward the behavior, subjective norms, and perceived behavioral control; and these intentions, together with actual behavioral control, account for considerable variance in behavior."[118] Figure 42 depicts the Theory of Planned Behavior.

[116] Ricardo Caro Cardenas, "Ser Mujer, Joven y Senderista: Pánico Moral en las Percepciones de Sendero" [Be women, young, and Sendero's member: Moral panic in the perception of Sendero], *Allpanchis* 67 (2006), 8.

[117] Icek Ajzen, "The Theory of Planned Behavior," *Organizational Behavior and Human Decision Processes* 50, no. 2 (December 1991) Online: http://www.sciencedirect.com/science/journal/07495978/50.

[118] Ajzen. "The Theory of Planned Behavior."

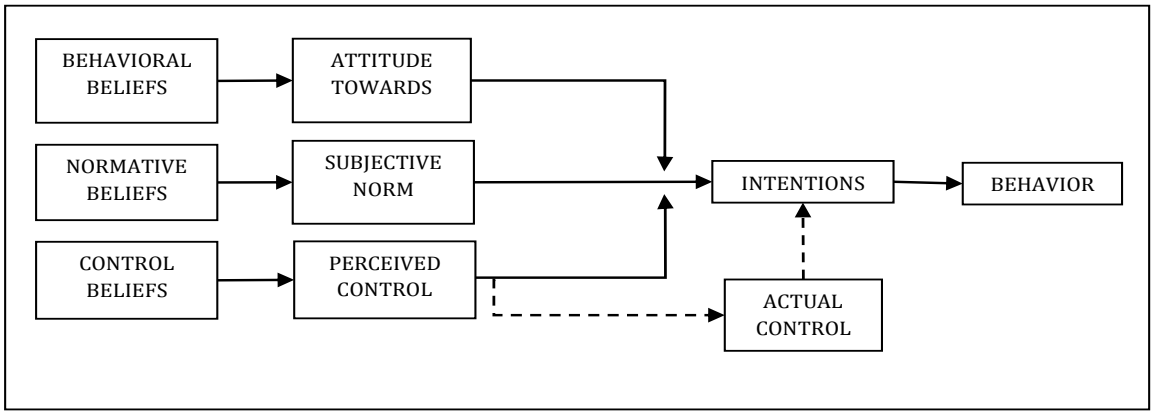

Figure 42. The Theory of Planned Behavior.

Ajzen points out that the strength of these beliefs can be used to predict behaviors. As one's strength of beliefs increases, that person's intention to perform a specific act increases as well. The strength of beliefs is a function of a person's past experiences and the information that is available to that individual. Also, these beliefs are conditioned on the accuracy of the person's perception of reality.[119] Any distortion of that reality could lead to a different set of beliefs and intentions.

Likewise, and of particular interest to this work, it is a fact that among a larger set of beliefs, people's intentions are more correlated to *salient* beliefs. This salience depends upon both the proximity in time to the intended act and the strength of the belief. According to Ajzen, "People can hold a great many beliefs about any given behavior, but they can attend to only a relatively small number at any given moment. It is these salient beliefs that are considered to be the prevailing determinants of a person's intentions and actions."[120]

In this regard, continuous and persuasive messages, either in the form of a narrative or as a product of insurgent events, will be required to alter people's beliefs. As a result, each belief should link the behavior in question to a certain desired outcome. Shaping an individual's intentions demands unambiguous

[119] Ajzen, "The Theory of Planned Behavior."

[120] Ajzen, "The Theory of Planned Behavior."

stimuli. If these stimuli or messages are perceived with distortion or delayed, a united dynamic in the system with undesirable consequences can be created.

Attitudes are formed based on beliefs that result from short- and long-term expectations about an intended action. Ajzen points out that "behavioral beliefs produce a favorable or unfavorable attitude toward the behavior [… in connection to] the likely outcomes of the behavior, and the evaluations of these outcomes."[121] As a general rule, a positive attitude towards a specific behavior is directly related to a personal perception of desirable consequences as a result of the behavior in question. Conversely, a negative attitude correlates with the perception of undesirable consequences of that behavior.

In the context of conflict, people's choices are often not left entirely to their own volition. Under certain circumstances, people cannot simply reject situations that carry personal or collective costs. Coercion and compulsion arise in the absence of incentives to compel people to perform specific behaviors. This particularity allows one to infer the existence of four possible scenarios related to the probability of people cooperating or not cooperating with the insurgency.

