# ABSTRACT

Title of Document: The Effect of Economic Condition on Civil
Unrest: New Insights from Agent Based
Modeling

Charles Thomas Harry, PhD, 2013

Directed By: Professor, John Steinbruner, Department of
Public Policy

On the morning of December 17th 2010, a Tunisian fruit vendor named Mohamed

Bouazizi took a can of gasoline and lit himself on fire in front of the local governor's

office in protest of having his cart and its inventory confiscated by a corrupt police force.

What began as act of individual protest against the Tunisian state evolved into mass

demonstrations across the Arab world significantly altering the political landscape.

While researchers have explored links between economic determinants and the outbreak

of civil conflict, use of large datasets and econometric analysis alone has been unable to

draw the indelible connections scholars had hoped. The use of country wide data are seen

as insufficient in capturing localized dynamics of civil violence calling into question the

applicability of current conceptual frameworks. Case study and data collection at

sufficient granularity are now necessary steps in the further exploration of this topic. To

help develop our understanding of how localized conflict emerges this dissertation steps

away from the use of traditional case study and econometric analysis to develop two

agent based models of protest that allow exploration to changes in the average level of utility, its distribution, and growth on the onset, size, and frequency of protest.

This dissertation finds that the level and distribution of utility affects the onset, evolution, magnitude, and frequency of civil instability. Further, empirical methods explored to date fail to account for significant micro dynamic behavior that influences the emergence of mass protest. This dissertation extends earlier modeling work on civil protest and discusses findings on how utility levels in a system of agents affect the magnitude, frequency, onset, and structure of civil conflict. The most surprising finding is the bifurcated relationship between utility distribution and the emergence of civil conflict. This specific result provides a plausible explanation for why empirical analysis has thus far been unable to correlate income inequality and civil violence.

THE EFFECT OF ECONOMIC CONDITION ON CIVIL UNREST: NEW
INSIGHTS FROM AGENT BASED MODELLING


By


Charles Thomas Harry


Dissertation submitted to the Faculty of the Graduate School of the

University of Maryland, College Park, in partial fulfillment

of the requirements for the degree of

Doctor of Philosophy

2013

Advisory Committee:

Professor John Steinbruner, Chair

Professor Peter Rueter

Professor Madiha Afzal

Professor Tim Gulden

Professor Victor Yakovenko

# Dedication

In memory of all peoples who have given everything
for themselves, their families, and their countrymen in the pursuit of liberty.

# Acknowledgements

Any effort of this magnitude relies heavily on the support of others, some for clarification of research questions, others for the ability to talk through conceptual problems, and yet still others for emotional support necessary to persevere. I would like to thank the Dissertation Chair, John Steinbruner who over years of study at the university has challenged me to think about the world in different ways, provided gentle critique that always made for better research drafts, and introduced me to the world of agent based modeling. His countless hours of guidance have helped me to become a better writer and scholar. I would also like to thank the CISSM Research Director Nancy Gallagher who over the years has become both a mentor and friend. Her countless hours of informal guidance has helped me both question conventional wisdom on various international security topics and provided useful critique of my thinking on a range of topics.

I would also like to thank members of my dissertation committee who have spent countless hours reviewing, marking, and commenting on my dissertation. I would like to specifically acknowledge Tim Gulden who spent time going through the ABM code to ensure that I had not made any catastrophic mistakes in the programming. I would also like to highlight the time Professors Afzal, Reuter and Yakovenko have set aside to meet with me to discuss and comment on the research in this paper. There is no doubt that the paper is a better product with their comments.

Lastly I would like to thank my friends and family and specifically my wife Nicole, without whom I might never have finished this paper. Her constant support during

periods of frustration, code rewrites, and program failures has made this project possible.

Her indelible love and affirmation during this process is a testament to her reservoirs of

patience and understanding.

# Table of Contents

# List of Tables

# List of Figures

## Chapter 1: Introduction

**"All civilization from time to time has become a
thin crust over the volcano of revolution"
-Havelock Ellis**

On the morning of December 17th 2010, a Tunisian fruit vendor named Mohamed

Bouazizi took a can of gasoline and doused himself in front of the local governor's office.

Yelling in the middle of a busy street "How do you expect me to make a living?", he

struck a match and lit himself on fire.  The sole income earner for his family, Bouazizi

was upset at having his fruit cart confiscated by local police who frequently harassed

vendors in the area. The morning prior, Bouazizi had borrowed money to purchase his

inventory only to have his cart and inventory confiscated by the state. With no other

means to support his household and now deeply in debt, Bouazizi sought an audience

with the local governor who refused to meet with him. With seemingly no other means of

voicing his discontent,  Bouazizi embraced an extreme form of protest against his

economic condition. The self-immolation and subsequent death of Bouazizi sparked

immediate protest in the localities outside of Tunis, quickly increasing in scale and

intensity eventually leading to the removal of the central authority. What began as an

individual protest of 's economic condition against an agent of the Tunisian state, spread

across the Arab world leading to civil protest, revolt, and in Libya and Syria -- civil war.

What has become known as the Arab Spring has dramatically transformed the domestic

politics of states in the region and has altered the geo-political calculations of the

international community.

Armed violence in its various shapes and forms has lead to the deaths of over 740,000 people per year.[1] While civil conflict is not a new phenomenon, the correlation between failed states and rising fatalities resulting from internal conflict has made it an enduring international security challenge. The problem of civil conflict includes its moral considerations, possible spillover effects, the use of denied areas as a base for terrorism, and the economic consequences associated with the possible impediment of trade in the region. From piracy in Somalia, insurgency in Mali, or the massive loss of human life in Congo serves to highlight the ongoing importance of this issue for international security practitioners and scholars.

### *Scholarship on Economic Determinants of Civil Conflict is Insufficient*

Central to developing policies that help stem the slide into conflict are efforts to understand the conditions associated with intrastate strife. Research efforts have explored environmental, political, and economic determinants using both qualitative case studies and large macro-economic regression analysis. Current theory on how economic conditions in a country affect the emergence of civil conflict explains its presence as a function of the difference between the benefits accrued to participants after its they account for the costs of rebellion. The so-called supply side eschews individualized grievance arguments and states that when the sum of estimated benefits outweighs the

---

[1] Global Burden of Armed Violence, Geneva Declaration Secretariat, Geneva 2008, http://www.genevadeclaration.org/fileadmin/docs/Global-Burden-of-Armed-Violence-full-report.pdf

perceived costs, conflict ensues.  Therefore, conflict is merely a quasi-criminal enterprise with its true purpose cloaked in the language of a more noble cause (e.g inequality or poverty).

The supply side explanation suffers from two primary weaknesses. First, it assumes that the populace who either directly or indirectly support insurrection calculate the benefits and costs of rebellion with the same value, weightings, and probability of success at the same time. By doing so this construct assumes homogeneity among individuals and does not account for non-financial costs (i.e possibility of death, separation from family, etc) in the calculation. This simplifies the decision to a point where an extra dollar of income from rebellion is enough to have them quit their profession and join a rebellion.  In addition to failing to account for non-financial costs, this construct must assume that all persons seeking to rebel calculate the benefits and costs in a similar manner and at a close enough interval to engage in mass action. Even if we set aside the timing problem, the construct that financial gain from lootable resources are the only gains one person would want from protest and revolt ignores very real motives human beings have had for engaging in protest.

The second problem with the current theoretical construct is that it does not account for localized dynamics. If the decision calculus is applied across the country to each citizen, there is no means by which 's decision is influenced by their neighbors. This provides us with an image that a individual finding that the benefits outweigh costs to protest runs into the street only to find that that no one else is ready to join. This creates a problem in understanding how protests originate, form, develop, and grow into larger movements.

*Towards Understanding the Dynamics of Localized Civil Conflict*

Civil conflicts are episodic in nature often stemming from localized conditions for which large country level data analysis is poorly suited to understand the evolving dynamics of protest and revolt. The lack of consensus on the applicability of some econometric results has lead to calls for additional data collection at sufficient granularity to capture localized conditions prior to and during outbreaks of civil conflict. Obtaining higher granularity data sets not only requires financial resources, but also are frequently undertaken in difficult conditions and often in areas that threaten the safety of the researchers themselves. Because of the inherent cost and difficulty of gathering data, the first step in developing higher resolution analysis must be conceptual exploration of localized conditions to help identify the most useful observations for subsequent analysis. This dissertation is an attempt to meet that challenge by conceptually exploring micro level dynamics of civil conflict, specifically how economic condition of the individual influences the evolution localized protest and revolt. This has the benefit of not only allowing for a better theoretical understanding of what is transpiring at the local level, but serves a practical purpose in defining what data would be useful in understanding the relationship between economic conditions and the emergence of civil conflict. In this regard, agent based models are uniquely suited to explore bottom up approaches and to identify localized dynamics that more traditional methods are unable to capture.

In this spirit this dissertation steps away from traditional case studies and econometric analysis to develop an agent based model of protest that allows us to conceptually explore how changes to the average level of utility, its distribution, and growth affect the onset, size, and frequency of protest. The approach taken allows us to make changes to

individual economic conditions and then observe the evolution of protest. I find that lower levels of utility increase the size, frequency, and onset of civil protest. I also find that the distribution of utility between individuals significantly impacts the magnitude and the frequency of punctuated protest. Most significantly I find that inequality is shown to have a more complicated relationship with civil protest than previously thought. In higher utility models, inequality has a direct relationship with civil protest, while in lower utility systems it reverses to help engineer greater civil protest. This result highlights a significant problem in most empirical models seeking to test for statistical correlation between inequality and civil conflict. Specifically this result demonstrates that most models that have sought to test the relationship between the two are mis-specified. Policy conclusions generated from the belief that inequality does not matter in the generation of civil protest need to be reassessed.

*The Structure of the Dissertation*

This dissertation is structured in a linear fashion: a review of the scholarly literature, a discussion the methodology employed in the study, the results of the static and dynamic models, and finally a discussion of the policy considerations and areas for future research. The literature review found in the second chapter of this dissertation broadly reviews determinants of civil conflict. This chapter also addresses conceptual changes on how we think about the emergence of civil protest and violence in society. This view is derived from earlier work utilizing agent based models, notably the Brooking Institution's Brookings Model.

The third chapter details the specific methodology and computer code developed for the purposes of conducting research. This chapter utilizes a framework that attempts to make the structure and assumptions in the model transparent to the reader who might not be familiar with agent based models. The full code utilized in this dissertation can be found in the appendix.

The fourth and fifth chapters of the dissertation lay out the results of a static and intertemporal model. The central findings build upon earlier work of Epstein, Steinbruner, and Parker who introduced the original Brookings Model. The findings stem from a more thorough exploration of conceptual changes to that model by highlighting how changes to average utility and its distribution affect the *onset, frequency, and duration of protest*. The fifth chapter moves beyond simple changes to average utility and distribution and introduces changes to utility over time. This effort is a broader extension of earlier research efforts by demonstrating how both changes to the average level of utility affect protest, but also *how the rate of change to utility directly affect the magnitude, duration, frequency, and evolution of civilian protest into open revolt*.

The final chapter of this dissertation discusses policy implications of the model's findings along with suggestions for future areas of research. The policy implications discussed primarily address the surprising results dealing with changes to utility and specifically how inequality of utility affects civil unrest. Areas of future research are divided between suggestions for improvement of the conceptual model and for areas of future empirical work to test the findings emanating from the model.

# Chapter 2: Literature Review

Turning and turning in the widening gyre
The falcon cannot hear the falconer;
Things fall apart; the centre cannot hold;
Mere anarchy is loosed upon the world,
The blood-dimmed tide is loosed, and everywhere
The ceremony of innocence is drowned;
The best lack all conviction, while the worst
Are full of passionate intensity.

-William Butler Yeats, *The Second Coming*

Modern scholarship on the origins and determinants of civil violence is multi faceted covering ecological, social, geographical, and economic variables that lead to social instability. In this chapter, I limit my discussion of social instability to the literature concerned with economic determinants of social instability discussing in broad terms the central finding of key researchers, the evolution of their ideas, and finally the current state of the field. Lastly, I advance my position that individual economic condition is a central motivator for men to engage in unorganized civil protest and is best understood as a resulting phenomenon emerging from interactions between individual agents who choose to either express their grievance or to remain quiet based on the legitimacy of the central authority or the presence of security forces. The argument draws from both grievance and rational actor literature and is centered on the individual as the primary unit of analysis. The resulting conclusion supports the use of agent based modeling as a useful and necessary tool for understanding the complexity and underlying dynamics of civil protest and violence. The use of agent based modeling allows us to overcome the

collective action problem that has been put forth by rational actor proponents as a fundamental weakness of grievance based determinants of civil violence. The use of this construct allows us to move beyond statistical analysis that attempts to connect variables through correlation and towards a system that provides a coherent and evolutionary model that ties individual economic condition to mass protest.

*Individual Grievance as Motivation: Relative Deprivation*

Political scientists extended the observations of Plato, Aristotle, and De Tocqueville for social instability more formally in the 20th century. The early theory for determinants of civil conflict and rebellion are tied to measures of individual or group grievance. Individual grievance, or what Ted Gurr termed relative deprivation, explores the psychological underpinnings of human frustration leading to aggression tying in societal condition and the mobilization problem of mass protest and rebellion. While the grievance literature encompasses a wide range of determinants leading to individual frustration, this dissertation specifically limits our definition of relative deprivation to economic factors.

 Group grievance, specifically frustration resulting from inequality, primarily discusses the role of land or income inequality and aggression between groups. Both views independent of individual or group grievance discuss the mobilization challenge of turning angst of individuals into mass protest. The mobilization problem for would be protestors therefore becomes an important determinant of organized protest, rebellion,

and possibly civil war leading future researchers to focus less on motivation and more on the feasibility of rebellion.

While conflict between rulers and the ruled have remained a constant throughout human history, speculative conclusions between the human condition and the manifestation of civil violence constituted the bulk of human knowledge on the subject until the mid 20th century. The modern treatment of the subject focused on two competing views of the determinants of human aggression: individual vice group grievance. While group grievance maintains elements of arguments associated with individual frustration, its primary focus is centered upon conflicts between groups/classes stemming primarily from inequality.

The modern treatment for understanding the reasons for individuals to rebel against the state stems from the work of Davies 1968 and Gurr 1970. Gurr examines the psychological and social sources of potential conflict, the potential for the political institutions to be blamed as the source of the individual's frustration, and finally what societal conditions magnify and form the rebellion (Gurr 1970). Developing what becomes known as the "Frustration-Aggression" proposition, Gurr asserts that the greater the intensity of the frustration among individuals in a society the greater the magnitude of violence witnessed. The frustration manifests itself into violence that affects the scope, intensity, and duration of action among the populace. Gurr outlines the manifestation of violent action as the movement from discontent of the populace, to politicization of that discontent, to finally actualization of the frustration towards aggression against the state.

Gurr formally defines the frustration of individuals as the difference between a person's value expectation and their value capabilities. The difference is identified as relative deprivation. The individual's value expectations include their desires to obtain for themselves and their family the physical (e.g shelter, food), political (e.g democratic rights, or expression), and psychological goods (e.g prestige) required to lead a fulfilling life. Their value capabilities are their *perceived* ability to achieve these goods at present and into the future. Therefore, Gurr argues that changes to the *intensity* of a person's deprivation and the *scope* of that condition across society motivate individuals to rebel.

The purpose of our exploration is to understand how purely economic conditions affect the actions of an individual to engage in protest against the state. While grievance arguments are multifaceted, I am specifically interested in how changes to income or state subsidies affect a person's condition. Therefore I use the term relative deprivation to specifically mean the difference between an individual's expected and actual economic condition. The intensity of the relative deprivation is primarily a measure of change to the individual's specific life condition. This condition can be thought to be primarily tied to income, but a broader measure of individual utility which includes the affect of state services, inflation, or economic growth are likely to capture the broader individual condition. Utilizing the cruder income measure an individual who earns 100,000 dollars in one year, but loses his job the next, finds his capability of achieving his value expectations is significantly reduced thereby intensifying the relative deprivation. The intensity of loss can be mitigated through diversified support structures such as savings, family, or the state. However, in extreme circumstances with little to no support, individuals might resort to dramatic action to stem the intensity felt.  When Tunisian

fruit vendor Mohamad Bouazizi had his vegetable cart confiscated in December 2010, his sole means of supporting a family of eight, the intensity of the loss spurred him to set himself ablaze in front of the regional police station as a protest[2]. Bouazizi's action was unlikely part of a highly thought out public relations campaign to engineer a rebellion against the Tunisian government, but more likely an expression of extreme frustration about the conditions he was experiencing.

The intensity of relative deprivation is important in understanding how a person's frustration about his or her situation translates to possible protest, however, the specific circumstances of individuals cannot alone explain mass protest or rebellion. Instead, given that mass protest or revolt is a group activity, the intensity of the deprivation must be shared amongst others for mobilization to extend beyond a single act of frustration. Gurr defines this as the *scope* of the deprivation, with the appropriate question being what proportion of the society is discontented beyond a specific threshold (Gurr 1970). Scope therefore is a horizontal measure of relative deprivation across more than one individual. The protests that emerged in Tunisia after Bouazizi set himself on fire began first as a voice of support, but soon morphed into larger protests centered on economic conditions (e.g unemployment) and the government's incompetence in dealing with those conditions[3]. The intensity of the deprivation first demonstrated by Bouazizi through his individual act of protest triggered other individuals to act in ways that revealed the scope of deprivation amongst the Tunisian populace, becoming the rallying call for organized protest against the state. So if the scope of relative deprivation is also important how do we measure it in a society? Instinctively we might want to understand the distribution of

[2] http://www.reuters.com/article/2011/01/05/ozatp-tunisia-suicide-idAFJOE70408420110105
[3] http://www.aljazeera.com/video/africa/2010/12/20101228182021539319.html

income as a proxy, but Gurr's point about scope is not purely distributive. Gurr cites that relative deprivation between groups, or horizontal inequity, drives an individual perception of their condition (Gurr 1993, 2000). It is possible to have a situation where a group of individuals are doing relatively well based on a national average, but compared to another group are lacking. This horizontal inequity can generate frustration as their inability to reach their expectations as compared to another group remains a source of relative deprivation. Therefore, the scope of deprivation implies that distribution within context matters. The combination of income, distribution, group dynamics, and percentage of populace living below some threshold determines the scope of deprivation not simply the distribution. This implies that a measure of inequality alone is insufficient as a determinant for civil protest or rebellion.

