Chapter 3
Agent-Based Modeling

INTRODUCTION

In 1998 the United Nations General Assembly stated in Resolution 52/167 on page one that they were:

Deeply concerned by the growing number of complex humanitarian emergencies, in particular armed conflicts and post-conflict situations, in the last few years, which have dramatically increased the loss of human lives, suffering of victims, flows of refugees and internally displaced persons, as well as material destruction, which disrupt the development efforts of countries affected, in particular those of developing countries.

Additionally in 1992, via resolution 46/182 the United Nations General Assembly adopted a series of Guiding Principles to strengthen the coordination of international humanitarian emergency assistance. Those principles state in part that:

The magnitude and duration of many emergencies may be beyond the response capacity of many affected countries. International cooperation to address emergency situations and to strengthen the response capacity of affected countries is thus of great importance. Such cooperation should be provided in accordance with international law and national laws. Intergovernmental and non-governmental organizations working impartially and with strictly humanitarian motives should continue to make a significant contribution

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in supplementing national efforts. … There is a clear relationship between emergency, rehabilitation and development. In order to ensure a smooth transition from relief to rehabilitation and development, emergency assistance should be provided in ways that will be supportive of recovery and long-term development. Thus, emergency measures should be seen as a step towards long-term development. (Annex, page 50)

Complex adaptive systems are different in that each of their parts follows an individualized set of rules that can vary as they interact within the larger system. There is no overarching set of rules governing the outcome – complex adaptive systems are non-deterministic. The non-deterministic, or stochastic, non-linear behavior of these complex adaptive systems can be extremely difficult to predict. Small variations in initial conditions can cause dramatic changes in outcomes. These variations become problematic to predict because their outcomes vary as the *product* of the system variables versus the *sum* of those variables. The problem as Holland (1995) describes it is that "It is much easier to use mathematics when systems have linear properties that we often expend considerable effort to justify an assumption of linearity" (p.15). Linear models have great difficulties predicting emergent behaviors. The difficulty is so great that the term "black swan" came into vogue thanks to Taleb's (2007) bestselling book, *The black swan: The impact of the highly improbable*. It is precisely these types of events – 9/11, the 2008 financial crisis, the success of the iPod – that causes dramatic change; what Gersick (1991) describes as punctuated equilibrium. These types of events dramatically alter the systems in which they occur and they do not always change them for the better. None of the linear models would have predicted such events because they were caused by outlier variables. The point of agent based modeling and other similar tools for modeling non-linear behavior is to conduct thought experiments to gain insight into the possible; regardless of its probability.

BACKGROUND

Characteristics of Agent Based Modeling

As previously stated, agent based modeling is one of the tools available to researchers studying complex adaptive systems. One of the key differentiating factors of agent based modeling is that the model simulations are constructed from the bottom up versus the top down. Top down models are typically the