In the first scenario, the insurgency is able to offer either tangible or intangible benefits for cooperation. In this case, the likelihood of cooperation plays in favor of the insurgency. In the second scenario, cooperation with the insurgency implies personal or collective costs that exceed the benefits of cooperation. In this case, the likelihood of cooperation with the insurgency is low. The third scenario is where the insurgency is capable of increasing the cost of non-cooperation in an attempt to force people to cooperate. Finally, there is a scenario where there are benefits to non-cooperation, and insurgents are not able to increase the cost of non-cooperation.

It is possible to affirm that insurgencies offer short- and long-term benefits as mechanisms of inclusion to attract more sympathizers. However, as the conditions inherent in an armed conflict become more challenging, the cost of

[121] Ajzen, "The Theory of Planned Behavior."

cooperation could increase. At this point, part of the population will be dissatisfied with the insurgency and, consequently, the insurgency will be forced to strengthen its mechanism of control and increase the cost of non-cooperation. It could create a self-reinforcing loop of increasing intimidation and increasing dissatisfaction with the insurgency. Under those circumstances, people naturally will tend to avoid participating in situations that render no net benefits or entail excessive costs. Likewise, if people are involved in a situation where the cost is high, they will tend to seek ways to escape from it. In the process of improving their situation, people will face a set of factors that hinder or facilitate their intentions.

In the TPB, these perceptions are part of the set of control beliefs. According to Ajzen, "the control belief is the set of beliefs about the presence of factors that may facilitate or impede performance of the behavior and the perceived power of these factors ... This perception is conditioned by past experience and anticipates impediments or obstacles."[122] In other words, one's personal perception of self-limitations and the complexity of the intended behavior set a notional limit to cooperation.

Another variable that correlates with the likelihood of executing a specific behavior is the set of normative beliefs. As a general rule, a person's intentions are directly related not only to the individual's perception of another person's acts,[123] but also to the perception of the actions of referent groups or individuals. In this regard, Ajzen asserts that "normative beliefs result in perceived social pressure ... , beliefs about the normative expectations of others and motivation to comply with these expectations ... these expectations are stronger when their source is a referent individual or collective."[124] In simple terms, people are more motivated to collaborate with the demands of a referent person or collective.

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[122] Ajzen, "The Theory of Planned Behavior."

[123] See as reference, McCormick and Giordano, "Things Come Together."

[124] Ajzen. "The Theory of Planned Behavior."

The perceived size of the insurgent group matters as well. McCormick and Giordano aptly describe this effect, explaining the impact of the perception of insurgency strength on potential supporters, arguing that the number of individuals willing to join the insurgency are directly related to the individual's perception (or belief) about the number of people already supporting the insurgency.[125] This is ultimately what can convince a large fraction of the population to participate in collective actions and create a civil insurrection.

The diagram in Figure 43 combines the six causes of popular rejection with the theory of rational actions and the physical structure of the flow transiting between the state of passive resistance and the state of active resistance.