In Gurr's argument, the central unit of analysis is the individual. His theory is grounded in the psychological desires for individuals to meet their expectations. Specific to this analysis is the desire to primarily provide the physical goods for oneself and family (e.g shelter and food) followed by political expression and finally by psychological goods (e.g honor or prestige). The intensity and scope of deprivation become instrumental as a motivation for unorganized protest or rebellion.

*Group Grievance as Motivation: Inequality*

 While individual hardship and the grievance that may result from it is a logical extension from psychological studies that draw the connection between frustration and aggression other researchers contend that while possibly true, *it is the inherent group inequality that*

*that drives mobilization for protest and rebellion*. This is the distinction that moves us from a single man lashing out in a crime or act of protest and towards a larger group that engages in peaceful protest or riot over their perceived hardship. The inequality proposition is divided into two competing views. First, that inequality, specifically in regards to land, is the primary determinant of protest. More specifically, "the land maldistribution hypothesis is based on the assumption that discontent resulting from a highly concentrated distribution of land and/or lack of land ownership (landlessness) in agrarian societies is an important direct cause of mass political violence" (Muller & Seligson 1987). Russett is typical of this view in stating that

> "extreme inequality of land distribution leads to political instability only in those poor, predominantly agricultural societies where limitation to a small plot of land almost unavoidably condemns one to poverty" (Russett 1964)

Russett finds in his research that inequality of land ownership does correlate with higher levels of political violence (Russett 1964). Yet despite this result, one of the problems proponents of this view have to contend with is the general lack of quality data on measures of inequality. Empirical evidence is generally drawn from case studies or limited cross-national datasets. Midlarsky addresses this issue by examining structured measures of inequality and finds a bifricated result between inequality and violence (Midlarsky 1982, 1988). He argues that simple generalizations of inequality, such as a Gini coefficient, are insufficient to capture the relationship between land distribution and political violence.

The second view of inequality and political violence contends that income inequality, and not mal-distribution of land, is the primary determinant of mobilized protest. Edward Muller and Mitchell Seligson are typical of this view asserting that income inequality of income serves to motivate urban dwellers vice rural peasants (Muller & Seigson 1987). They argue that the problem with the land inequality hypothesis is that the organizers suffer from a mobilization problem, where in urban settings individuals find it easier to find a larger group of disaffected individuals and find it easier to organize. Supports of this view tend to argue that the large concentrations of disaffected are both aggrieved and are in proximity to one another allowing for better organization, thus making income inequality a better measure of the probability of violent action.

*Mobilizing Discontent: Beyond Motivation*

To this point we have discussed mostly the motivation by which individuals might justify their action against the state. Early theory focused on the individual or group motivation that inspires this action acknowledging that moving from individual or group discontent toward action required overcoming the mobilization problem (Tilly 1978, Tarrow 1994). The development of what became known as the mobilization theory discounted the grievance argument all together citing that individual hardship or organized grievance always is present (e.g. there will always be poor people), but what is important is the ability to mobilize large numbers of individuals. Specifically supporters of this view move the debate on the determinants of civil conflict away from measures of individual grievance or perceived inequality and towards the issue of collective action (Lichbach 1994). Specifically the collective action problem frames the conundrum of joining a protest or revolt where a representative rational actor evaluates the costs versus benefits

of the action (Olson 1965). Central to the conundrum is if one can enjoy the benefits of a protest without joining, why not free ride on the efforts of others? If this holds true grievance alone is not enough to organize mass protest or sustained violence (Lichbach 1994). The cost-benefit structure assumes a representative agent who evaluates the benefits of engaging in a successful rebellion versus the highly significant personal costs of failing in the endeavor (e.g death or jail). Of course rebellions have in fact occurred, thus challenging the collective action problem and leaving proponents of the mobilization problem to deduce the need for private benefits to the would-be rebels (Lichbach 1990, 1994). The benefits that are needed by individuals to motivate them to protest have become the basis for the analysis put forth by the rational choice and specifically the greed hypothesis researchers of the 1990s and 2000s.

*Rational Choice: Origins of the Greed Hypothesis*

Understanding the origins of civil violence had been for decades the domain of political scientists, however economists have taken interest in the subject applying models that seek to explain human behavior as a set of outcomes based on decisions grounded in preferences and future expectations. The rational choice literature is based on the premise that individuals evaluate costs and benefits based on their preferences and the information they possess. Eschewing political and cognitive explanations of individual grievance or deprivation, the choices made by individuals to rebel are due to the individual's perception, preferences, and most importantly the opportunity to take from others. Deducing the benefits of protest and rebellion become the primary area of analysis and reason for men to rebel. In this construct rebellion is a phenomenon where the collective

action problem is overcome by specific inducements to individuals large enough for them overwhelm the consequences to their actions. The origins of this conflict theory are based on the crime model proposed by Becker (Becker 1968), and more formally from Lichbach (Lichbach 1990, 1994) and Hirshleifer (Hirshleifer 1994). Hirshleifer defines his model formally by describing individuals as presented with a decision space that based on their perceptions, preferences, and opportunities for obtaining income from others inform their actions either to engage in conflict or to negotiate a settlement. Essentially the model dictates a profit calculation for the individual. If the person feels that the benefits of a successful revolt outweigh the costs of that action then they will choose to rebel. If their calculus implies that the costs outweigh the benefits they will seek a negotiation. The space for agreement is formed by the actor's perceptions for their likelihood of success. Therefore, the size of the settlement space between individuals, or groups, can change based on specific information or to the change in perception. If a individual thinks that the chances for victory are high then that will weight their decision more heavily towards action. So based on this model, how do individuals mobilize for protest or revolt? This view assumes that all individuals roughly weigh and value the benefits and costs in the same manner. The opportunity for collective action therefore is what results from rational decision making by the representative individual. This approach has been termed as the "supply-side" of rebellion. By assuming that the representative agent broadly applies to all people in the society you are able to overcome the collective action problem, but it ignores how a conflict can evolve over time leaving us with the impression that individuals will reach the decision to rebel at the same time. The rational choice framework is useful in advancing our understanding of conflict as a

function of individuals weighing the benefits and cost of rebellion. However, this
approach suffers from some serious deficiencies as it primarily is utilized to quantify the
economic benefits of rebellion (e.g rents from lootable resources) while ignoring
unquantifiable benefits to the individual (e.g democratic representation). Further, it has
no explanation for an evolutionary processes as the representative agent roughly
processes all information simultaneously. If in fact we relax this binding constraint the
individual would need not only calculate all benefits and costs, but also the probabilities
of others showing up, thereby falling victim to the same collective action problem it cites
against grievance based arguments.

The ability to overcome the collective action problem for rebels became a central concept
of conflict scholarship in the 1990s. Researchers noting the pervasive and intractable
problem of poverty world-wide attempted to move the debate to one where the
emergence of civil violence moved beyond reasons that are likely to always persist (e.g
poverty), and to one where the conditions made it possible for rebellions to sustain itself
financially, allowing protest to evolve into civil war. While Lichbach and Hirshleifer
defined the individual logic and conceptual ground for rebellions to occur only where the
benefits of rebellion outweigh the costs, it wasn't until Collier & Hoeffler defined a
construct and attempted broad based testing that these concepts rose to the vanguard of
conflict scholarship.

*Deducing Benefits for Mobilization: Emergence of the Greed Hypothesis*

Rational choice theory of civil war has profoundly shaped scholarship of civil violence, specifically the discussion of causes of civil war over the past 15 years. The papers, books, and case studies generated over have served to mold public policy initiatives aimed at reducing the chance of large-scale civil conflict. The work of Grossman and Hirshleifer focused the interests of economists who sought explanations that separated the romantic idealization of the revolutionary leader fighting for freedom towards the conditions that made civil war feasible. Two sets of researchers have moved this area of scholarship forward. Collier & Hoeffler and Fearon & Laitin have articulated and adopted the feasibility hypothesis as a likely explanation for the onset of civil war providing the field with its dominant view of the likely causes of civil conflict.

Collier & Hoeffler formally defined their model of the likelihood of civil war by proposing a utility model of benefits and costs that define the decision of individuals to engage in civil war (Collier & Hoeffler 1998). The model defines a decision of a representative individual to rebel as essentially a profit calculation where benefits minus costs are defined and computed. If the value is strictly non-zero then war will occur. The benefits to the individuals are calculated by summing across periods from the end of hostilities through infinity the gains accrued which itself is a function of the taxable base and the size of the population. The costs to the individual, summed from the onset of rebellion to its conclusion, are lost income and the coordination costs between groups to sustain a rebellion. The model implicitly assumes that all actors perceive and calculate the benefits and costs equally (or at least on average). The Collier & Hoeffler model moves the conflict literature away from discussions of personal or political grievance as the source of angst and conflict, and towards a model for which aggregated societal

decisions about the benefits of rebellion are the determining factor for the emergence of civil war. This model implies that all members of society have access to complete information in order to make their calculation, and that all members of society will at some point reach the cost benefit calculation at the same time. Collier & Hoeffler do not provide a framework on how this phenomenon emerges amongst the populace, only simply to identify the activity as a binary condition (e.g civil war occurs or does not occur).

The model presented in the initial rational choice argument lays out a theoretical framework from which to test specific variables utilizing a logit regression model(Collier & Hoeffler 1998). To test the viability of their theory, Collier & Hoeffler specify independent variables aimed at capturing correlating effects between them and the outbreak of civil war. They test measures of economic activity, political and economic grievance, as well as socio-demographic determinants for civil war (Collier & Hoeffler 1998, 2002). They conclude that high incomes, smaller populations, average social fractionalization are the most stable, while countries with low income, higher levels of natural resources, and average fractionalization increase the level of conflict.  Mostly importantly, they find that measures of grievance (levels of democracy, income inequality, and high ethnic fractionalization) have little to no explanatory power for the emergence of civil war (Collier & Hoeffler 1998, 2002). Yet they do find a strong relationship between specific levels of primary commodity resources (e.g 22-31%) relative to GDP, and measures of economic output (e.g lower GDP per capita and lower economic growth) (Collier & Hoeffler 1998).

Collier & Hoeffler interpret their results in the construct of the benefit cost model for the onset of civil war (Collier 2000, Collier & Hoeffler 2002). The authors explain the significance of primary commodity share of GDP as a readily accessible financing measure for rebels due to the immobility of resources by the government. As the level of primary commodity as a share of GDP increases the value to a potential rebel group increases thereby increasing the benefits accrued to a rebel force. Interestingly, the authors note that the result is not monotonic and instead implies a parabolic shape. They reason that as the share of that primary commodity increases relative to total GDP, there is a greater incentive for the government to protect the resource. While Collier & Hoefeller cite this as strong evidence of rebels motivated by the benefits they accrue from lootable resources, others find the result to be fragile, log-liner in shape, and mostly explained by oil producing countries (Fearon & Laitin 2003, Fearon 2005).

In addition to the benefits obtained from the acquisition of a natural resource such as timber or diamonds, Collier & Hoeffler find that economic measures such as lower GDP per capita and low economic growth increase the probability of an onset of civil war. They reason that lower GDP per capita, acting as a proxy for a person's income, lowers the opportunity cost of joining a rebellion. Additionally, lower economic growth implies fewer jobs thereby also lowering the opportunity cost of joining in a rebellion. Strangely, the authors ignore income per capita as a likely source of individual economic grievance instead choosing to see these results as a measure of joining an alternative work structure (e.g rebellion against the state).  The authors also find that increased ethnic fractionalization lowers the probability of an onset of civil war supporting their contention that numerous ethnicities increase the costs of maintaining a unified rebellion.

Lastly, they find that large populations apparently correlate with greater probabilities of civil war onset.

The empirical result stemming from Collier & Hoeffler's model defined a relatively narrow view of what generates the onset of civil war. They moved the discussion away from an individual grievance model, and instead focused the analytic efforts on the opportunity for civil war informed by multiple citizen's' calculus of the costs and benefits of a rebellion. This became the basis for what is termed the "greed" hypothesis. In its extreme version, civil war is simply a quasi-criminal activity, with rebels seeking income from looting natural resources while using the language of grievance (e.g inequality, political rights) as part of a larger public relations campaign. The identification of specific examples such as the conflict in Sierra Leone (e.g diamonds), or the FARC in Columbia (e.g cocaine) provided specific case studies that lend credence to the belief that civil war is simply a quasi-criminal enterprise. However, the greed hypothesis does not appear to be a good model for explaining more recent revolutions in the Arab world (e.g Jordan or Syria). Collier & Hoeffler although acknowledging personal grievance as a factor for rebel support, see the "feasibility" of civil war, defined as the financial and military feasibility of victory, as the definitive determinant of civil war and not group grievance (Collier, Hoeffler & Rohner 2007).

*An Alternative Explanation in the Rational Choice Framework*

Responding to Collier and Hoeffler and putting forth their own view on the onset and prevalence of civil war, Fearon and Laitin support the rational choice framework but challenge the primary commodity hypothesis (Fearon & Laitin 2003). Fearon and Laitin

broadly agree with Collier and Hoefeller's view that civil war is a manifestation of opportunity by rebels rather than a grievance for lack of political rights or economic equality. Yet, while supportive of the rational choice framework in principal, they challenge two primary findings of the Collier and Hoeffler model: the relationship between primary commodities as a share of GDP and the effect of ethnic fractualization. They find that the relationship between primary exports and conflict is both a fragile result and one mostly explained by countries with large percentage of oil based exports (Fearon & Laitin 2003, Fearon 2005). They also note that once they control for income, they are unable to replicate Collier & Hoeffler's findings of a substantial negative relationship between ethnic fractualization and the onset of civil conflict (Fearon & Laitin 2003). Instead, they argue that the lack of governmental strength manifested in weak governance is the primary determinant of civil onset. They also find that similar to Collier and Hoeffler, traditional measures of political and economic grievance do not appear to be significant.

*Grievance Arguments in Response to the Rational Choice Hypothesis*

The emergence of the rational choice theory and the subsequent articulation of the "greed hypothesis" provided a significant challenge to the broadly accepted grievance theories of previous decades. The shift away from individual or group grievance determinants and towards a feasibility approach to the emergence of civil violence is largely based on the large cross-country datasets used by Collier & Hoeffler and Fearon & Laitin who argue that the principal determinant of civil war onset is the feasibility of the conflict and not

any underlying grievance. The empirical work that formulates the basis of the greed hypothesis has provided some solid statistical evidence. It has pushed the field to address some significant questions concerning the determinants of civil war onset and prevalence, however, despite the claims of its proponents it has yet to refute the contention that grievance of individuals remain an important determinant of civil conflict. Supporters of rational choice theory, specifically the greed hypothesis, have acknowledged weaknesses in the quality of grievance variables, specifically income inequality. The findings in this paper show that assuming a simple direct relationship between inequality measures and civil conflict are insufficient to capture the complexities of distributional phenomenon in a country and its relationship with civil instability. Researchers have also acknowledged that their statistical methods may not be sufficient and have proposed additional work on the subject (Collier 2000). While some evidence in the original Collier & Hoeffler model are supported by others, the lack of consensus on a purely primary commodity explanation for civil violence undermines the universal conclusion that all civil war is a function solely of rent seeking behavior. In fact, other researchers have explicitly stated that there remains no consensus on the issue of income inequality and conflict, arguing that the data is both incomplete and insufficiently transparent to draw the inference that some grievance indicators are unrelated to the onset of civil war (Sambanis 2004).

In the wake of research that minimizes the importance of grievance indicators, supporters of grievance based motivators for civil conflict have more recently explored these outstanding questions by conducting additional studies examining the lack of political representation, ethnic tension, and chronic income disparities and have found that they have been linked to violent action most specifically terrorism (Crenshaw 2007). Gurr, a

strong supporter of individual grievance as a motivator for violent action, has identified

that ethnic tensions account for significant numbers of conflicts that can not be explained

by resource based arguments (Gurr 2000). Sambanis finds that as you separate ethnic and

not ethnic wars, there appears to be a positive relationship between the level of ethnic

heterogeneity and civil violence (Sambanis 2001). Others have noted that economic

grievance indicators and not primary commodities are shown to help in the intensity of

civil wars with grievance factors leading to pent up explosions of frustrations among a

populace (Lu & Thies 2011). While others show that drops in foreign aid to countries

leads to civil conflict (Nielsen, R & et al 2011)).

So where do we stand in our understanding of the determinants of civil conflict? What is

apparent is that while a great deal of statistical work has been done  on economic,

political, and socio-demographic condition and the probability of civil conflict, there

remains significant disagreement on how unorganized protest manifests itself into violent

collective action. Grievance based arguments of relative deprivation or group inequality

suffer from the dilemma of collective action, while purely greed based arguments fail to

incorporate individual or groups grievance as motivation, instead focusing only on rent

seeking behavior of individuals. While some empirical evidence supports the economic

greed arguments, the lack of quality event data at local levels for grievance estimators

calls into question the broader conclusion that individual grievance remains uncorrelated

with civil violence.

*Moving to Case Studies and Examination of Local Data to Understand Civil Conflict*

In the roughly 15 years since the rational choice economic models were proposed, several articles have been published examining the statistical relationship of greed and grievance indicators on social instability. While several earlier papers have confirmed the correlation between economic determinants with civil conflict, later work has called into question the broad applicability of those results to all forms of civil violence (Collier 2000, Collier 2007, Fearon 2005, Epstein 2010, Goldstone et al 2010). Goldstone, Gurr, and others have directly refuted the results claiming that changes to model specifications show that other measures including political institutional structure matter more than economic conditions (Goldstone, Gurr, et al 2010). While a robust debate has continued, a consensus has emerged where additional exploration of local conditions is required to understand the complex phenomenon occurring in conflict prone areas. A noteworthy voice of this consensus is Nicholas Sambanis. In response to the results presented by proponents of greed-based determinants, Sambanis argues that comparative case studies are required to refine our understanding of the statistical results (Sambanis 2004). He argues that a general weaknesses in the economic models of civil war are that they cannot distinguish civil war from other forms of political violence and have been shown to suffer from problems with measurement error, unit heterogeneity, model misspecification, and lack of clarity about causal mechanisms. The inability for these models to understand the formation of varying degrees of civil conflict from local conditions seriously undercuts our ability to understand political violence (Samabanis 2004).

In response to a call for localized analysis to help refine our understanding of determinants of civil conflict, some case studies and statistical analysis of specific localities have begun to be pursued. Three such articles detailing conditions in Nepal,

Nigeria, and India highlight the local level data required to understand the local conditions that foster social instability (Deraniyagala S (2005), Oyefusi, A (2008), Vadlamannati, K. (2011)). In the case of Nepal, Deraniyagala examines the economic causes of the civil conflict. He finds that relative deprivation and related economic grievances are key casual factors in the conflict. The resulting civil instability is found to be a byproduct of uneven development policies during a period of economic liberalization (Deraniyagala 2005). Oyefusi's analysis of civil conflict in the oil producing region of Nigeria utilizes extensive surveys of combat aged men in the area. He finds that increasing individual levels of income reduce the probability of men joining a rebellion against the state (Oyefusi 2008). Lastly, Vadlamannati examines local data to understand how economic conditions and political violence in North East India are tied together. He finds that poverty (relative to other areas of India) has a substantial effect on the outbreak of civil violence. Each of these studies highlights the inherent value in conducting localized analysis to provide greater fidelity to broader statistical results. While case studies and localized statistical analysis are essential, a shortcoming is that while data can be shown to correlate with each other, the lack of a coherent conceptual model that allows us to understand the evolution of political violence is missing. If the current models for economic determinants of civil conflict are insufficient then we require a new construct for which political violence can evolve into many forms.

*Revisiting Relative Deprivation as a Motive for Protest, Revolt, and Civil War*

This chapter thus far has presented the literature that appears to be most relevant in the discussion on the major determinants of civil conflict in human society. I am specifically

26

interested in exploring how *the economic condition of individuals acts as a determinant of protest and possible revolt*. I explore the conceptual space of how changes to individual's condition affect the larger system. Changes to relative deprivation, both in its magnitude, its distribution, and its rate of change are all likely to provide disparate outcomes that are worth exploring. The results from this exercise are aimed to provide both conceptual insights and propositions that could be testable if and when suitable data is made available. Therefore, I do not discuss in detail the political, religious, or socio-demographic characteristics of persons as possible motivators for them to rebel against the state. Instead, I argue that individual economic condition such as a person's general level of utility are an important determinant of hardship and serves as a motivator for growing mass protest against the state which if left unchecked can serve as the basis for a general revolt of the populace.

The investigation of the literature thus far has been specific to the scholarly works investigating the economic conditions for which individuals decide to engage in protest, revolt, or full rebellion against the state authority. These studies primarily utilize case study research and econometric analysis using large data sets. The first research method although extremely informative for the specific example is more difficult to broadly apply, while the second method crudely defines civil conflict (e.g 1000 deaths per year), utilizes country-wide average measures of proposed determinants, and is unable to shed light on the dynamic conditions leading to emergent phenomenon. Researchers have shown that macro level data often misses important signs of growing dissent within the populace, arguing that localized event data is a better predictor of protest (Jones 2007). To develop higher granularity data sets requires not only financial resources, but are

frequently undertaken in difficult conditions and often in areas that threaten the safety of the researchers themselves. Because of the inherent cost and difficulty of gathering high resolution data, the first step in developing higher resolution analysis is conceptual exploration. This dissertation is an attempt to conceptually explore micro level dynamics of civil conflict, specifically how economic condition influences the evolution localized protest and revolt. This has the benefit of not only allowing for a better theoretical understanding of what is transpiring at the local level, but serves a practical purpose in defining what data would be useful in understanding the relationship between economic conditions and the emergence of civil conflict. Utilizing a modified form of the Brookings Model, I demonstrate that changes to individual deprivation in the form of average utility and its distribution in a system of agents determines the onset, frequency, and magnitude of protest. I discuss the methodology of the model in Chapter 3 with findings in the model discussed more broadly in Chapters 4 and 5.

*Moving from Individual Economic Condition and towards Individual Grievance*

The decision to engage in protest and subsequently conflict against the state is an inherently personal choice that is driven by an individual's condition and their understanding of the external conditions they face in the society (e.g the presence of security forces, what other citizens are doing, etc). The individual as a singular entity or as part of a identified group experiences what Gurr refers to as relative deprivation. The change to relative deprivation can come from a variety of different source: loss of a job, a pay cut, reduction to purchasing power (e. g inflation), or cuts in public transfer payments. The gap between their capability and their expected outcome measures the size of the deprivation. Therefore, while either a job loss or a cut to a government subsidy

might cause an increase in their relative deprivation, the loss of a job is likely to lead to greater hardship. The relative deprivation in turn leads to grievance if the situation can be assigned to a specific entity (e.g state or another individual). If the deprivation increase is simply a result of their own actions, such as being fired for incompetence, the hardship they face is unlikely to emerge as grievance against another entity. Grievance against the state therefore emerges when an individual or group of individuals assign the source of their deprivation to the central government authority. In the simplest case, an individual who is experiencing extreme economic hardship, and who sees government inaction or policy as the root of that condition, might turn that angst to engage in some form of protest. That protest might be purely expressive in form with the image of a person standing on the corner yelling about the transgressions of the state on the people or in the attacking of a representative of the state. The intention of the protestor is likely not to radically transform a legislative agenda, but more to express their discontent. It is not infrequent to see individuals during tough economic times erecting tent cities protesting. The "Occupy Wall Street" movement, albeit aimed at corporate entities, is a good example of this phenomenon. However, the grievance people feel might also turn more violent if that individual decides to cause harm to themselves or others as a way of drawing attention to the problem or as an expression of pure frustration against a system they are individually powerless to change. This instrumental form of protest is likely to have deeper aims than a simple statement of frustration. The self-immolation of Mohammed Bouazizi in Tunisia demonstrates a expressive form of protest, while the subsequent protest and revolt of the Tunisian populace was instrumental.

*From Individual Grievance towards the emergence of Mass Protest*

While the motivations of an individual to vent his frustrations are easy to understand, what becomes more challenging to researchers is how that individual disaffection, even when shared by others, transforms into a mass protest. At the heart of the problem is again an individual's analysis on the likelihood of being successful in venting their discontent while not being arrested or killed by state forces. The cost of being the first person to demonstrate and thereby bear all the costs of that action is the heart of the collective action problem. From an instrumental standpoint no one wants to be the first person to protest if the costs of that protest are high and the probability of policy change is slim. In free societies where peaceful protest is permitted, the costs of protest are minimized as long as peaceful assembly is maintained. Therefore, the cost to the individual standing on the corner yelling about the transgressions of the state is effectively nothing. However, in less free societies even peaceful protest could be met with arrest, injury, or possibly even death. Therefore no single individual, unless highly risk tolerant or doing it for expressive reasons, is likely to be the first to protest their state of affairs. Instead, they may seek a private regress of grievance, or simply muddle through the hardship they are experiencing. However, if other citizens who are voicing similar concerns are seen by an individual who harbors similar thoughts, the potential for being singled out by police declines thereby reducing the overall disincentive of protest.
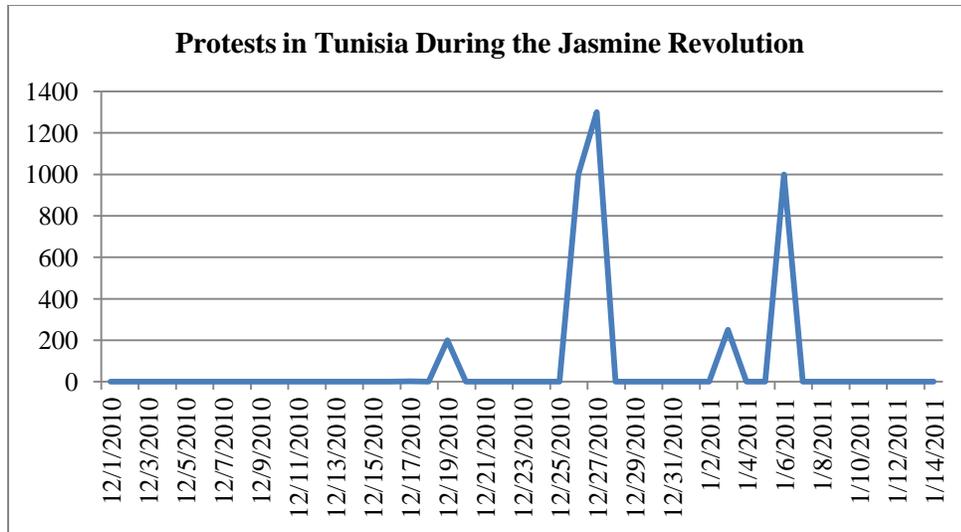
Figure 1: Protest Numbers in Tunisia during the Jasmine Revolution

In large enough groups, the costs will be minimized to such a degree that it is effectively

reduced to zero encouraging an exponential increase in the numbers of persons

protesting. This might occur because the number of security forces in a specific

geography in the short-run are relatively fixed thereby reducing the ratio of protesters to

security forces as the collective action grows[4]. As the protest expands, security forces

might intercede and seek to disperse the gathering. Thus, protests can take the form of

rapidly increasing protest followed by its quick dispersal. This is known as a punctuated

protest. Figure 1 highlights this phenomenon by graphing the number of protestors during

the Tunisian revolution. This figure demonstrates that while the press characterized a

general revolt amongst the populace in Tunisia, the form that action took included the

emergence of protest, followed by its collapse. The reemergence of protest after police

---

[4] The collective action problem is outlined in Mancur Olson's "Logic of Collective Action: Public Goods and the Theory of Groups"

action demonstrates that the underlying grievance of individuals (e.g their relative deprivation) remained unchanged. The introduction of security forces including the use of tear gas broke up the immediate protest, but failed to solve the underlying problem driving the civil unrest.  The cycle repeats until the government was toppled in early 2011, satisfying protestor demands and leading to the quelling of protest among the citizenry.

The emergence of individual angst into collective protest against the government stems from a myriad of issues unique in character and weighting to each situation. However, we might find that in general that personal hardship, the level of perceived legitimacy of the government, the actions of other citizens to either protest or not, and the presence of security forces who can maintain the peace or repress citizen action are important. Significant changes to the initial condition of personal hardship either in its absolute magnitude or to its distribution should have a material effect on the emergence of mass protest, ceteris paribus. Accordingly I  explore the proposition that changes to individual condition, on average, in distribution or over time, have an impact on the emergence, size, and magnitude of mass protest. To test this proposition, I utilize a modified form of the Brookings Model to test the effect of these changing conditions.

*Transforming Personal Grievance into Mass Protest: A New Approach on a Old Model*

To approach the problem of understanding how a change to individual condition affects the emergence of protest, I utilize a agent based model framework derived from the Brookings Institution's "Rebellion" model. The Brookings Model was the first attempt to understand the emergence of protest in a agent based system. The model utilizes many of

the concepts already touched upon in this paper: government legitimacy, hardship, grievance, security services, and risk tolerance. However, the Brookings model does not allow for changes in agent hardship on average either across the system or to its distribution. Second, it does not allow for changes to agent hardship over time.

I show that these small changes to the model have wildly different impacts on the emergence of mass protest. In many cases, the results confirm centuries old propositions about the relationship between increasing levels of hardship and protest (e.g the bread riot). However, some surprising results do emerge from the model regarding the effect of distribution on the emergence of protest.  In chapter 3, I discuss the methodology of the original Brookings model and the changes I make in the model. Chapter 4 discusses the results of the revised model in which no changes to individual condition occur over time (e.g Static). In chapter 5, I present finding associated with the dynamic model which allows for a system of agents to respond to changes in individual condition. This dissertation does not directly compare the model results with real world events because the lack of data available at sufficient granularity to verify the propositions in this paper puts it beyond our current abilities. Instead, the model generates insights that could be empirically tested if and when data becomes available.

# Chapter 3: Methodology for Understanding Civil Conflict

**"In perpetrating a revolution, there are two requirements: someone or something to revolt against and someone to actually show up and do the revolting. Dress is usually casual and both parties may be flexible about time and place, but if either faction fails to attend, the whole enterprise is likely to come off badly."**

**-Woody Allen**

Understanding the determinants of civil conflict remains an open research question despite the considerable efforts over the past decade. Empirical modeling in particular has been used to draw stronger conclusions between human behavior and its underlying causes. Yet, this is an inherently complicated task as interactions between factors are not easily teased out through simple mathematical or statistical models based on insufficient data sets. Researchers over the past decade have highlighted this challenge, empirically testing and validating some determinants, yet failing to reach consensus on others. The problem with many of the empirical approaches is both one of conception and one of data. The current state of the field currently lacks a coherent and evolutionary approach to individual economic condition and the outbreak of civil violence. While tremendous effort has been exerted to develop a "greed" theory that eschews individualized grievance factors and focuses on the benefits derived to would-be rebels it fails to account for how protest evolves into revolt and finally rebellion. Serious challenges can be made about the interpretation of greed variables that would provide evidence for a grievance theory of economic determination of civil conflict. Second the lack of data at local levels severely limits the ability to both test current propositions as well as help form new theory on localized civil conflict. Unfortunately the collection of data at a sufficient granularity can be both inherently dangerous as well as extremely resource intensive. Therefore it is

34

important to first conceptually explore how local dynamics contribute to emergent civil instability to help identify key data useful for empirical testing.

I  attempt to add to this conversation by utilizing a different modeling approach, conceptually exploring how changes to agent utility, both in magnitude and in its distribution, affect the emergence of civil protest.  The models and results presented demonstrate that the economic condition of the individual is a central determinant for the size, frequency, onset, and evolution of civil conflict.  While some results are intuitive (e.g greater hardship associated with greater magnitude protest), others provide fresh insight into the complexities of inequality and economic growth. This chapter discusses the approach I take in defining my modeling approach and how it builds on previous work done in this area to develop a new method useful in exploring concepts in changing conditions for individuals and their behavior in a defined system. I expand the Brookings model by changing the distribution used to examine utility, thereby allowing me to change the average level of utility, its variance, and allow for changes over time. The first section of this chapter briefly defines some key terms used in the model, the second section discusses the model class I will be using, while the third section discusses the Brookings Model that is used as a starting point for my work in this area. The last section thoroughly discusses changes made to the original model made for the purposes of this dissertation.

*Defining Utility, Protest, Revolt, and Rebellion: How are we Measuring Economic Condition and the Outbreak of Civil Unrest?*

The first question we have to answer before we begin our discussion of agent based modeling is what we exactly mean by economic condition and civil conflict. This dissertation attempts to use a generic and broad concept of economic condition of the individual. I use both the terms utility and distribution as a way to generally talk about how individuals are fairing in a society. I formally use the following utility definition of utility to encompass all of the benefit derived by an individual from consuming goods and services that are either purchased with their own income or provided by another source (e.g state). In this sense, this measure quantifies all goods and services the individual consumes thereby capturing both individually acquired goods (e.g private income) as well as state provided services and subsidies.

The second term used to describe economic condition of individuals is distribution, specifically distribution of utility. This term is used in two ways. The first is the traditional definition to describe the shape of data relative to its frequency of occurrence (e.g uniform and normal distributions). I also use the word distribution when referring to the standard deviation or variance about the mean. References to the relative dispersion away from the mean and is used to measure changes in inequality of utility. Formally this is represented by the standard deviation from the mean. Therefore smaller standard deviations are associated with higher levels of utility equality, and higher standard deviations are associated with greater inequality.

The next set of terms that need a formal treatment in this section are terms that are used frequently but often mean different things to different people: protest, revolt, and rebellion. This paper specifically deals with protest and revolt. I define protest as activity where citizens engage in either violent or nonviolent action against the state. During

protest, the state maintains control and has the ability to deploy security forces to disperse

protesters. In the model protest is identified by an eruption of protestors who eventually

turn quiet as security forces intervene. This activity is associated with punctuated protests

similar to what we saw in Figure 1 in the preceding chapter.

Revolt is a more serious situation where citizens are engaging in violent or nonviolent

protest against the state, but where the security forces are *unable* to control and quell

citizen action. Unlike protest, which exhibits punctuated citizen activity, revolt generates

an equilibrium condition where protesters remain persistent in their voicing of grievance.

This distinction allows us to examine the model results with an eye towards evolutionary

change where a stable system can move to protest and finally revolt.

Rebellion follows revolt and one where citizens engage in coordinated violence against

the state, and where central authority is taking direct military action against rebels. I do

not model rebellion in this paper, and while the Brookings Model discusses rebels, it is

primarily a model of protest with no citizens being killed (only jailed).

*Agent Based Modeling: An Approach to Understanding Complex Behavior*

The computer models utilized in this paper are a class of simulation known as Agent

Based Models (ABM). ABM simulations attempt to "grow" emergent phenomenon by

observing behavior through simple interactions amongst individual agents. Utilized by

physical and social scientists to understand complex interactions, ABMs provide useful

insight into how group behaviors emerge enabling us to both understand how simple

behavior informs complex system dynamics, as well as serve to test policy interventions

that might alter those outcomes. The model is therefore not used as a predictive tool for

real world scenarios, but as a means of understanding system outcomes that help inform other research approaches to the problem. ABMs are a ideal candidate for addressing civil conflict as it is episodic in nature and is affected my local level dynamics. In a study of Guatemalan civil violence, Gulden finds that civil violence is driven by localized conditions and is not a continuous activity (Gulden 2004). Unlike statistical approaches, ABMs can address this issue as they incorporate geography and adaptive behavior by individuals.