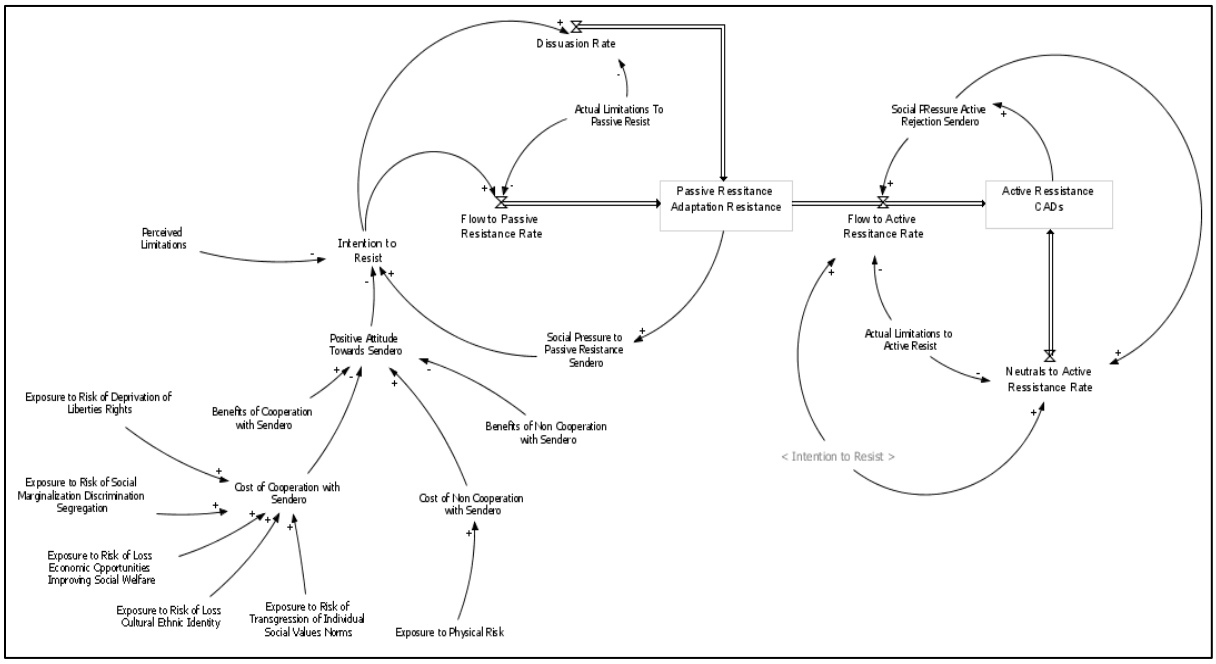

Figure 43. Suggested Main Causes of Popular Rejection.

The main causes of popular dissatisfaction with Sendero in the countryside have already been discussed. In Metropolitan Lima and other urban areas, Sendero faced several difficulties in linking the party with the masses. This

125 McCormick and Giordano, "Things Come Together."

happened in part because society in Lima was fractionated far beyond the common stratification of social classes. The degrading conditions of life in the capital, hardened by the collapse of several public services, created a complex network of small social structures. These small organizations included the "mothers' committees," "glass of milk committees," "neighborhood committees," "community kitchens," etc. These were social structures that Robin Kirk called "survival organizations."[126] They were small self-organized collectives with some independence of authority, although generally affiliated with traditional political parties.

As was the case in the countryside, Sendero gradually generated tensions within the community of Villa El Salvador, a district in south of Lima. Sendero pretended to infiltrate those social structures in order to usurp local power and to eliminate all forms of authority, coordination and popular control. It is not surprising that under such conditions, the urban population began to openly reject Sendero.[127] These tensions reached their climax when Sendero, once again, began to impose its will through violence and coercion. As expected, the population continued to reject the insurgents' proposal. By 1992, some collectives of the people of Villa El Salvador were expressing open opposition to Sendero. The most noticeable was the opposition of the Federation of Women of Villa El Salvador and its leader, Maria Elena Moyano. She and other communal leaders began to expose the true intentions of Sendero and protest against terrorist violence. On February 15, 1992, Moyano was assassinated by a death squad.

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[126] Robin Kirk, "Untold Terror: Violence Against Women in Peru's Armed Conflict," Report, Human Rights Watch, (1992): 50, http://www.hrw.org/sites/default/files/reports/SKMBT_55213062512100.pdf.

[127] Jo-Marie Burt, "Sendero Luminoso y la 'Batalla Decisiva' en las Barriadas de Lima: el Caso de Villa El Salvador" [Sendero Luminoso and the "decisive battle" in Lima's shanty towns: Villa el Salvador case] in *Los Senderos Insólitos del Perú: Guerra y Sociedad, 1980–1995* [Unusual Paths of Peru: War and Society, 1980–1995], ed. Steve J. Stern (Lima, Perú: Instituto de Estudios Peruanos, 1999) 263–300.

In spite of the increasing levels of popular rejection of Sendero, it became clear that the formation of self-defense committees was impractical in an urban environment. Conversely, in the countryside, the beginning of the peasants' direct and open resistance began in late 1982 and coincided with the arrival of the Armed Forces to Ayacucho. Although this might have redefined the character of the population and encouraged people to face Sendero, the increasing number of CADs was reinforced by the perception that other people were joining self-defense committees. Several communities in different areas of Ayacucho began to fight back against Sendero. In Huaychao and Uchuraccay, which were the first communities to combat the insurgency, the peasantry openly rejected Sendero in a coordinate manner. These communities, though separated by distance, had reached a consensus for coordinated actions against Sendero Luminoso.[128]

The presence of the Armed Forces in the countryside helped to coordinate the communities' response to Sendero's advances, mainly through organizing the population. Several communities began to form multi-communal groups around military bases. These collectives organized and distributed the tasks of production and security with the support of the Armed Forces.[129] This would be the equivalent of Sendero's longed-for revolutionary Support Bases, but directed instead against insurgent violence and its usurpation. Gradually, popular resistance against the insurgency became stronger. By 1984, it is estimated that more than 21,000 peasants had been organized into Self-Defense Committees.[130] Despite Sendero's incessant harassment, the insurgency in Ayacucho no longer had any chance of progressing. Figure 44 depicts the SFS of Opposing Civilian Forces.

[128] Coronel, "Violencia Política y Respuestas Campesinas en Huanta," 48.

[129] Coronel, "Violencia Política y Respuestas Campesinas en Huanta," 55–60.

[130] DESCO, *Violencia Política en el Perú: 1980–1988* [Political Violence in Peru: 1980–1988] (Lima, Perú: DESCO 1989).

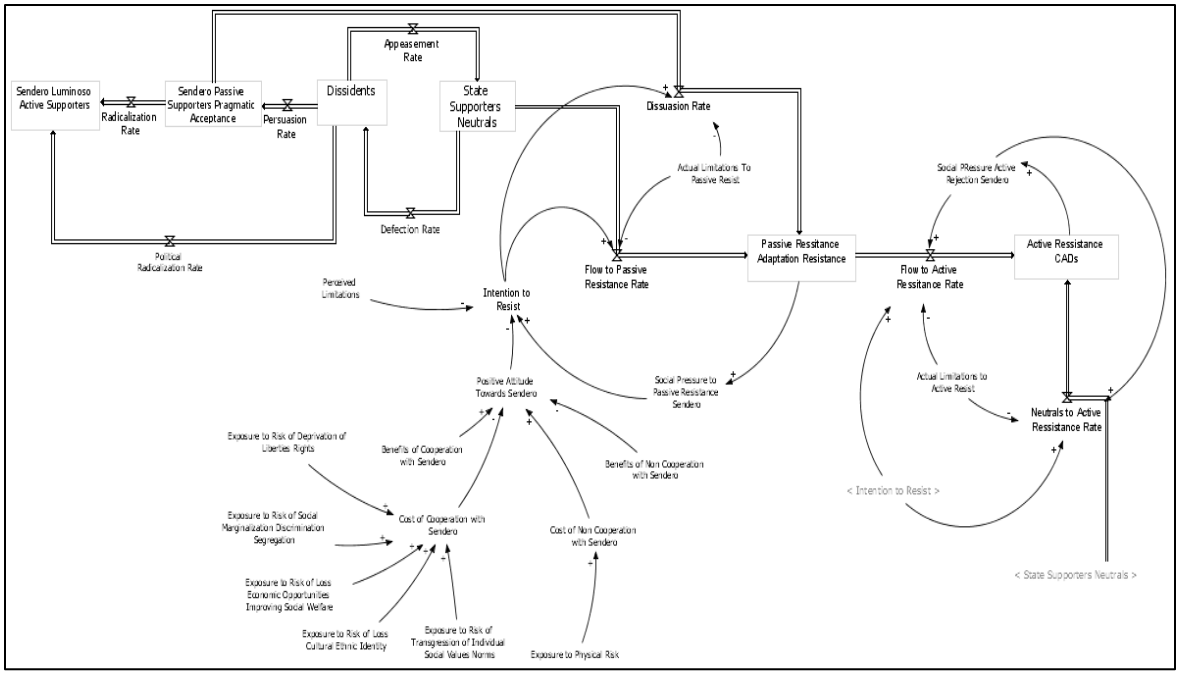

Figure 44. Opposing Civilian Forces Stock and Flow Structure.

C. CLOSING LOOPS: INTEGRATING SUBSYSTEMS AND INFERRING A FEEDBACK STRUCTURE OF THE PERUVIAN INSURGENCY SYSTEM

The models presented in the previous sections of this thesis can be used to infer the Feedback Structure shown in Figure 45, which is comprised of six loops. These six loops are discussed below.