Emergent behavior is a phenomenon whereby well-formulated aggregated behavior arises from localized, individual behavior (Miller & Page, 2007). Whereas mathematical and statistical models capture the aggregated affect and determine relationships based on those results, ABM models define conditions at the local level and examine the individual interactions that lead to the larger emerging behavior in the system. This effort "grows" complex behavior from seemingly simple agent interaction. The ability to examine the dynamics of a complex social system provides deeper insight and helps form theories based on our knowledge of local attitudes that may be testable later through statistical methods.

*The Brookings Model*

The first effort to date utilizing an ABM framework to study civil violence was conducted by the scholars at Brookings Institution and Santa Fe Institute. They presented two variations of a framework exploring initial conditions of unorganized civil conflict (Epstein, Steinbruner, Parker 2001). The first model analyzes the dynamics of decentralized rebellion against a central government authority. The second model

represents the emergence of violence between two ethnic groups. For purposes of discussion in this paper, I focus on the structure of the first model and its corresponding results. I refer to this as the "Brookings" model.

The Brookings Model has two types of actors: citizens and cops. The first type of actor, known as , is representative of an individual in society. The agent is a heterogeneous actor in several aspects including perceived hardship, legitimacy of the central government, individual risk aversion, and finally the knowledge, or vision, of what is happening in the local proximity (Epstein, Steinbruner, Parker 2001).

Hardship (H): This represents the individual citizen's level of perceived hardship. The Brookings Model defines this variable as exogenous taken from a uniform distribution between 0 and 1.

Legitimacy (L): This represents the perceived legitimacy of the central authority. This variable is exogenously provided by the researcher and is constant amongst all agents with a value between 0 and 1.

Grievance (G): This represents one part of the citizen's decision to rebel against a central authority and is a function of both their individual hardship and the perception of the central government's legitimacy. The simple calculation of grievance follows as:

$$G = H(1-L)$$

The authors note that the impetus for the grievance calculation is such that agents with high levels of hardship are less likely to rebel in societies with highly legitimate governments. They cite the example of the London Blitz during World War II as an

example where extreme hardship was imposed on the populace, but given their resolve and support of the central government, no civil violence emerged. Likewise, a highly illegitimate government is more likely to see civil disruption in the presence of increasing hardship.

Risk Aversion (R): This represents the citizen's individual risk aversion. This variable is heterogeneous across agents and is taken from a uniform distribution between 0 and 1. This variable does not change during the citizen's lifetime.

Citizen Vision (v): This value represents the number of positions on the lattice that the agent can see that might be occupied by other agents and cops. Since the citizen's vision is limited, information is local to its position.

Estimated Arrest Probability (P): This represents the probability that an agent is arrested. The citizen's calculus for estimating its arrest probability is a function of the local ratio of the number of cops to active agents in their field of vision. The authors note that the logic behind this estimate is such that citizens are less likely to be arrested when more citizens are rebelling, citing that it is less risky to be the $10,001^{st}$ rebelling citizen versus the first.

$$P = \left(1 - e^{-k\left(\frac{C}{A}\right)}\right)$$

Citizen Net Risk of Arrest (N): This represents the citizen's overall risk of arrest. This incorporates not only the probability of risk but also the consequence of being caught, namely being placed in jail for a period of time.

$$N = RPJ^{\alpha}$$

The citizen's net risk is a function therefore of the citizen's own Risk Aversion (R), estimated arrest probability (P), and finally the jail-term (J).

Citizen Decision Rule (Rule A): Based on the identified citizen characteristics cited above the agents make decisions to rebel when grievance minus their net risk of arrest is greater than some threshold T.

<center>If G-N>T be Active; Otherwise, be Quiet</center>

The second type of actor in the Brookings Model is a cop. Cops represent the security forces of the central government and arrest any active agents. Cops unlike the agents have only a single variable, their vision (v*).

Vision (v*): This is the cop vision, or the number of lattice positions that the cop is able to inspect. It is exogenous across all cops. The cops have one rule:

Cop Rule C: Inspect all sites within v* and arrest a random active citizen.

The authors cite five major findings from their runs of the Brookings Model. The central findings from the model include:

1) Citizens engage in deceptive behavior changing their status based on the presence of cops;

2) Free assembly catalyzes rebellious outbursts, with congregations of citizens to precede a outburst of activity;

3) The model generates periods of punctuated protest where periods of quiet are followed by extreme activity among citizens;

4) The emergent behavior finds that there all exists a distribution of the outburst size and their frequency

5) They find that there is an index for the ripeness of protest serving to identify tension in the system.

Those results are explored in detail in Epstein 2001 and in Epstein, Steinbruner, and Parker 2002, and are not discussed in this paper. A limitation of the Brookings Model is the inability to change the hardship of citizens in the model. The imposition of a uniform distribution on the hardship variable, effectively fixes the variable at 0.5. The central aim of the Brookings Model was not meant to represent a detailed exploration of each citizen motivation, more to demonstrate the type of results that can be obtained through ABM modeling. This limitation however serves as a motivation for this paper to explore the conceptual insights we can obtain through changes to this measure of 's economic condition.

*Introducing the Revised Brookings Model: The ODD Framework*

The complexity of ABMs has traditionally made them difficult for researchers to have a full understanding of the underlying dynamics built into a model. These complexities have lead to concerns by some researchers who have had difficulty in replicating the results of some of the models. In 2006 several experienced modelers (Grimm et al 2006) published a procedure for researchers using ABM designs to give readers a understanding of the underlying processes, decision calculus, and adaptive behavior built into a model. The framework put forth and largely adapted by researchers has been identified as the Overview, Design Concepts, and Details (ODD) protocol. It lays out a means from which

a reader can understand the basics of the model, how it is designed, programmed, and the values that are defined within the model (endogenity) versus what values emerge from the interactions between agents. The ODD protocol is divided into three major sections each with a series of underlying topics that the modeler should address: The overview of the model to include its purpose and process overview, the major design concepts, and the details of the model to include the initial setup and input data. To better equip the reader with a understanding of how the model was designed and implemented for the simulation runs in the next chapter I have used the ODD protocol. A detailed description of each element of the protocol is found in the appendix of this paper.

*ODD Protocol: How is the model related to previous thinking about the problem it addresses?*

The modified Brookings Model builds on the initial work of Josh Epstein, John Steinbruner, and Miles Parker at the Brookings Institution. The original model looks at the effects that government legitimacy, agent hardship, and security forces have on the emergence of civil violence. The original Brookings Model was successful in unifying in an ABM construct, some major proposed causes of civil violence.

The original Brookings model develops relatively simple decision logic amongst agents in a system. At its core, agents decide to rebel if the level of grievance minus the arrest probability is greater than a threshold set by the researcher. More simply stated, when 's grievance overwhelms the anticipated risk of capture by security forces by some margin, he rebels. Grievance is a function of the level of hardship imposed on the agent and on

the citizen's perception of the government's legitimacy. The level of hardship for each agent is a randomly assigned value from a uniform distribution, while the legitimacy of government is an exogenously conferred value from the researcher. The estimated risk of being arrested is a function of the number of security forces in the vicinity of the citizen and the number of rebelling agents in the same area.

The first major divergence from the Brookings model changes the distribution of utility (e.g hardship) in the system. In the original model, hardship for each citizen is randomly assigned a value between 0 and 1 from a uniform distribution. This variable is assigned during the setup of the simulation and does not change during the entire run. There are two problems with this approach. First, the original model assumes a mean hardship of 0.5 no matter how many times the model is run. Second, the imposition of the uniform distribution evenly distributes hardship between the lower bound of zero and an upper bound of one. By imposing a consistent mean of 0.5 and a uniform distribution, the original model *can only test one specific case of hardship*. The ability to modify these initial conditions opens up a new avenue of research that sheds light on the relationship between average utility, distribution, and the emergence of rebellion.

Brookings Model Grievance Calculation

$G = H(1-L)$

Where:

$G$ = Grievance

$H$ = Hardship uniformly distributed between 0 and 1

$L$ = Legitimacy

Revised Grievance Calculation in Model of Rebellion (Utility is Constant between

Periods)

$G = (1 - U_n)(1 - L)$

Where:

G = Grievance

U = Utility ~ $N(\mu, \theta)$

L = Legitimacy

n = Time Period n

The second major change to the original Brookings model incorporates the dimension of time. This new dimension to the model allows us to evaluate how changes in the utility, and the variability of that change over all agents, affects the emergence of violence. To achieve this, the calculation of utility is expanded from the grievance equation above to incorporate a citizen's utility values, weighted, over the current period t and the previous 6 periods. The function is weighted such that nearer term utility are counted more than previous values. The equation represented below calculates its grievance as the product of their perception of the central governments legitimacy and their relative economic condition averaged over the previous six periods. By averaging the economic condition of the citizen we can smooth how a person values their utility level thereby reducing the chance that a single period change in 's utility greatly changes the weighted utility level.

$$G_{i,n} = 1 - (\propto U_{i,n} + \beta U_{i,n-1} + \gamma U_{i,n-2} + \delta U_{i,n-3} + \varepsilon U_{i,n-4} + \vartheta U_{i,n-5}) * (1 - L)$$

Where for each ith citizen, and each time period (n) and $\alpha > \beta > \gamma > \delta > \varepsilon > \vartheta$

$$\alpha + \beta + \gamma + \delta + \varepsilon + \vartheta = 1$$

G = Grievance

U = Utility ~$N(\mu, \theta)$

L = Legitimacy

$\propto$ = Citizen Utility Weighting in Period n

$\beta$ = Citizen Utility Weighting in Period n − 1

$\gamma$ = Citizen Utility Weighting in Period n − 2

$\delta$ = Citizen Utility Weighting in Period n − 3

$\varepsilon$ = Citizen Utility Weighting in Period n − 4

$\vartheta$ = Citizen Utility Weighting in Period n − 5

*ODD Protocol: What is the Purpose of the Model?*

The revised Brookings model expands on our understanding of how the interactions between utility, legitimacy, and security forces affect decisions by citizens to rebel. To achieve these ends, the original Brookings Model is modified to allow changes to average citizen utility, utility distribution, and to allow for changes to utility over time.

This revised model deviates from the original Brookings model in two major ways. First, exploration of citizen hardship and its relationship with outbreaks of protest are limited in the Brookings Model by not allowing for changes in the mean utility or to its distribution. The revised model addresses this shortcoming by allowing for changes to both the mean

and distribution. Second, the original Brookings Model does not allow for changes to hardship over time limiting exploration of how changes over time might affect emergent protest. Modification to both allows for an expansion in our understanding of the relationship between utility levels, distribution, and their affect on individual's decisions for rebellion.

*ODD Protocol: What is the problem that you are trying to address?*

The changes to the model were primarily driven by a desire to conceptually explore how changes to utility levels, its distribution in a system, and changes to it over time affect emergent protest. This problem has not been addressed by previous research efforts. Specifically this model attempts to answer several key questions:

- What is the effect of differing levels of average utility on the frequency and magnitude of rebellion?
- What is the effect of differing utility distributions on the frequency and magnitude of rebellion?
- What is the relationship between "poor" utility agents and the outbreak of rebellion?
- How does declining mean utility over time impact the emergence of rebellion?
- How does declining mean utility, with variability, impact the emergence of rebellion?
- How does differing starting utility distribution affect the magnitude and frequency of rebellion?

47

Each of these questions are addressed by variations of the model that allow runs at regular intervals of mean utility and specific distribution levels to more completely explore the conceptual space providing concrete findings.

*ODD Protocol: What are the things that are represented in the model?*

The model represents a system of citizens who make decisions to either rebel or stay quiet given specific exogenous variables, the presence of security forces, and the rebelling status of neighboring citizens. As in the original Brookings Model, the system specifically represents two types of actors, cops and citizens[5]. Cops represent security forces that are in charge of identifying rebelling agents and putting them in jail. Agents are civilians who based on their hardship, perceived legitimacy of government, and their risk calculus of being arrested and jailed make decisions about whether to engage in rebellion. The model outputs include the number of people rebelling, the number of agents jailed, the average level of discontent, and a measure of persons about to rebel. The outputs are displayed through the lattice interface and through a series of charts.

*ODD Protocol: What are the variables used to characterize them?*

The two types of computer actors in this model are citizens and cops. The citizen is represented as a circle in the lattice, while the cop is represented as a triangle. While the cop only has a single variable (vision) which informs their ability to see rebelling citizens, the citizen has both endogenous and exogenous variables that inform their behavior. The citizen's characteristics include:

---

[5] The Brookings model defines citizens as agents, however cops are also agents so to reduce confusion I use terminology of citizens to denote the agents that make decisions to become active.

Risk Aversion (R): This is a value for the citizen that is their internal value that would characterize them as either risk taking or more risk adverse.

Utility ($U_{i,n}$): This is a value for the current period's utility (n). In this model, there is a significant divergence from the Brookings "Rebellion" model in that it substitutes "Utility" for "Hardship".

utilityn-1 ($U_{i,n-1}$): This is a value for the "n-1" period of an citizen's utility. This value is used as an citizen's memory of their previous period's utility value.

utilityn-2 ($U_{i,n-2}$): This is a value for the "n-2" period of an citizen's utility. This value is used as an citizen's memory for two periods previous to the current period.

utilityn-3 ($U_{i,n-3}$): This is a value for the "n-3" period of an citizen's utility. This value is used as an citizen's memory for three periods previous to the current period.

utilityn-4 ($U_{i,n-4}$): This is a value for the "n-4" period of an citizen's utility. This value is used as an citizen's memory for four  periods previous to the current period.

utilityn-5 ($U_{i,n-5}$): This is a value for the "n-5" period of an citizen's utility. This value is used as an citizen's memory for five periods previous to the current period.

active?: This is a variable for the citizen that defines if they are in a state of rebellion (Value of 1) or are quiet (Value of 0).

jailterm: This characteristic represents how many turns an citizen still has in jail.

*ODD Protocol: Who are the agents?*

The two types of actors in the model represent individuals (citizens) and security forces (cops). Individuals, or citizens in the model, are representative of persons in a society who make decisions to either rebel or stay quiet. The security forces, cops in the model, are representative of forces tied to the government who are charged with maintaining order in the model.

*ODD Protocol: What is the environment they live in?*

The simulated environment does not represent any specific terrain, as it does not incorporate any features such as mountains, forests, or buildings that would inhibit movement. The lattice is meant to represent an abstract space focusing on citizen interaction. The model is a localized environment and does utilize the notion of neighborhoods, focusing citizen risk calculus on the number of security forces within a neighborhood. The model allows for wrapping thereby allowing citizens to move from one side of the lattice to the other.  The model's physical landscape is a 33x33 lattice structure.

*ODD Protocol: What are the values the citizens possess?*

The citizen defines some of the values of its variables during the set-up of the model, while others will change over time. The values of the previous defined characteristics are as follows:

risk-aversion: This value is set-up at the start of the model and is a uniformly defined variable  between the values of 0 and 1 The value for each citizen does not change during

the run of the model.

utility ($U_{i,n}$): This value is defined as a random variable within a normal distribution with a mean and standard deviation defined by the user. For the purposes of the model runs, the value for the mean is tested at the following intervals: 0.9, 0.8, 0.7,0.6, 0.5, 0.4, 0.35, 0.3, 0.2, and 0.1. The standard deviation for each mean is run with the following values: 0.01, 0.05, 0.1, 0.15, and 0.20.

utilityn-1($U_{i,n-1}$): The initial value is defined as the value of utilityn. With each subsequent time period in the model the value for utilityn-1 becomes the value of utilityn in the previous period. This allows for the retention of the utility value from the previous period when the model allows for utility change per period. Utility is either added or decremented determined by the user. The user can also determine the distribution of additional utility added in each model iteration. This allows for either an equal distribution of growth or some variance in growth. For the dynamic model runs I assume a variance of zero (equal distribution).

utilityn-2($U_{i,n-2}$): The initial value is defined as the value of utilityn. With each subsequent time period in the model the value for utilityn-2 becomes the value of utilityn-1 in the previous period.  This allows for the retention of the utility value from the previous period when the model allows for utility change per period.

utilityn-3 ($U_{i,n-3}$): The initial value is defined as the value of utilityn. With each subsequent time period in the model the value for utilityn-3 becomes the value of utilityn-2 in the previous period.  This allows for the retention of the utility value from the previous period when the model allows for utility change per period.

utilityn-4 ($U_{i,n-4}$): The initial value is defined as the value of utilityn. With each subsequent time period in the model the value for utilityn-4 becomes the value of utilityn-3 in the previous period. This allows for the retention of the utility value from the previous period when the model allows for utility change per period.

utilityn-5 ($U_{i,n-5}$): The initial value is defined as the value of utilityn. With each subsequent time period in the model the value for utilityn-5 becomes the value of utilityn-4 in the previous period. This allows for the retention of the utility value from the previous period when the model allows for utility change per period.

active?: This is a variable for the citizen that defines if they are in a state of rebellion (Value of 1) or are quiet (Value of 0). The initial condition for this variable is set to zero, but can be set to 1 each period if an citizen's decision calculus is met. That decision calculus is discussed later in this section.

jailterm: Is initially set to zero. If the citizen is caught rebelling, this value is set to a random variable between 0 and a maximum term defined by the user. In this model the maximum jail-term is set at 15 periods.