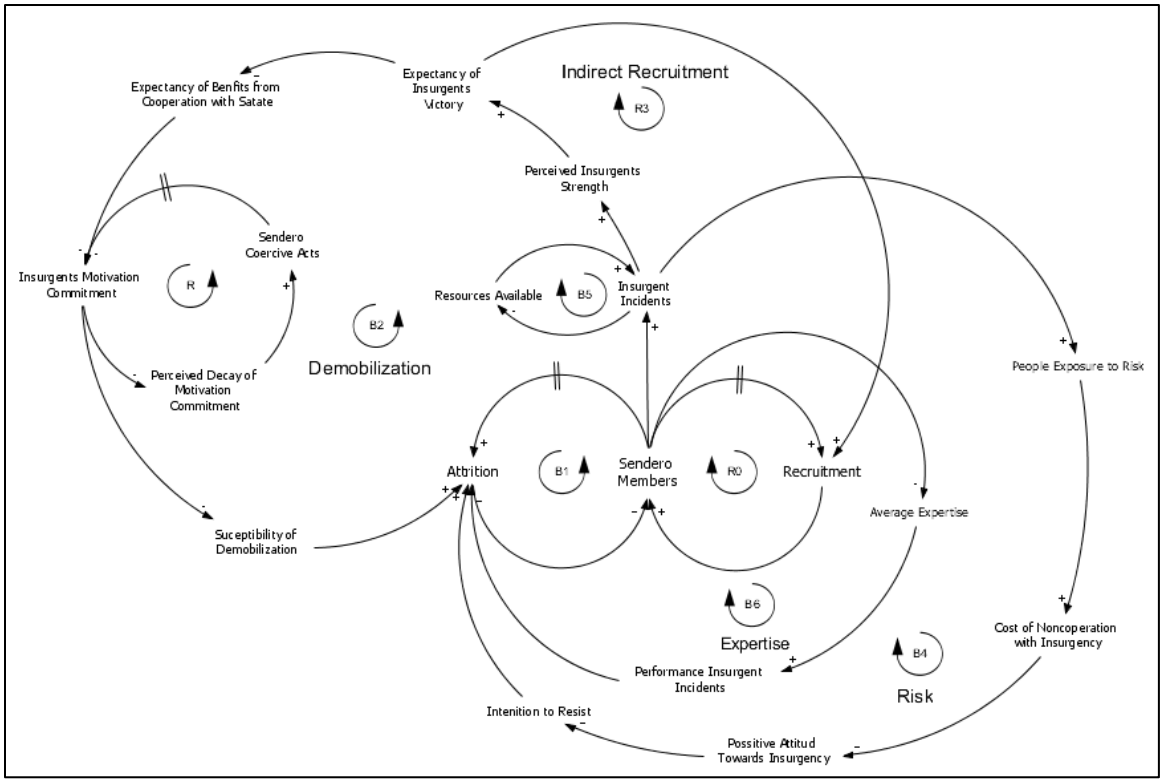

Figure 45. Feedback Structure of the Peruvian Insurgency System.

1. Recruitment and Attrition Loop (R0—B1).

As the number of insurgent members increases, those insurgents can interact with more frequency with neutral and other sectors of population, thereby increasing the organization's recruitment rate by direct affiliation of new members. Likewise, it is assumed that, as the number of insurgents increases, so does the insurgency's "signature," which makes the insurgents more visible to State agents. This, in turn, allows the State's agents to increase the insurgency's attrition levels by neutralizing (through death or capture) more insurgents. Finally, these two loops are affected by reasonable delays.

2. Demobilization Loop (B2).

As the insurgency recruits more members, the organization will have more human resources at its disposal to develop its activities and increase the number

of attacks and operations (incidents) it can undertake. This, in turn, causes the population to perceive that the insurgents are growing strong and, therefore, increases the expectation that the rebels will be victorious. If people assign a greater chance of victory to the insurgents, their expectation of profiting by supporting the State are reduced. This leads to an increase in motivation and commitment, both to join the rebels and to stay within the organization. By keeping these morale factors high, the insurgents will be less susceptible to demobilization, leading to less attrition, which will prevent the size of the organization from shrinking.

Likewise, in this cycle, if the motivation and commitment of insurgents decays, the signs of moral weakness will increase and will alert leaders and other members of the organization who, faithful to Sendero's policy of terror, will increase their coercive acts aimed at preventing defections and other shortcomings. This violence, although it might control the behavior of people in the short term, decreases people's motivation to enter to the organization and their commitment to remain in it in the long term.

3. Indirect Recruitment Loop (R3).

The indirect recruitment loop is related to the previous loop, but with a reinforcing effect of recruiting more members. Unlike those insurgency activities oriented exclusively to recruitment, which occurred at the beginning of Sendero's campaign when the organization identified and "invited" those radical dissidents to join the revolution, indirect recruitment resorts to massive actions—especially violence—aimed at producing a propaganda effect that helps recruitment. This effect has already been discussed in Chapter III of this thesis, and has been perfectly described by McCormick and Giordano. With more human resources at its disposal, the organization can carry out more attacks and operations. This increase in insurgent incidents increases the popular expectation of insurgent victory and, consequently, the idea that a person will gain more benefits by supporting the rebels rather than the state. The idea of receiving greater benefits

results in an increased rate of recruitment, which causes the insurgent organization to grow.

4. Risk Loop (B4).

As the number of insurgent incidents increases, the number of people exposed to physical risk at the hands of the insurgency also increases and, in consequence, the cost of non-cooperation with the insurgency goes up. From the standpoint of the insurgents, this relationship works due to terror tactics aimed at intimidating and coercing the population. However, the cost of non-cooperation has an inverse relationship with a positive attitude toward the insurgency. As the cost increases, the positive attitude decreases; this leads to an increase in intentions to resist the insurgency, in spite of the fact that a fraction of the population is under the insurgency's influence (or control). This popular intention to resist will increase up to the point where individuals will seize the opportunity to flee from the insurgency, which increases the attrition rate by demobilization and reduces the number of the insurgency's rank and file.

5. Logistics Loop (B5).

Although the logistics chain is usually a complex issue for any organization, it was quite a simple process for the Peruvian insurgency. Sendero Luminoso was based on the self-sustaining type of logistics, with each unit not only responsible for engaging in combat and politically mobilizing the masses, but also for production and supply. As was discussed earlier, the armed actions were combined with covert and clandestine actions aimed to penetrate social structures (rural communities, social groups, labor unions, etc.), public and private institutions, and even State security forces. By infiltrating these entities, Sendero was able to extract resources and information while corrupting and disrupting social and federal processes. For instance, Sendero infiltrated some national hospitals, from which it systematically robbed medical supplies that were later distributed within the rebel organization and among the families of its members. However, terrorist acts and other actions such as propaganda depend

simply upon available resources. As the quantity of resources decreases, so do the number of insurgent incidents, even those aimed at acquiring resources.

6. Expertise Loop (B6)

Finally, the expertise, both military and political, of the members of the insurgent organization has a fundamental role in this system. As the organization was losing members who had much military and political experience, Sendero was forced to replace them with less-qualified people. In some cases, Sendero replaced cadres who had years of indoctrination and training with young leaders who had served only a few months in the organization's ranks. This lack of experience, couple with the immaturity of young recruits, provoked a very low level of performance in political and combat functions. From a military and tactical point of view, this led to the repeated degradation of insurgent forces by the actions of the State's forces. From a political and leadership standpoint, this poor performance resulted in multiple defections that eventually reduced the ranks of the organization.

V. CONCLUSIONS AND RECOMMENDATIONS

In recent years, an increasing number of government and private institutions have used a System Dynamics (SD) approach to address critical issues. This set of tools is aimed at improving the processes of decision making and learning in complex systems. With many applications in many fields, SD provides powerful tools for strategic analysis and can foster systemic and design thinking among strategists, decision makers, and researchers.

By helping strategists and decision makers to understand the dynamics of very complex social phenomena, such as insurgencies, and encourage them to develop systematic and critical thinking, SD might lead to innovative solutions that can efficiently suppress insurgent activity. Likewise, understanding complex problems as a whole rather than deconstruct them into parts can help strategists to focus on leverage actions that seem to be too separate from the actual problem to be a solution, but that are, in reality, connected to and influencing the problem through a chain of causal relationships that are usually not evident.

The research reported in this thesis has yielded two types of knowledge. The first focuses on general knowledge about System Dynamics, highlighting the advantages of using this tool to solve complex and dynamic problems. The second body of knowledge derives from the analysis of the Peruvian insurgency of Sendero Luminoso as a dynamic system. Although the models suggested here are far from complete, by analyzing the pattern of insurgency incidents, they have demonstrated the impact both of the entry of the Armed Forces into the counterinsurgency fight, and of the capture of Abimael Guzman.

A. GENERAL KNOWLEDGE FROM SYSTEM DYNAMICS

As has been demonstrated in this thesis, System Dynamics tools are suited to conduct both prospective and retrospective research. Models for prospective research can help strategists, decision makers, and military planners to comprehend complex systems and project the consequences of different

strategies and policies. Likewise, this study has shown the benefits of SD for carrying out a thorough analysis of the causal relationships of a complex phenomenon such as an insurgency. In some circumstances, such as when studying insurgencies, researchers cannot always have all the necessary data to simulate the model and obtain numerical results; however, modeling past events using SD models can produce knowledge at the strategic and political levels. Nonetheless, the potential of this approach lies, first and foremost, in fostering strategic and systemic thinking, and in developing conceptual models, allowing one to arrive, perhaps not at perfect solutions, but at solutions that are certainly innovative and practical.