*ODD Protocol: What are time dependent elements?*

The citizen's internal calculation of grievance in this model is a function of changes in utility, and to the citizen's perception of government legitimacy. For the purposes of the simulation, legitimacy is held constant across all citizens and time. Citizen utility however can change based on user inputs at the start of each model run. The first set of

simulation runs assume no utility changes, referred to as *static* runs, thereby tying each utility variable to the initial value set at the beginning of the model. The second set of simulation runs do allow for changes in utility over time, referred to as *dynamic* runs, and therefore can alter grievance calculations over time. The *dynamic* model constructs the grievance value for each citizen as:

$$G_{i,t} = (1 - (\propto U_{i,n} + \beta U_{i,n-1} + \gamma U_{i,n-2} + \delta U_{i,n-3} + \varepsilon U_{i,n-4} + \vartheta U_{i,n-5})) * (1\text{-}L)$$

Where for each ith citizen, and each time period (n) and $\alpha > \beta > \gamma > \delta > \varepsilon > \vartheta > 0$

G = Grievance

U = Utility $N(\mu, \theta)$

L = Legitimacy

$\propto$ = Citizen Utility Weighting in Period n

$\beta$ = Citizen Utility Weighting in Period n − 1

$\gamma$ = Citizen Utility Weighting in Period n − 2

$\delta$ = Citizen Utility Weighting in Period n − 3

$\varepsilon$ = Citizen Utility Weighting in Period n − 4

$\vartheta$ = Citizen Utility Weighting in Period n − 5

The weighting of utility in the grievance citizen decision equation allows for the user to define nearer term utility values as having greater significance on the citizen than previous values. The model holds utility weightings for all citizens constant (e.g. all citizens weight utility in time periods the same). The weighting values used in the dynamic model runs from period n through period n-5 are: 0.5, 0.25, 0.125, 0.06, 0.03, 0.015.

The method used to calculate the citizen's arrest probability is the one used in the original

Brookings model. Although it changes over time with the ratio of active cops to active

citizens it is not time dependent.

$$\text{Estimated Arrest Probability} = \left(1 - e^{-k\left(\frac{C}{A}\right)}\right)$$

C = Number of Cops within a neighborhood

A = 1+ number of active citizens in a neighborhood

*ODD Protocol: What are the model entities doing?*

The behavior of the actors in the model is relatively simple. At the most basic level,

citizens and cops move, citizens determine their behavior (e.g rebel or stay quiet), and

cops enforce (e.g arrest citizens).

The first thing that happens in the model is the "move" procedure. Citizens and cops

identify and then move to open spaces in the lattice structure. Limitations to this action

are tied to the relative density of the lattice structure. With greater numbers of citizens

movement in the structure could be constrained.

Movement Rule M: Move to a random site within your vision.

The second action called in the model is the "determine-behavior" procedure. This

procedure is run for each citizen and determines if an citizen should rebel or stay quiet for

that period of time. If an citizen's grievance minus their assigned risk aversion multiplied

by the estimated arrest probability  is greater than an exogenously determined threshold,

the citizen will rebel, if not they will remain quiet.  This is the same function rule as in

the original Brookings Model.

Citizen Rule A: If G-N>T be Active; Otherwise, be Quiet

The last action called in the model is the "enforce" procedure. This procedure is run for

each cop, and asks each one to identify a rebelling citizen within their "vision", move to

that location, and then arrest that citizen. That cop is able to change the jail-term variable

for the rebelling citizen thereby removing them from other citizens' view. This simulates

an citizen being removed from the system thereby eliminating their participation in a

rebellion. The citizen maintains their last utility level until they are released. It is

believable that their utility level would decline as the person would likely have lost their

job or suffered other consequences, but I do not address this issue in the model.

Cop Rule C: Inspect all sites within v* and arrest a random Active Citizen.

*ODD Protocol: What behaviors do the citizens execute as simulated time proceeds?*

There are two major behavioral changes in the model as the simulation progresses. The

first is an citizen behavioral change. An citizen will begin to rebel and no longer stay

quiet based on changes to utility, the behavior of other citizens, or through the presence

of cops. The second is a behavioral change to cops. When citizens are not rebelling

within their field of vision, cops move normally, akin to being on a patrol. When citizens

are rebelling in their field of vision however, cops will move purposefully towards the

rebelling citizens. There is a slight difference between the original Brookings model and

the one implemented in this approximation. In the original model the cops do not move to

the same space where the agent is active, however in this version cops do move to be on top of the protesting citizen. While both approximations are defendable, it is important to acknowledge the difference.

*ODD Protocol: What is the schedule of the model?*

The modified Brookings Model cycles through five major actions for each time interval. The user starts the model by selecting the "Go" button which calls the "Go" procedure. The model conducts a test to see if an citizen jail-term is 0 or if the breed is a cop. If this value is true, then the move procedure (Rule M) is called. The code is as follows:

```
 to go
   ask turtles
[
    if (breed = agents and jailterm = 0) or breed = cops
      [
        Move
```

The move procedure directs citizens or cops to move to squares that are not occupied, in a random manner. The second part of the move procedure shifts utility values back by one period. This process allows the citizen to maintain a "memory" of utility levels. The second part of the procedure bounds the values of utility between 0 and 1. Values of utility that are above one are set to 1, while a utility value that is less than zero is set to zero. The last part of the procedure then resets the present utility figure to be the current value of utility (utilityn) plus a random increment with a mean and standard deviation that has been defined by the user. Again the code is as follows:

```
to move

 if movement? or (breed = cops)

  [

 let targets neighborhood with

       [

          not any? cops-here and all? agents-here

             [ jailterm > 0]

       ]

  if any? targets

        [

           move-to one-of targets


set utilityn-5 utilityn-4                    ; Sets Utility in N-5 as Utility in N-4

set utilityn-4 utilityn-3                    ; Sets Utility in N-4 as Utility in N-3

set utilityn-3 utilityn-2                    ; Sets Utility in N-3 as Utility in N-2

set utilityn-2 utilityn-1                    ; Sets Utility in N-2 as Utility in N-1

set utilityn-1 utilityn                      ; Sets Utility in N-1 as Utility in N

if utilityn > 1

  [

        set utilityn 1

  ]

        if utilityn < 0

        [

         set utilityn 0

        ]
```

```
          set utilityn utilityn + random-normal mean-income stddev-income
          end
```

After the "move" procedure is called, the model then calls the "determine-behavior"

procedure to determine if an citizen will be active (rebel).  If the condition is met then the

model will set an citizen as active (e.g. Rebelling). The procedure is identical to the

original Brookings model, however, the individual citizen grievance in the model is

expanded in this simulation to account for changes to initial utility mean, standard

deviation, while allowing for change over time.

```
 to determine-behavior
set active? (grievance - risk-aversion * estimated-arrest-probability > threshold)
end
```

After citizen behavior is determined the simulation asks all cops to run the enforce

procedure which moves cops within the vision constraint to move and arrest an active

citizen. Upon reaching an active citizen, the cop resets the citizen's jail term to a random

number with an upper limit imposed by the setting at the start of the model run.

```
 if breed = cops
 [
       Enforce
 ]
```

Once movement, agent behavior determination, and cop enforcement procedures have been executed, any citizen that has a jail-term of greater than 0 has their sentence reduced by one.

ask agents

  [

        if jailterm > 0

    [

    set jailterm jailterm - 1

The last major action called is to modify the appearance of the citizens in the simulation. If an citizen is rebelling, it will change the color from green to red. If the citizen's jail-term value is greater than zero it will change the citizens color to black. A non-active citizen will be colored a shade of green based on their grievance level.

to display-agent

  ifelse visualization = "2D"      ; Reads the chooser button

    [ display-agent-2D ]          ; If the dropdown is listed as 2D it runs this
procedure

    [ display-agent-3D ]          ; If it is false it runs the 3D procedure

  end

to display-agent-2D  ;; agent procedure

  set shape "circle"

  ifelse active?

     [ set color red ]

    [ ifelse jailterm > 0

     [ set color black + 3 ]

    [ set color scale-color green grievance 1.5 -0.5 ] ]

end

*ODD Protocol: Initial Conditions: What are the Constant Variables for all Model Runs?*

All model runs utilize the same values to exogenous variables with the exception of measures of utility and utility growth. The number of citizens is set to 762 with 54 cops in the system. The cop's vision is set to 7. The rebellion threshold is set to 0.20, while government legitimacy is set to 0.70. The maximum jail-term is set to 15 turns. The first set of model runs are designed to test the effect that differences in mean utility and its distribution have on the outbreak of violence. The values for citizen utility are normally distributed about different means and standard deviations. Values for mean utility range between 0.9 and 0.1, while measures of standard deviation that are tested include values of 0.01, 0.05, 0.1, 0.15, and 0.2.

$$U_n \sim N(\mu, \theta)$$

where:
$\mu = 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.35, 0.3, 0.2, 0.1$
$\theta = 0.01, 0.05, 0.1, 0.15, 0.2$

The second set of model runs are designed to capture the effects of changing utility over time. While the static models explicitly tested the effect of changes to utility mean and distribution on rebellion, dynamic model runs are designed to explore how changes in utility over time affect the frequency and magnitude of rebellion.

$$U_{n,i} = U_{n,i} + V_i$$

60

Where:
$U_n \sim N(\mu, \theta)$

$V_i \sim N(\tau, \varphi)$

$\mu = 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.35, 0.3, 0.2, 0.1$

$\theta = 0.01, 0.05, 0.1, 0.15, 0.2$

*Simulation Results*

The results of each model variation are discussed at length in chapter 4 & 5. Chapter 4 lays out the key findings of the static model that allows for changes to the mean and distribution of the utility level within the model. Chapter 5 discusses how changes to utility with changes over time affect the frequency, magnitude, and speed of onset for rebellion. Both models demonstrate that changes to the average level of utility and its distribution have demonstrable effects to the system affecting the onset, duration, and magnitude of civil protest.

# Chapter 4: The No Growth Model of Utility

**"Inferiors revolt in order that they may be equal and equals that they may be superior. Such is the state of mind which creates revolutions."**

**-Aristotle**

This chapter discusses the findings of the first model which specifically explores how different average utility and distributions effect emergent behavior in a system of agents. Changes to both have significant impacts on agents in the system leading us to identify five key findings. The first three findings conclude that utility affects the magnitude, frequency onset of protest. Next, inequality between citizens in our system has a complex relationship with the outbreak of protest demonstrating a direct relationship between inequality and protest in high utility environments, while exhibiting a indirect relationship in lower utility environments. Lastly, regardless of the utility level, the percentage of lower utility citizens maintains a direct relationship with system instability. This chapter is broadly structured to first run a baseline model of the original Brookings simulation using the same exogenous variables that will be used in the modified model and then compare the results with runs of the revised model.

*Baseline: The original Brookings "Rebellion" Model*

Prior to running the modified Brookings "Rebellion" models, an instance of the original model was run to create a baseline from which to compare. The exogenous variables for vision, legitimacy, jail term, and cop and citizen density were the same as those run in the

modified simulations[6]. Given that the original model does not allow for changes in mean

hardship (Hardship = 0.5) or to its distribution (uniform distribution) a single variation of

the model is run.
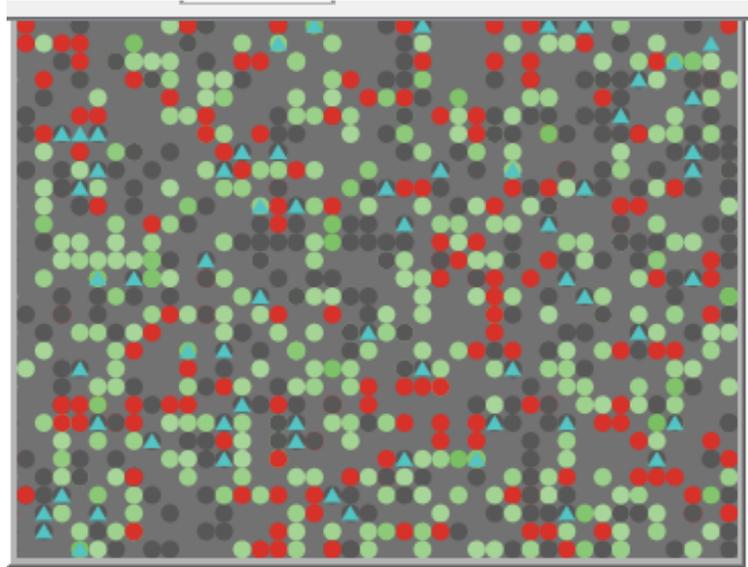


**Figure 2: Snapshot of Brookings Model**

Figure 2 represents a specific iteration of the Brookings model with non-active citizens

(green circles), active or protesting citizens (red circles), jailed citizens (dark grey

circles), and cops (blue triangles) . As we can see from this iteration of the model there

are a number of active (protesting) citizens in the system with cops moving to arrest and

impose a jail-term removing them from other citizen's view for a period of time between

0 and the maximum jail-term set in the model (15 iterations in this particular scenario).

Figure 3 shows the number of active citizens in the system over time providing, a longer

look at the equillibrum reached in the system. For the given set of exogenous variables

---

[6] For details on the setup of the models please see Chapter 3 on model methodology.

defined in the model, the citizens revolt[7] with an average active citizen level of

approximately 160 citizens and a peak protest spike of over 600 citizens. There is an

initial spike in active citizens, followed by a steep decline towards the equillibrium

protester level. The spike at the start of the simulation is typical for ABM models when

they start. In this case the intial conditions for citizens produce a larger spike in protest,

but as citizens move, the system reaches its equillibrium. While the initial spike is not in

line with the long-run equillibrium, it does not dramatically affect our long-run average

of a constant state of protest of roughly 160 citizens.
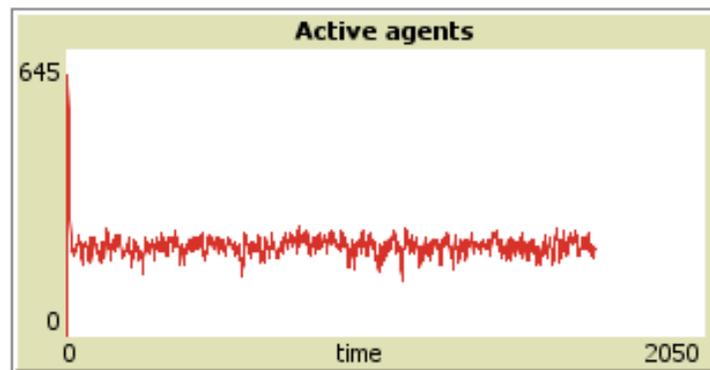


**Figure 3: Active Citizen Count in Brookings Model**

This model does not allow for changes to the level of hardship, nor to its distribution. The

Brookings model uses a uniform distribution for the hardship variable. This approach

effectively fixes this variable as 0.5 in the model. In order to explore more thoroughly the

dynamics of utility level, distribution, and of time it is necessary to modify the original

model and run a series of simulations.

---

[7] Based on our definition, a revolt is a situation in which protestors are never fully controlled by the cops. The inability to control protesters in the system leads to our characterization as a system in revolt. Chapter 5 details this phenomenon more thoroughly.

*The No Growth Model of Utility*

In order to explore the dynamics of changes to mean utility and its distribution[8] on decisions by citizens to rebel, it is necessary to make changes to portions of the initial model. Details on justification and specification are in chapter 3 of this dissertation. The first variation leveraging the changes to the original Brookings model was to run an alternative to the model with a mean utility of 0.5 and a standard deviation of zero.
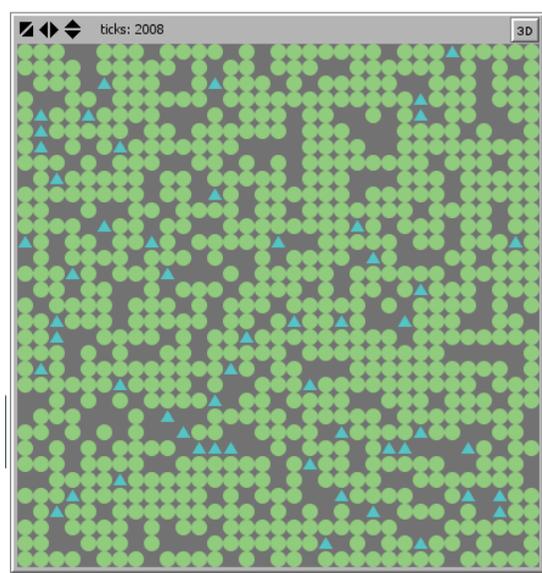


**Figure 4: Modified Brookings Model Run with Mean Utility of 0.5 and Std Dev of 0**

This model run is done to test an alternative to the uniform distribution of the original Brookings model with another, albeit extreme example, where all citizens have the same utility. This exercise serves two purposes. The first is to demonstrate that changing the distribution of the utility variable has a verifiable change to the behavior of citizens in the model and therefore highlights the value of changes to the original Brookings model. In

---

[8] Here I mean distribution as a dispersion or variance in the utility among agents.

the Brookings model, we generate revolt with an average protester count of 225 (Figure 3), however, in the modified model where all citizens have a utility of 0.5, no citizens are active in over 2000 iterations of the model (Figure 5). Moving from a continuous protest of citizens with a peak count of over 600, to a model run where not a single citizen is active in over 2000 iterations clearly demonstrates the importance of the utility variance on an citizens decision to become active (e.g. protest). The second purpose for running this model variant is to provide a lower bound to our changes of utility variance. This generates a natural set of experiments in which we can examine the role of mean utility, and its variance on the decision of citizens to rebel.
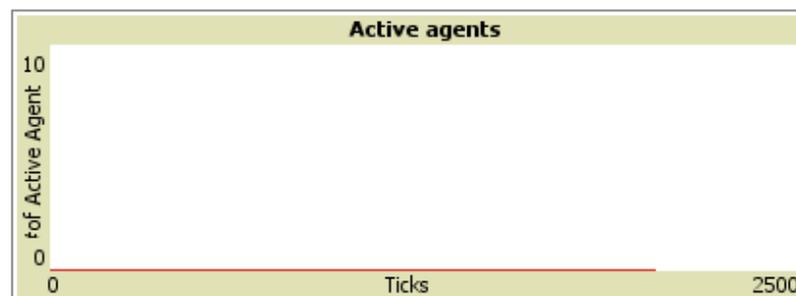


**Figure 5 Count of Active Citizens with Mean Utility of 0.5 and Std Dev of 0**

The set of experiments of the first version of the revised "Rebellion" model, which is termed the No Growth Model of Utility, includes over 50 simulations each run with over 2000 iterations. Simulation with values of mean utility between 0.9 and 0.1 coupled with varying distributions[9] (standard deviation of 0.01, 0.05, 0.10, 0.15, and 0.20) produced divergent results from the Brookings model. Analysis of the results generated five key findings. While the nature of computational modeling is such that each run will provide

---

[9] Again the use of the word distribution is used to denote variance and not the form (e.g. normal distribution).

closely related but marginally different results, the data presented provides representative

model runs that demonstrate the larger trends that emerge from the experiments.

Regardless of the individual sample run, the emergent phenomenon is the same.

**Finding 1**: Lower levels of average utility are correlated with higher magnitude protests,

regardless of utility distribution.

Simulations with lower levels of starting utility, holding distribution constant,

demonstrated increasing numbers of both peak and average protesters across 50 variants

of the model. Tables 1 & 2 provide data on the peak and average numbers of protesters

generated in the model variants. Each table illustrates how lowering average utility from

0.9 to 0.1 corresponds with increases in the number of protesters generated in the

simulation regardless of the starting variance.  For example with a starting mean of 0.9

and a standard deviation of 0.15, we find that peak rebellion increases from 0 active

citizens to over 630 as we slide starting utility to 0.1. Likewise, the average level of

active citizens in the simulation increase from 0 to 340 as we move from 0.9 to 0.1 mean

utility.   There appears to be a hard threshold at utility level 0.33 and standard deviation 0

for which the system moves from complete stability (e.g no protesting) to large scale

protest.  This implies that the population of agents below this threshold directly affects

the protest figures and onset. This is discussed more thoroughly in Finding 5.

| | Peak Number of Citizens During Protest | | | | | |
|---|---|---|---|---|---|---|
| | Standard Deviation | | | | | |
| | **0** | **0.01** | **0.05** | **0.1** | **0.15** | **0.2** |
| **0.9** | 0 | 0 | 0 | 0 | 0 | 0 |
| **0.8** | 0 | 0 | 0 | 0 | 0 | 0 |
| **0.7** | 0 | 0 | 0 | 0 | 1 | 1 |
| **0.6** | 0 | 0 | 0 | 0 | 1 | 2 |
| **0.5** | 0 | 0 | 0 | 1 | 5 | 17 |
| **0.4** | 0 | 0 | 4 | 21 | 60 | 169 |
| **0.35** | 0 | 1 | 182 | 248 | 247 | 247 |
| **0.3** | 682 | 668 | 472 | 382 | 345 | 356 |
| **0.2** | 648 | 644 | 646 | 594 | 487 | 434 |
| **0.1** | 667 | 667 | 673 | 649 | 630 | 580 |

*Mean Utility* (row label, vertical)

**Table 1: Peak Number of Active Citizens during Protest**

In practical terms this result demonstrates that as we lower the utility level, the calculation for grievance [(1-U)*(1-L)] increases on average for all citizens, thereby increasing the number of citizens in the simulation that are approaching the threshold for protest. This experiment is akin to increasing the deprivation of citizens as we maintain the same utility distribution amongst citizens. Lower levels of utility are tied with increasing magnitudes of protest. This is not surprising in that it is discernible from the citizen rules.

| | | Average Number of Protesters | | | | | |
|---|---|---|---|---|---|---|---|
| | | Standard Deviation | | | | | |
| | | **0** | **0.01** | **0.05** | **0.1** | **0.15** | **0.2** |
| | **0.9** | 0 | 0 | 0 | 0 | 0 | 0 |
| | **0.8** | 0 | 0 | 0 | 0 | 0 | 0 |
| | **0.7** | 0 | 0 | 0 | 0 | 0 | 0 |
| | **0.6** | 0 | 0 | 0 | 0 | 0 | 0 |
| | **0.5** | 0 | 0 | 0 | 0 | 1 | 1 |
| **Mean Utility** | **0.4** | 0 | 0 | 2 | 2 | 4 | 14 |
| | **0.35** | 0 | 1 | 30 | 56 | 51 | 43 |
| | **0.3** | 375 | 383 | 195 | 115 | 77 | 95 |
| | **0.2** | 386 | 382 | 382 | 318 | 232 | 169 |
| | **0.1** | 386 | 382 | 382 | 377 | 340 | 294 |

Table 2: Average Number of Protesters

**Finding 2**: Lower levels of utility are associated with higher frequency of protests, regardless of the distribution.

The simulation produces increased levels of protest as the level of average utility declines. As we see in Table 3, regardless of the starting variance, we see increasing frequency of punctuated protest in the model as we move from model variants with high average utility (0.9-0.6) to lower levels (0.3-0.1).

| | | Frequency of Protest | | | | | |
|---|---|---|---|---|---|---|---|
| | | Standard Deviation | | | | | |
| | | **0** | **0.01** | **0.05** | **0.1** | **0.15** | **0.2** |
| | **0.9** | 0% | 0% | 0% | 0% | 0% | 0% |
| | **0.8** | 0% | 0% | 0% | 0% | 0% | 0% |
| | **0.7** | 0% | 0% | 0% | 0% | 0% | 0% |
| **Mean Utility** | **0.6** | 0% | 0% | 0% | 0% | 0% | 0% |
| | **0.5** | 0% | 0% | 0% | 0% | 6% | 11% |
| | **0.4** | 0% | 0% | 1% | 7% | 14% | 34% |
| | **0.35** | 0% | 0% | 13% | 36% | 30% | 33% |
| | **0.3** | 100% | 100% | 99% | 57% | 65% | 64% |
| | **0.2** | 100% | 100% | 100% | 100% | 100% | 100% |
| | **0.1** | 100% | 100% | 100% | 100% | 100% | 100% |

Table 3: Frequency of Protest (Percentage of Model Iterations Citizens Protesting)

As we move closer to the threshold value (T) for protest, greater numbers of citizens begin to protest until the punctuated equilibrium of outbursts devolves into sustained revolt. Similar to the first finding, this result is not entirely surprising given that higher grieved citizens are more likely to be prone to either start or join an ongoing protest thereby increasing the chances of an outburst of activity. The two previous findings characterized the impact to both the magnitude and the frequency of protest by citizens in the model. Findings 3, 4, and 5 explore the impact of distribution in the no growth utility variability model.

**Finding 3**: Variance of utility is associated with the earlier onset of protest

As the distribution[10] of utility among citizens is increased, the onset of protest occurs at higher levels of average utility. Tables 1& 2 demonstrate this finding. For a mean utility level of 0.5 and standard deviation of .01, there are no active citizens in the model. As we move horizontally across both tables, we note the emergence of active citizens in the model. Increasing the distribution of utility appears tied to the emergence of protest at higher levels of utility as compared to cases where the distribution is narrow.

At the most basic level, as the distribution of utility widens, more citizens with lower utility are present in the model. The citizens with lower utility are then prone to protest when either their net risk calculus changes (as security forces move) or other citizens protest within their vision. Moving between extremes, we can see this quite clearly. In a model variant that has an average utility of 0.5 and a standard deviation of zero, we do not record any active citizens over 2000 iterations of the model. If we define low utility

---

[10] The term distribution is referring specifically to the size of the variance or the standard deviation.

citizens as ones with utility levels of 0.25 and below, we would have no low utility

citizens in the model, when the standard deviation is zero. As we move from a standard

deviation of zero to 0.2 however, the peak protester count moves from  0 to 17.  Again, in

practical terms this means that although the mean utility for all citizens remains 0.5, some

citizens in the model have utility levels well below this value, thereby creating some low

utility citizens each that have higher levels of grievance. These more aggrieved citizens

are then more sensitive to the spatial interplay between security forces (cops) in their

field of vision as well as to the activity of others around them. Finally, if we move to the

results of the original Brookings model with a uniform distribution, we see peak number

of rebels swell to over 600. The much wider uniform distribution dramatically increases

the number of more aggrieved citizens in the lattice, thereby increasing the number of

citizens more likely to rebel even as average utility remains high.

> **Finding 4**: In high average utility models, higher variance *increases* magnitude
>
> and frequency of protest; a lower utility model with higher variance lowers
>
> magnitude and frequency of protest.

The relationship between utility variance and its effect on the magnitude and frequency

of violence is the most interesting and surprising result of the No Growth model. The

result from the data imply a bifurcated result. In models that have higher levels of

average utility, magnitude and frequency of protest grow as we increase the variance of

utility (e.g higher standard deviation about the mean); however, in lower average utility

models higher variance is associated with *smaller and less frequent* protest.  In other

words, as we increase the inequality between agents in better off societies social

instability grows. However in societies that are worse off and that are below a threshold

for protest, increasing inequality reduces protest in the society. This result is surprising as it implies that increasing utility variance, or inequality of utility between citizens, is not always associated with higher and more frequent levels of protest. If in fact distributional affects of utility are bifurcated, then empirical tests of measures inequality such as a gini coefficient on the outbreak of civil violence are obfuscated. This result demonstrates that other measures of inequality will be better testable variables in empirical testing.

The distributional affects on rebellion in the model are demonstrated in Figures 6 & 7. In Figure 6 mean utility levels of 0.5, 0.4, and 0.35 are correlated with higher peak protester counts than with cases of more narrow distribution. However, in lower average utility levels of 0.2 and 0.3 this relationship flips, with smaller distributions correlated with extreme levels of protest, while larger distributions have lower levels of protest.
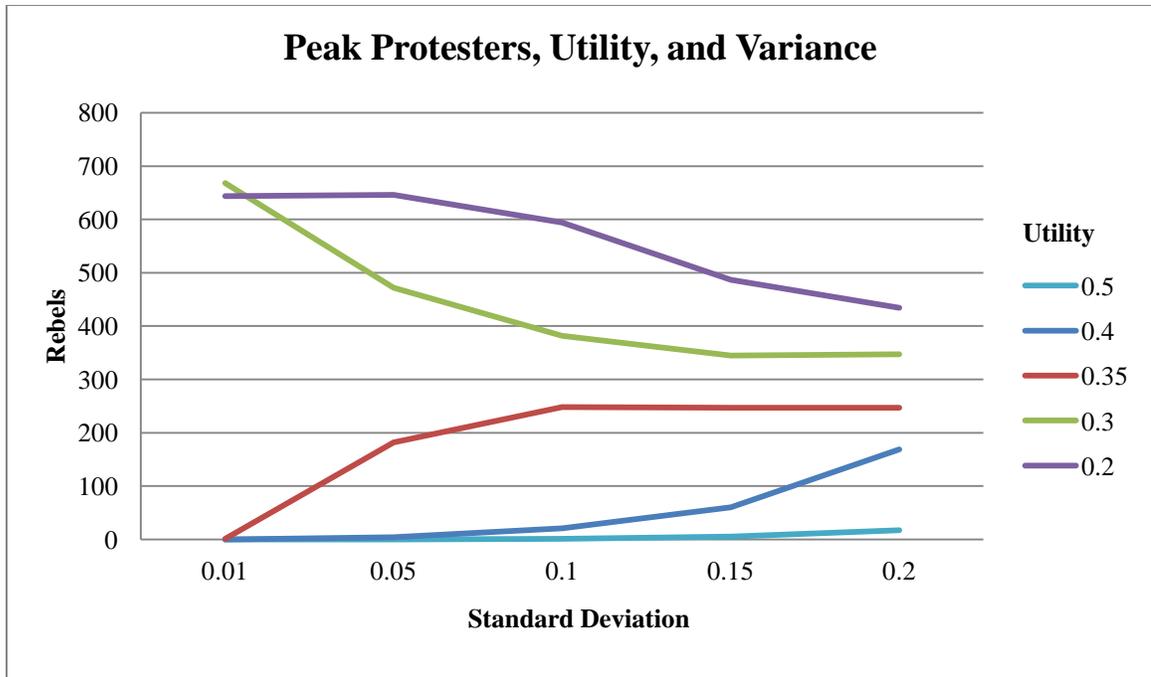
**Figure 6: Distribution Changes and Protest**

We can see this relationship switch in citizen behavior more clearly in Figure 7. With higher levels of mean utility, protester counts remain low across all distributions as the grievance amongst citizens is not enough to trigger the "active" rule[11]. As we move to lower levels of utility, however the distributional effects on utility begin to emerge. In the initial setup, higher levels of utility distribution generate larger numbers of low utility citizens who are dispersed within the lattice. These citizens are more sensitive to movements of security forces and create more pools of unrest once a protest begins.

---

[11] The rule to turn agents "active" is defined as G-N>T. For more detail please see chapter 3 on methodology.
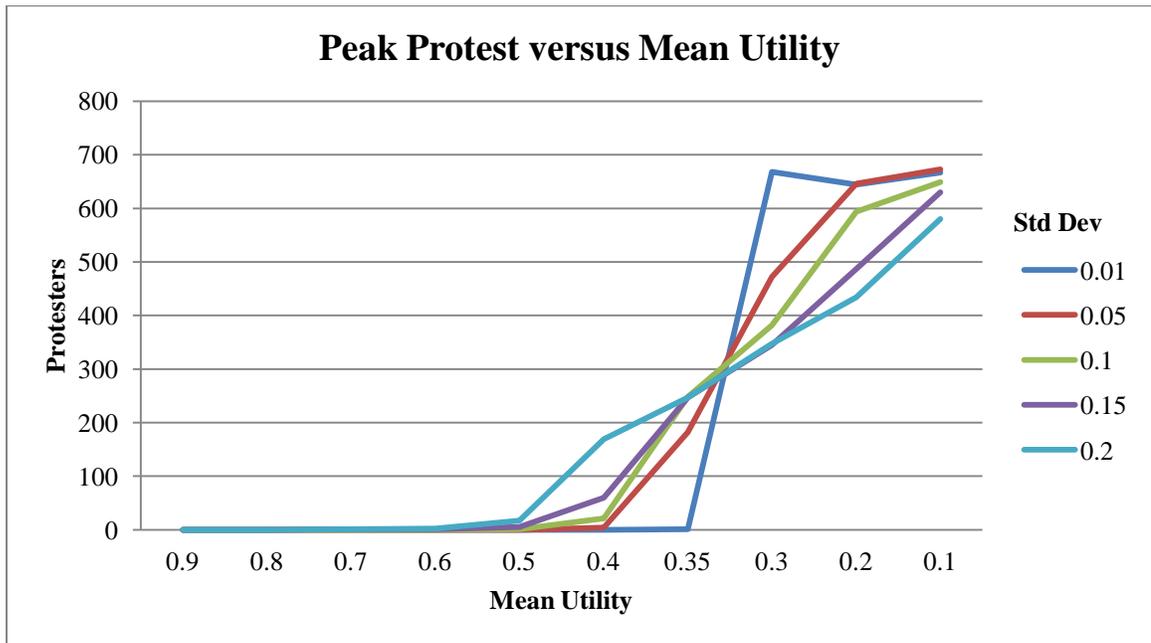
**Figure 7: Variance, Mean Utility and Protest**

At a mean utility level of 0.4, the higher distribution of 0.2 generates close to 200 active citizens at the peak, yet the low distributions of .01 and .05 do not see any citizens protesting. As we move to a mean utility of 0.2, the higher distributions exhibit a lower level of peak rebels whereas the lower distributions now see higher levels of intense protest. In a similar manner in which the higher distribution of utility generated higher levels of utility poor citizens, the higher distribution at lower levels of mean utility create more utility rich citizens. This serves to help create islands of stability or instability that can either to serve to destabilize or stabilize the system. In a model with a mean utility of 0.5 and a standard deviation of 0, all citizens have the same level of utility and are relatively uniform in their level of grievance. Figure 8 demonstrates this uniformity with

all citizens showing the same gradation of green. However, as we open the aperture of utility distribution we begin to see higher levels of grievance amongst some citizens. Figure 9 demonstrates this with more highly aggrieved citizens a lighter shade of green. These lighter shaded citizens represent islands of instability.
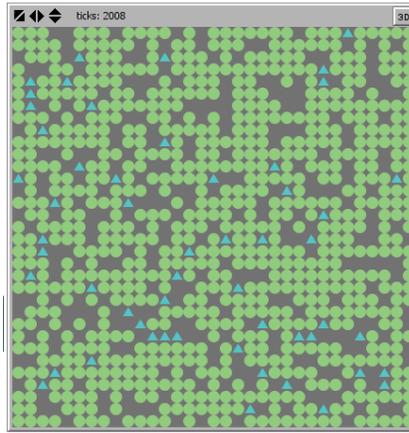


Figure 8: Mean Utility 0.5 Std Dev 0
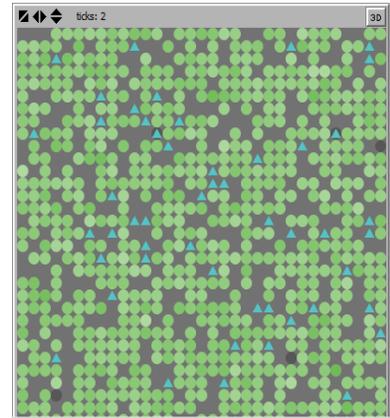
Figure 9: Mean Utility 0.5 Std Dev .2

In both cases, the reduction of mean utility will push citizens towards protest, however in cases with larger utility distributions some citizens in the lattice will rebel at higher levels of mean utility. Conversely, the instability introduced by larger distributions are flipped at lower levels of utility as more high utility citizens create islands of stability serving to reduce the intensity and frequency of protest.