In System Dynamics, Feedback Structures are the central features. As this thesis has stated extensively, Feedback Structures are responsible for the behavior of the system, and they ultimately have the ability to communicate the key elements in a dynamic system. Nevertheless, Feedback Structures must be complemented with a physical structure that represents accumulations and flows of tangible quantities that affect the system. Other intermediate variables or auxiliaries must also be aggregated into the system in order to give the full sense to the system.

System Dynamics tools allow large and complex systems to be broken down into simpler sub-systems or components in order to facilitate the work of researchers, as this thesis has demonstrated. By understanding which and how causal relationships interact and the effects of these interactions over the parameters of the system, strategists, policymakers and military planners will be more able to identify potential unintended consequences of their actions. This is paramount when crafting multi-agency strategies, and can prevent actions that inadvertently foster the enemy's campaign or hamper the efforts of other groups that are trying to defeat the same enemy. Although it may not be possible to simulate system effects due to a lack of precise data, knowing the behavior of the systems can help to identify when the system diverges from what is expected.

SD tools have the ability to provide a consistent platform through which basic models can be refined and complemented over time. SD tools can also be mounted on a collaborative platform, making it possible to create a virtual space where various models can be integrated and handled by different researchers investigating similar cases. This would allow researchers working in different places and times to maintain consistency in terms of variables and attributes and, as is the case with most mathematical models, to make improvements on the basic model. Even more, several groups of researchers from different specialties can develop models for specific research areas, which can be then integrated with other models.

Likewise, SD tools for modeling have the ability to efficiently communicate research findings to users. Although the models can become visually loaded, there are various ways to simplify the presentation of the models. Once this is done, these models can even be shared between different state agencies, facilitating coordination on strategic issues. The fight against insurgencies requires the participation of various public and even private entities, and SD tools can provide useful insights to strategist and policymakers.

SD tools can be used to model the decision-making processes and intangible attributes of tangible entities and allow them to be investigated. As shown in this thesis, attributes such as motivation and commitment or expertise can be modeled.

It should be noted, however, that it can be difficult to model decision making, because doing so requires knowledge of specific decision rules and, too often, complete information about the situation is lacking. Likewise, the accuracy of SD models and the ability to run simulations both depend heavily upon the availability of data and the correct formulation of equations. However, if a simulation cannot be run due to lack of data, it should still be possible to conduct a loop dominance analysis to draw some inferences regarding the presence, absence or even performance of either negative or positive feedback loops. As was demonstrated in this thesis, analyzing a few variables and conducting further

loop dominance analysis can enlighten strategists and decision makers about the behavior of complex systems.

B. GENERAL KNOWLEDGE FROM THE HYPOTHETICAL COUNTERINSURGENCY MODEL AND SENDERO'S SYSTEM DYNAMICS

The general knowledge gained from the hypothetical model of counterinsurgency and the Peruvian insurgency system, analyzed in chapters III and IV, respectively, provides researchers and military planners with a foundation upon which to integrate details of specific cases. Although theory and knowledge by their nature are designed to provide guidance and insight, the humans—the decision makers—can control the system and give full sense to it by applying simple logic and good sense to decisions that must be made. Dr. Milan Vego, when writing about Clausewitz's Center of Gravity, stated that "the true value of Center of Gravity may be the framework the concept provides for thinking about war. In other words, the process of determining centers of gravity may be as important as the product."[131] The same is true in System Dynamics.

Such a deep-thinking process allows scholars and planners to be aware of external elements of influence in the system. Not all decisions in a decision-making process are rational, and a number of factors can induce a decision maker to decide in a thoughtless manner. However, a solid base of knowledge can help to limit this risk and to preclude the state from making uninformed decisions that could carry unintended consequences. By knowing the system and being aware of the causal relationships that interact within it, scholars and planners should be able to separate the essential from the accessory.