We observe a similar bifurcated result in analyzing the frequency of protest. In figure 10, we find a similar structure as in figure 7 where with higher mean utility, the frequency of protest increases as the distribution of utility is increased.
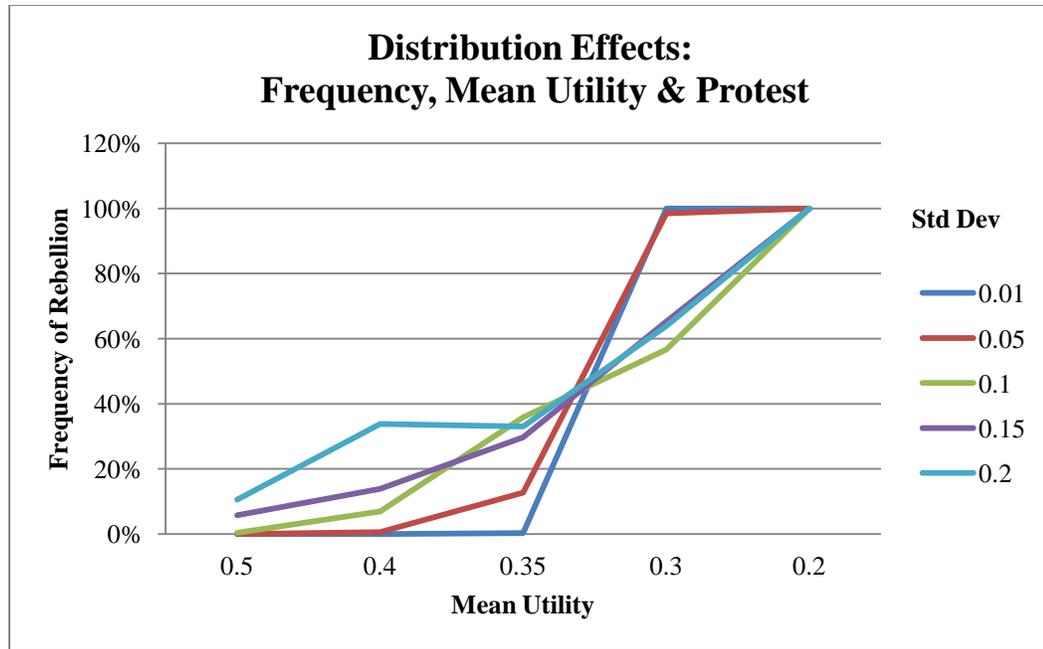
**Figure 10: Distribution Effects: Frequency, Mean Utility & Protest**

While the frequency of protest continues to increase as we lower the mean utility level, it is surpassed by model variants that have a lower initial variance. It appears that the variance of utility affects the functional form to the growth of magnitude and frequency of protest. In models with high distributions, the growth both in the magnitude and the frequency of rebellion is more linear, where in standard deviations that are smaller (e.g 0.01 or 0.05) the growth becomes exponential. This particular result should be of broad interest to the research community, as inequality measures have not been linked to increase likelihood of civil conflict. This result implies that distributional effects of individual well-being are more complicated than has been discussed in the conflict literature. If in fact a bifurcated relationship exists, then the results of a model that assumes a direct relationship mispecifies the true relationship. This could generate results that are insignificant.

The central problem with past approaches in testing for the effect of inequality and conflict revolves around how we think about conditions for individuals. In the simplest terms, proponents of the argument that inequality is a determinant for civil conflict contend that as utility or income become more divergent in a society, the grievance level amongst individuals grows significantly. Conversely, more equal outcomes amongst individuals are less likely to provoke these interpersonal conflicts thereby removing motivation for larger scale violence. It is possible to imagine a situation however, when greater distribution of utility might in fact be more stabilizing? In a extreme case where all individuals have the same utility or income, but that level is below a minimum amount acceptable by the population you are likely to see protests. *All individuals are equally starving*. In this case you would have a perfectly equitable society with a gini coefficient of 0, but still likely to see violence from a desperate starving mob. A greater distribution however, would place some individuals above the minimum level reducing motivation by those individuals to protest. If the distribution were great enough a larger group of elites who have no stake in participating in violent protest would remain as islands of stability. While this result is interesting it does not capture all of the possible dynamics in the society. This model does not allow for citizens to compare their situation with others. There is no representation of horizontal equity which would likely affect the outcome of protest. This finding is specifically aimed at understanding how individual deprivation alone might affect decisions to protest.

The lack of statistical correlation remains a significant barrier in our understanding the relationship between inequality and determinants of civil conflict. The example discussed above illustrates a central problem with using a gini coefficient alone as a measure of

inequality in empirical modeling. If in fact a gini coefficient is used, then a specification for higher and lower income countries would need to be added to account for the bifurcated nature of distribution of utility on protest levels. To date this has not been done, with researchers primarily testing for a direct relationship between the gini coefficient and the outbreak of civil conflict. All find that the measure is neither statistically significant nor of a value of any consequence. Sambanis in particular has argued that the problems with model specification and data quality have made the testing of inequality difficult. The no growth model's findings explain why empirical testing of gini coefficients alone might not be the right variable of choice.

To this point, I have discussed the effects of changes to the average level of utility and its distribution on the level and frequency of rebellion. The fourth finding highlighted one of the challenges with looking at distribution measures alone as a predictable determinant of citizen activity. The bifurcated result highlights the challenge of analyzing measures of income inequality and its relationship with civil conflict.


Finding 5: Lower utility citizens are associated with higher instability.

In the previous finding, I showed that using a direct measure of utility variance is not as straightforward as the empirical literature suggests. While it is possible to utilize a measure like a gini coefficient, it is necessary to correct for high or low utility cases to determine the sign of the correlation. Leaving this problem aside, is there a better measure for the problem of variance in utility? In the modified model, I find that in all cases increased numbers of low utility citizens, defined as having utility lower than 0.34,

are correlated with greater levels of protest. The model runs show that as you increase the number of low utility citizens a system, regardless of the variance of utility, the system becomes more unstable. Unlike a measure of inequality such as a gini coefficient, the number of low utility citizens appears to be a better measure for the effect of utility variance on protest. In the sample runs of the model where variance is fixed at zero (e.g all citizens have exactly the same utility), there is a point at which all citizens will move from being quiet to protesting. This threshold is 0.33 utility and is how I define citizens with low utility. When utility for all citizens moves from 0.34 to 0.33 the system moves from being completely quiet to extreme protest.

The relationship between the low utility rate and protest is quickly observed in the two figures below. Figure 11 represents a higher utility case showing average rebellion increasing in the model as the number of low utility citizens in the model increases.
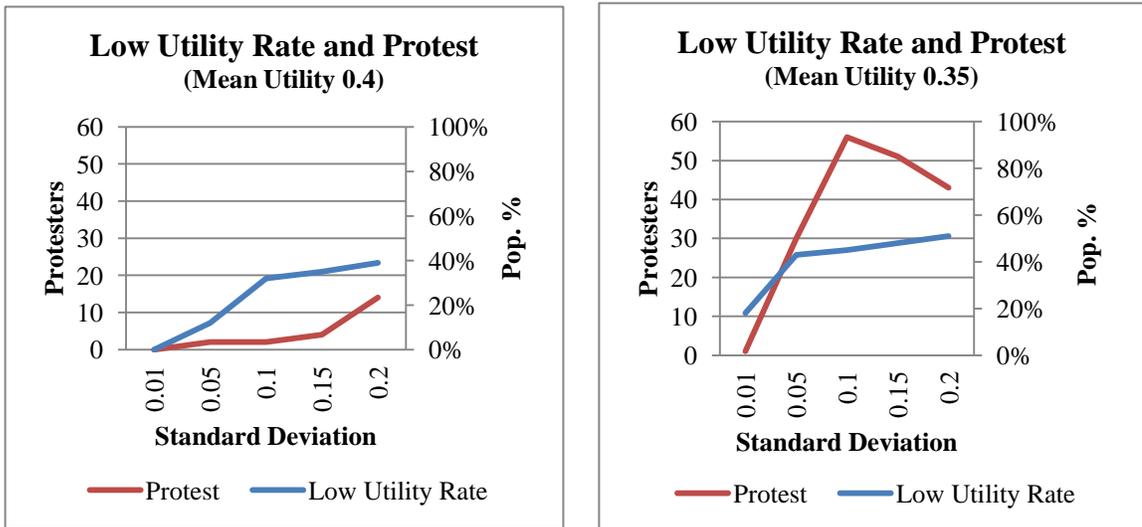


**Figure 11: Low Utility and Average Protest**

The figures above demonstrate that with a widening variance (standard deviation) in utility among citizens, the population with utility below the threshold 0.33 helps generate the increasing instability of the model. Simply stated the variance increases the number of citizens protesting.

Likewise, in Figure 12, we also see a direct relationship, but this time we are on the other side of the threshold of 0.34 so as the low utility population falls we see a corresponding decrease in average protest. Low utility's relationship with protest appears to hold in both higher and lower cases.
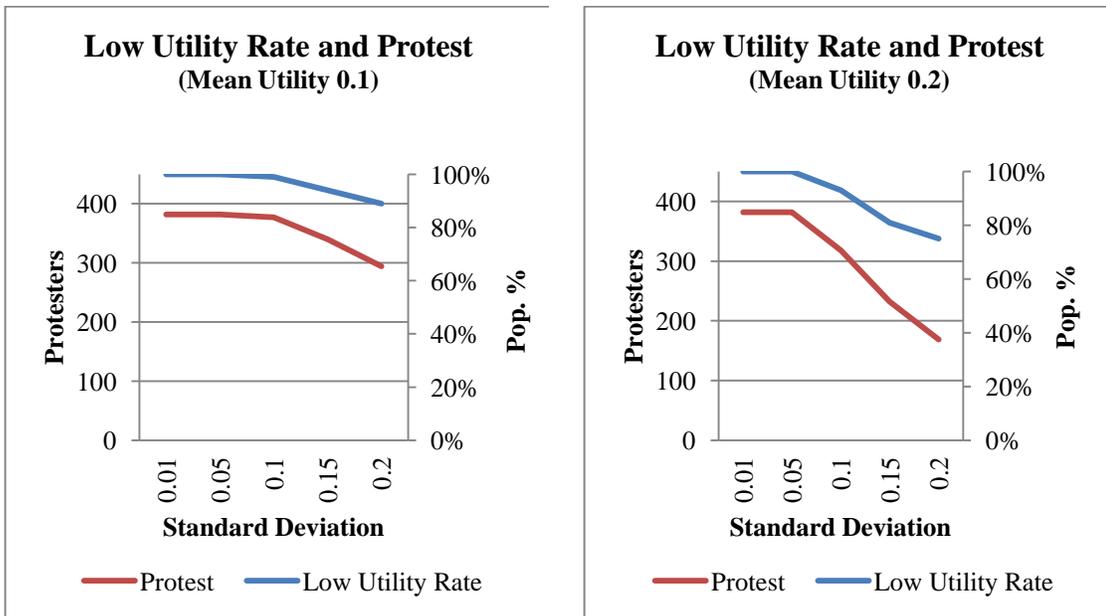


**Figure 12: Low Utility and Average Protest, Low Utility Cases**

Moving beyond our simple figures for high and low utility cases this relationship broadly holds across our testing space. In Table 4, low utility rates across all cases are identified,

with two trends seen. First, not surprisingly, as we lower the average level of utility, regardless of the distribution, we see corresponding increases in the low utility rate. Second, the data highlights an interesting condition as we change the variance. We find that in higher utility level models (0.9 through 0.35), higher variance leads to higher low utility rates among citizens. This is consistent with how we casually think about measures of inequality, but this is really only one perspective. In low utility cases such as mean utility levels of 0.2 or 0.3, we see that increased distribution *lowers* the population of citizens with low utility. Simply stated as you increase variance about the mean you will see more citizens with values above the level we have defined as low utility (e.g less than 0.34). Histograms of these cases can be found in the appendix demonstrating the movement of citizen utility from lower to higher levels.

| | | Standard Deviation | | | | | |
|---|---|---|---|---|---|---|---|
| | | **0** | **0.01** | **0.05** | **0.1** | **0.15** | **0.2** |
| **Mean Utility** | **0.9** | 0% | 0% | 0% | 0% | 0% | 0% |
| | **0.8** | 0% | 0% | 0% | 0% | 0% | 1% |
| | **0.7** | 0% | 0% | 0% | 0% | 1% | 4% |
| | **0.6** | 0% | 0% | 0% | 0% | 4% | 10% |
| | **0.5** | 0% | 0% | 0% | 6% | 16% | 21% |
| | **0.4** | 0% | 0% | 12% | 32% | 35% | 39% |
| | **0.35** | 0% | 18% | 43% | 45% | 48% | 51% |
| | **0.3** | 100% | 100% | 78% | 70% | 61% | 61% |
| | **0.2** | 100% | 100% | 100% | 93% | 81% | 75% |
| | **0.1** | 100% | 100% | 100% | 99% | 94% | 89% |

**Low Utility Rate (<.34 Utility)**

**Table 4: Low Utility Rates for the Model**

A simple comparison of the low utility rate with the average level of protesters in the

model in Table 5 demonstrates a direct relationship between the number of low utility

citizens and the number of protesters.

| Average Number of Protesters | | | | | | |
|---|---|---|---|---|---|---|
| | Standard Deviation | | | | | |
| | | 0.01 | 0.05 | 0.1 | 0.15 | 0.2 |
| Mean Utility | 0.9 | 0 | 0 | 0 | 0 | 0 |
| | 0.8 | 0 | 0 | 0 | 0 | 0 |
| | 0.7 | 0 | 0 | 0 | 0 | 0 |
| | 0.6 | 0 | 0 | 0 | 0 | 0 |
| | 0.5 | 0 | 0 | 0 | 1 | 1 |
| | 0.4 | 0 | 2 | 2 | 4 | 14 |
| | 0.35 | 1 | 30 | 56 | 51 | 43 |
| | 0.3 | 383 | 195 | 115 | 77 | 95 |
| | 0.2 | 382 | 382 | 318 | 232 | 169 |
| | 0.1 | 382 | 382 | 377 | 340 | 294 |

<div align="center">Table 5: Average Number of Protesters</div>

This relationship is interesting in that it shows that growing populations below a

threshold can generate instability in a system of citizens. While we might be tempted to

think of this as a simple poverty measure, the threshold is not tied to some absolute

definition of poverty. It is easy to imagine a society where all of the necessities of life are

met, but as conditions worsen beyond some acceptable level, social instability ensues.

Examples of this are the protests over austerity in Spain and Greece in 2012-2013. Both

countries are relatively wealthy as compared with others, with their citizens enjoying a much higher standing of living, however mass protests ensue when the government announced large cuts to state employment and some social programs[12]. A growing population who's actual or perceived utility declines below an acceptable threshold generates the potential for social instability.

The direct relationship between the population of citizens below the threshold of 0.34 and the increasing level of protest is demonstrated in the Figure 13. In this graph, I have plotted for the utility levels 0.4, 0.35, 0.3, 0.2, and 0.1 and their corresponding variances, the number of protesters active in the system versus the number of low utility citizens. What we find is that as we increase the number of low utility citizens the number of protesters increases. This represents a key finding in the model.

---

[12] http://www.dw.de/protesters-demonstrate-against-austerity-measures-across-spain/a-16662588
http://www.dw.de/thousands-across-greece-protest-austerity/a-16612903
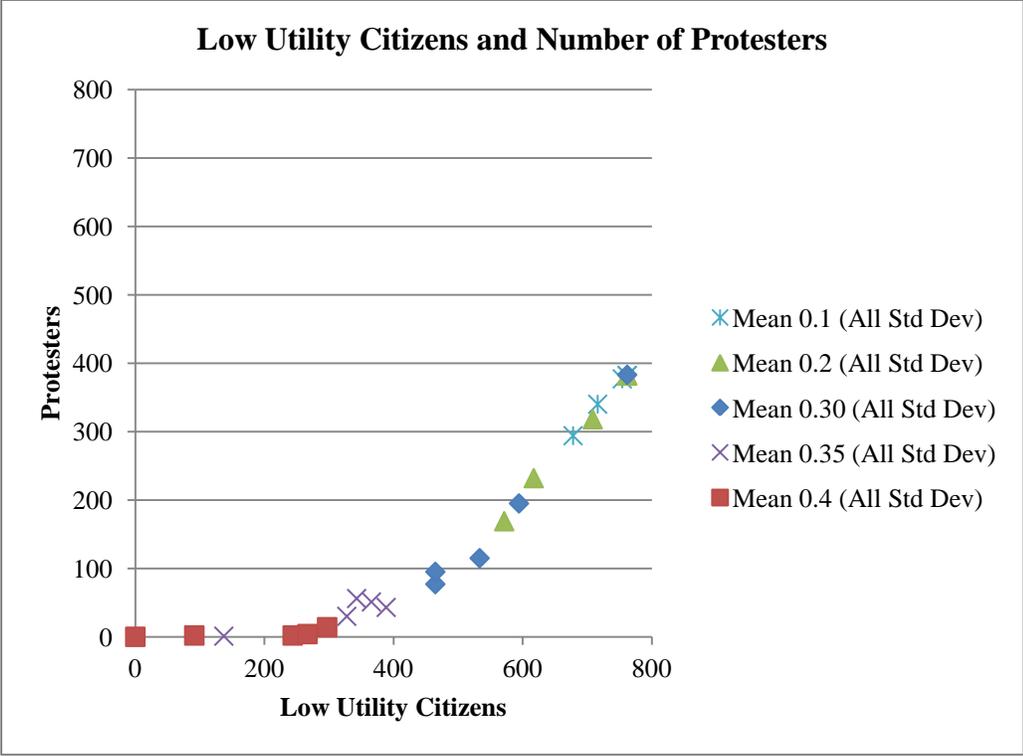
**Figure 13: Direct Relationship between Low Utility Citizens and Number of Protesters**

# Chapter 5: Results - The Growth Utility Model

**"…revolt is a thing of the stomach."**

**-Hugo, Victor**

In the previous chapter, I covered how simple changes to the Brookings Model resulted in different outcomes as the mean utility level and its distribution amongst citizens is changed. What the previous iteration of the model did not address however, was how citizen behavior changed as utility levels fluctuate over time. Are there discernible changes in our model as we allow changes to mean utility over time? If so, what are the behaviors and emerging phenomenon in this system? In this chapter, I discuss the evolution of citizen behavior in models where utility is allowed to change. I find that the magnitude, frequency, onset, and evolution of protest to revolt are affected by the level and distribution of utility. While some results such as declining utility for citizens are associated with protest over time are to be predicted, the dynamics of that change are unique to the research presented in this paper. In total, I discuss nine central findings in this chapter. These include:

- Increasing average utility over time leads to quelling of continuous revolt followed by periods of punctuated protest;

- Increasing average utility over time associated with lower numbers of protesters in continuous revolt;

- Higher initial utility distributions associated with lower number of protesters in continuous revolt;

- During continuous revolt, increasing the utility distribution affects the rate of change of active citizens in the system;

- Higher utility distribution associated with higher magnitude and frequency of punctuated revolt in systems with increasing levels of average utility;

- Higher utility distributions have punctuated protests that take longer to quell;

- Decreasing average utility over time leads to punctuated protest followed by the outbreak of continuous revolt;

- Decreasing average utility associated with *higher magnitude and frequency* of protest; and

- Higher initial utility variance leads to *earlier* punctuated protest;

This chapter expands our investigation into utility and its distribution by introducing two different models focused on intertemporal change to utility. The first model, or the "Utility Growth Model", is a set of model runs that take a low average utility system and grow it by specific utility intervals. This provides us insight into transitions in a system as we move from a period of continuous protest (e.g. revolt) due to low levels of average utility to a environment that becomes more stable. In the second model, the "Negative Utility Growth Model", we reduce utility from a higher average level. This allows us to explore the problem of citizen behavior as the model transitions from relatively stable conditions to an environment more prone to protest. Both scenarios are important in understanding how mean utility, distribution, and incremental change matter to citizen behavior and highlight findings that serve to help us understand empirical results by researchers obtained over the past decade.