It is important for strategists, decision makers and military planners to understand the effects of two key aspects of counterinsurgency: Intelligence and Information Operations. As was demonstrated in the simulation of the hypothetical counterinsurgency system in chapter III, the best outcome can be

[131] Milan N. Vego, *Joint Operational Warfare: Theory and Practice* (Annapolis, MD: Department of the Navy, March 2007) VII-14.

achieved by efficient COIN operations supported by very good intelligence and effective IO operations. Without been able to articulate these three essential elements, military executors not only will face difficulties in degrading insurgent forces but also can fuel the revolutionary process, forcing people to embrace the insurgency due to dissatisfaction with the incumbent regime.

This work has demonstrated that Sendero Luminoso, despite pronouncements made circa 1988, was losing operational capacity in the second half of the 1980s. At that time, Abimael Guzman stated that Sendero had reached a state of strategic equilibrium, which would, in a few years, lead to the strategic offensive considered as the precursor step to the insurgency's victory. However, the pattern analysis allows it to be inferred that Guzman knew that Sendero had reached its limit of growth and the culminating point of his terrorist campaign. From there, his only remaining option was to increase Sendero's psychological campaign in hopes of convincing his followers that the victory of the insurgency was imminent. Such rhetoric found fertile ground, in part because Peru had entered a condition of general crisis in the late 1980s. Although these conditions were primarily the consequence of factors outside the actions of the insurgency, they allowed Guzman to manipulate social grievances and expectations.

Likewise, based on the pattern analysis of the Operational Performance of the organization, it can be inferred that the entry of the armed forces into the counterinsurgency campaign had a negative effect on the insurgency (as would be expected). This effect was replicated nationwide, gradually slowing down the operational capacity of the insurgency until it begins to show a negative trend around 1989. The effect of the actions of the armed forces was even more evident in the region of Ayacucho where, around 1985, Sendero showed a negative trend in spite of the fact that Ayacucho was the location of the main regional committee and the historic stronghold of the Sendero Luminoso.

Although the results of the dynamic models suggested in chapter IV are not definitive, they demonstrated theoretically that factors such as experience,

motivation and commitment, logistics, and the opposition of counter-revolutionary militias affected the Operational Performance of Sendero Luminoso. To be clear, the research reported in this thesis did not discover these factors; it has, however, highlighted some of the chains of cause and effect that contributed to the operational decline of the insurgency in Peru.

One final point should be made about the Peruvian insurgency system: when Sendero became overwhelmed by the demands of a protracted war and the constant pressure of the security forces, it entered a cycle of systemic "rankism."[132] Rankism refers the abuse of power by those in authority against those below them in the organization's hierarchy. In Sendero's case, this involved the indiscriminate use of weapons and violence. Many people had been encouraged to put their fates into the hands of Sendero due to the organization's highly inclusive rhetoric, which proposed major social changes and economic progress, as rankism increased during the campaign, those people were quickly disillusioned when they became victims of those who had claimed to be their protectors and their revolutionary vanguard.

C. RECOMMENDATIONS FOR ADDITIONAL STUDIES

Insurgencies, unfortunately, are recurrent social phenomena and will likely remain formidable challenges for armies in the present and future. Analyzing Sendero Luminoso as a dynamic system will demand the contributions of many experts in several fields of knowledge. The models suggested in this works might contain inaccuracies, and they are, without a doubt, incomplete. Nevertheless, this work represents the initial steps in the development of a formal and complete model of an insurgency that was based on the dogmatic compliance of Marx, Lenin and Mao.

This study has been limited to an exploratory analysis of Sendero Luminoso from the standpoint of the insurgency. However, further explorations

[132] Robert W. Fuller, "Rankism: A Social Disorder," *Breaking Ranks* (blog) n.d., http://www.breakingranks.net/rankism/.

should be made on the other Peruvian terrorist organization, the Movimiento Revolucionario Tupac Amaru (MRTA), and—perhaps the most difficult investigation—the network of drug trafficking in Peru. Exploring the dynamics of these three main infamous actors could be extremely helpful to better understand domestic politics under the context of internal conflict.

This thesis was limited to the events that occurred between 1980 and 1992. A closer look into the dynamics of Sendero Luminoso before and after this time period is recommended.

Finally, the role of the armed forces in counterinsurgency campaigns should be reviewed. Such scenarios demand a different set of military capacities than conventional campaigns do. The armed forces should focus on creating influence units that are capable of creating positive relations with the population. They should also focus their organizational energy and resources on conducting more Information Operations, Intelligence Operations and Civil Affairs actions, rather than kinetic actions. In this way, the State will have a more efficient tool in service to disrupt an insurgency's ability to manipulate popular grievances and expectations.

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