The growth utility model moves beyond our previous model by expanding our investigation of distribution to include changes to utility over time. By introducing change in utility, we are able to explore citizen behavioral change outside of the equilibrium reached in the no growth model.  Specifically the addition of time allows us to explore the relationship between changes in mean utility, its distribution amongst citizens, and the trade-off between selection and peer effects in the model.

In the first set of model variations, I construct a system starting from a lower level of utility at varying levels of distribution and increase utility incrementally.  I start each model run with a low average utility level of 0.2 and grown it at a regular interval of 0.0001 utiles per iteration.  The starting distributions run in these models are: 0.01, 0.05, 0.10, 0.15, and 0.20. There is *no variation in growth*[13] introduced in this simulation, which serves to maintain the initial distribution throughout the period of growth to the model.

> Finding 1**:** Increasing average utility over time leads to quelling of revolt followed
> by periods of punctuated protest.

The first finding in the growth utility model concerns a basic observation across all distributions. Over time each system, which begins in equilibrium of revolt, eventually sees that activity quelled only to be followed by periods of punctuated protest. Figures 14

---

[13] Allowing variation in utility growth is an important topic that needs to be explored and is highlighted in the conclusion of this paper as an area for future research.

& 15 demonstrate this result. As we find at the start of each model run, the number of citizens that are active (e.g. revolt) never reach zero. This condition is a state of revolt in the model. Over time as the level of utility is increased, we find that the number of active citizens declines. At some point in each model variation, the number of active citizens collapses to zero, quelling the revolt.
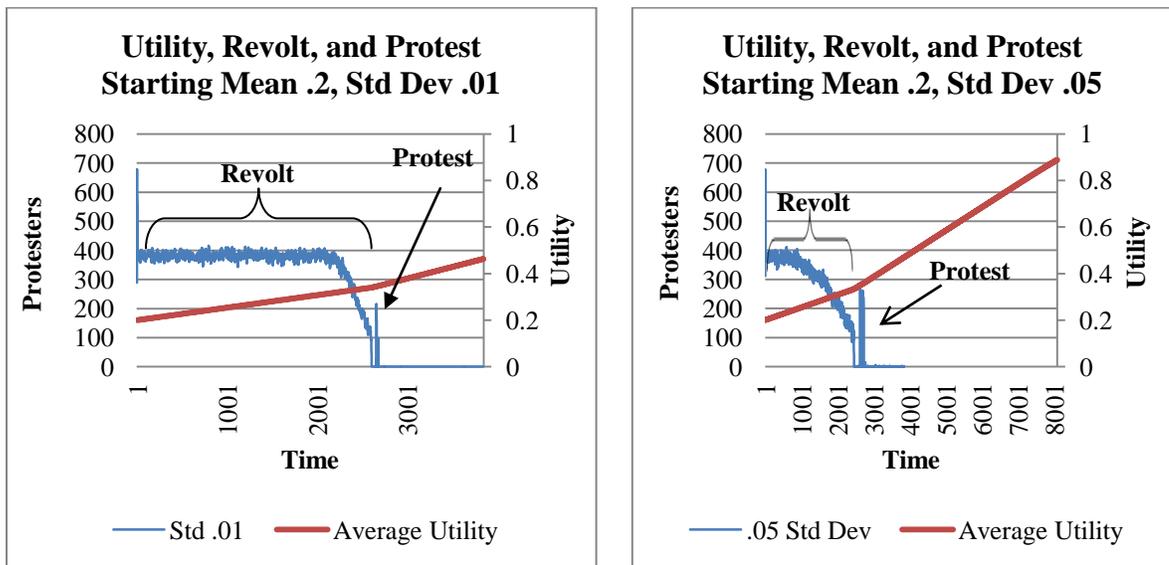


**Figure 14: Increasing Utility, Revolt, and Protest in Low Distribution Systems**

We find that once rebellion revolt is quelled it is followed by a short period of protest. The size, frequency, and duration of that protest is correlated to the distribution of utility in the model. Over time, as utility is added, the size and frequency of protest is reduced. The amount of utility required to quiet all citizens however is also correlated with the distribution of utility in the system. A more detailed discussion of the characteristics of

protest is found later in this chapter, however it is enough right now to highlight the

general characteristic of revolt followed by periods of protest.
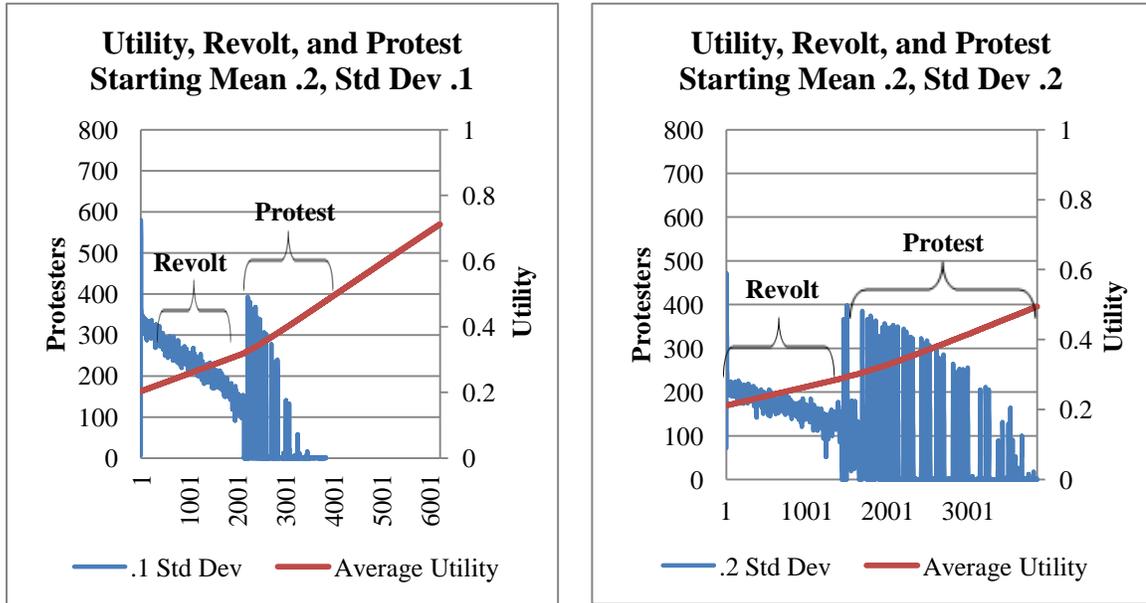


**Figure 15: Utility, Revolt, and Protest in Higher Distribution Systems**

Finding 2: Increasing average utility over time associated with lower numbers of

rebels in revolt

As we grow the system from a starting average utility level of 0.2 to higher levels, the

average number of rebels in revolt falls. This result is independent of the starting

distribution and is a direct result of increasing utility that lowers grievance levels. While

a simple comparative analysis amongst differing distributions highlights the differences

of active citizen counts between models, it is true that all models reflect a decline in

active citizen counts as utility increases.  Figure 16 demonstrates this result by showing

active citizen levels over time as utility increases by a rate of 0.0001 utiles per iteration for each level of distribution tested. For purposes of this discussion, I have not included citizen counts from punctuated protest after the revolt is quelled.
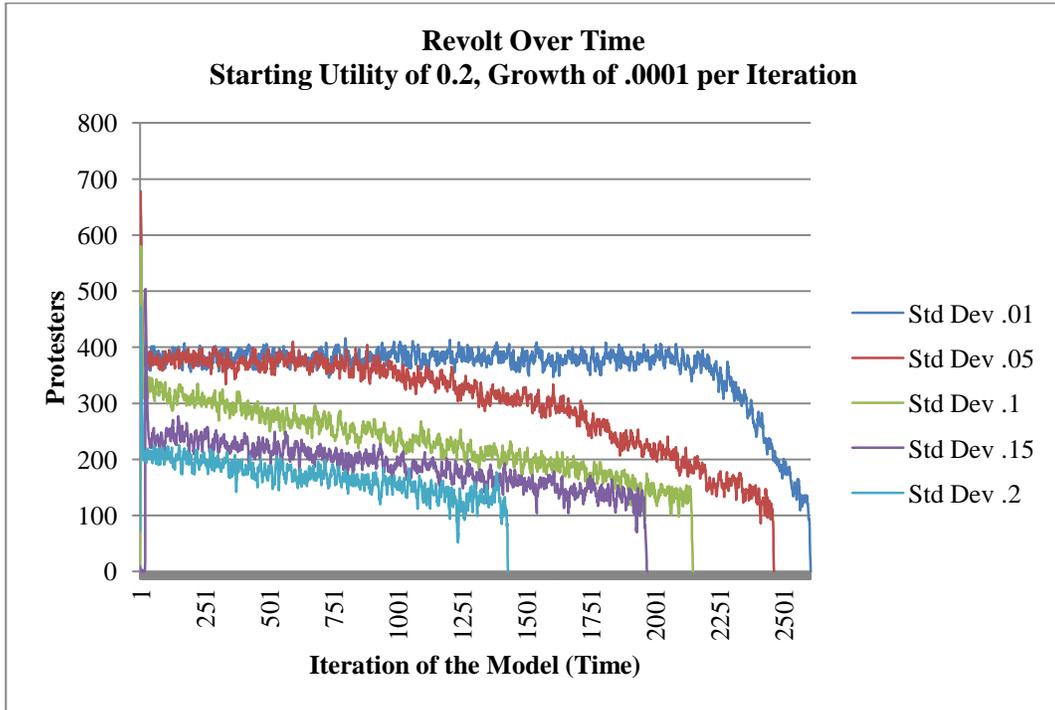


**Figure 16: Revolt Over Time**

At the micro level, citizens in the system see their utility levels increase over time. This reduces grievance to levels where some citizens, depending on the initial distribution, find their grievance level below the threshold of becoming active. Once below the threshold (T), some citizens go quiet. This reduces the overall average of citizens active in the system, yet is not enough to quell the outbreak of activity. Over time however, regardless of the distribution, the active citizen count is lowered to where it reaches a tipping point (around 100 citizens protesting or 13% of the total population) resulting in the collapse of active citizens in the system. Continuation of the simulation after this

point introduces a dynamic of punctuated protest with magnitudes and frequency closely tied with utility distribution. This result is addressed in more detail later in the chapter.

Finding 3: Higher initial utility distributions associated with lower number of citizens in revolt.

In low utility environments, greater levels of utility variance between citizens lead to greater stability. Similar to finding four in the last chapter, we see that in a low average utility environment, a higher distribution results in a lower level of active citizens. All model variations exhibit the presence of citizen revolt, but the average number of active citizens is higher in cases of lower distribution. Table 6 provides a representative run of this phenomenon. In this table as we move to higher levels of distribution, we find increasing levels of active citizens in the system. While lower levels of distribution don't see pronounced differences, the larger the difference in distribution the greater the impact to the number of active citizens.

| Standard Deviation | Active Citizens at Interval 100 |
|:---:|:---:|
| 0 | 383 |
| 0.01 | 375 |
| 0.05 | 373 |
| 0.10 | 325 |
| 0.15 | 241 |
| 0.20 | 208 |

Table 6: Starting Levels of Active Citizens by Utility Distribution

For example, a utility distribution of 0.20 exhibits 84% fewer active citizens as compared with a distribution of zero. This relationship holds as utility changes as the structural difference introduced at the start is maintained, although the size of that difference does change. In Table 7, we see this result with large differences in active citizen counts as we move between lower and higher levels of distribution.

| Measure of Distribution (Standard Deviation) | Active Citizens at Interval 100 | Active Citizens at Interval 1000 | Active Citizens at Interval 2000 |
|---|---|---|---|
| 0 | 383 | 374 | 386 |
| 0.01 | 375 | 375 | 375 |
| 0.05 | 373 | 359 | 228 |
| 0.10 | 325 | 228 | 138 |
| 0.15 | 241 | 205 | * |
| 0.20 | 208 | 146 | * |

**Table 7: Distribution and Active Citizens Model Iterations 100, 1000, 2000**

*Revolt Quelled

The increased level of distribution means that there are more utility rich citizens that do not become active unless their perception of political illegitimacy or their net risk causes them to protest. This behavior at the citizen level helps create more variability in citizen decisions leading to lower levels of active citizens. Over time as utility reaches a certain level, these large distributions disrupt the system leading to a collapse of continuous active citizens and ushering in a period of punctuated protest. Conversely, with lower distributions of utility there are not as many individuals whose grievance is sufficiently low to buttress against the behavior of other active citizens. Therefore, the revolt level

remains persistently high even as average utility climbs higher. With citizens more or less homogenous in their utility, the peer effect of constant revolt reinforces the stability of that equilibrium. However, as we will see later, the same dynamic that serves to sustain a persistently high rebellion in low utility models, serves to lower the level of punctuated protest after revolt is quelled.

This result presents a situation in which greater equality among citizens leads to higher levels of revolt in low utility models. This result implies a counterintuitive proposition; greater inequality leads to less protest. Does this make practical sense though? In a case where there is perfect equality in a society, but all persons are starving it would be entirely plausible to see starving mobs taking to the streets to either protest or to riot for food. If we accept this premise then this result implies a more complicated (e.g exhibits both a direct and indirect relationship) problem for empirical tests that attempt to link inequality and stability. In fact, the empirical literature that seeks to explore the relationship between measures of inequality and conflict do not account for this problem. It is likely that the non-significance or directionality problem they encounter is a result of the phenomenon identified in this model.

Similar to our finding in the previous chapter, our result in the growth utility model reinforces the conclusion that a direct measure of inequality is difficult to use as a predictor of civil conflict. The challenge for researchers is to understand when the directionality of the relationship flips. This is directly related to the average level of utility as well as the distribution. However, understanding an individual's threshold for protest is extremely difficult. It seems that a more direct measure such as the number of

low utility citizens is a better as the correlation between low utility and conflict is maintained in both high and low utility environments.

Finding 4:  During citizen revolt, increasing the utility distribution affects the rate of change of active citizens in the system.

The previous result found that the distribution of utility affected the number of active citizens observed in a state of revolt. While that result is stable as we increase utility over time, we also observe that the rate of decline in active citizen counts changes with utility distribution. As we see in Figure 16, the rate by which active citizens decline differs as we change the distribution of utility. The figure highlights differing functional forms for each model run as we move from exponential declines in active citizen counts when we have small distributions to a linear rate of decline with larger distributions of utility.

 In the low distribution model with a standard deviation of  0.01 we find that the number of active citizens is relatively stable even as average utility climbs higher. However, in a sample run there is a quick decline of active citizens starting around the $2200^{th}$ iteration of the model. The precipitous decline follows a non-linear form with active citizens declining from 371 active citizens at the $2200^{th}$ iteration to 0  by the $2609^{th}$ iteration in the representative model run.   This represents only .04 additional utility added to each citizen to move the system from its' long-term equilibrium of around 370 active citizens to zero.

Conversely, in models with larger distributions we find that active citizens decline immediately and at a linear rate, until the ultimate collapse of the revolt.   In the sample run of the model with a 0.20 standard deviation we find that the count of active citizens moves from its starting count of roughly 210 and reach zero by the 1434th iteration. While the general trend of this decline is linear, the final 100 active citizens around iteration 1434 do collapse in a non-linear fashion.

The rate of decline of active citizens is a function of the variance of citizen utility. When citizens are relatively more homogenous in their utility (e.g small distribution/variance), they exhibit larger active citizen counts and require large increases to average utility to suppress revolt. However, when citizen counts decline, they collapse quickly. Alternatively, in larger distributions, smaller levels of utility are required to move active citizen counts lower. Each of these cases demonstrates that the distribution of the utility is as important as the level itself in supporting levels of active citizens.

To this point, we have discussed the characteristics of revolt we find in the Utility Growth Model. We have discussed how the distribution of utility affects frequency, magnitude, and the rate of change in active citizens during a period of revolt. The next several findings discuss the characteristics of punctuated protest that we find emerges after the revolt is quelled.

> Finding 5**:** Higher utility distribution is associated with ***higher magnitude and frequency of*** protest

We notice that our models begin to develop levels of punctuated activity after a revolt is quelled. The punctuated protests are discernible by the large spikes of active citizens

emerging in the system, but are then suppressed by security forces. This phenomenon is detailed in Epstein, Steinbruner, and Parker's original paper and is a signature in ABM modeling.

For our purposes, the punctuated protest is interesting in that the magnitude and frequency of it is tied to the distribution of the citizens' utility level. We see in figure 17 evidence for this finding. In our model run where the utility distribution is 0.01 standard deviation we see that once revolt is quelled around the 2500 iteration in the model, punctuated protest is observed. The count of active citizens is just over 220, before the cops in the model are able to suppress the outbreak of protest. There are only a handful of outbreaks of protest before the system becomes relatively peaceful with active citizen counts becoming zero for the rest of the simulation.

On the other hand, models with larger distributions have different observables. In our case with a utility distribution of 0.20 standard deviations, we see multiple outbreaks of punctuated protest with a initial active citizen count of almost 400. The magnitude of the punctuated protest declines over time as the average level of utility for the citizens is increased.
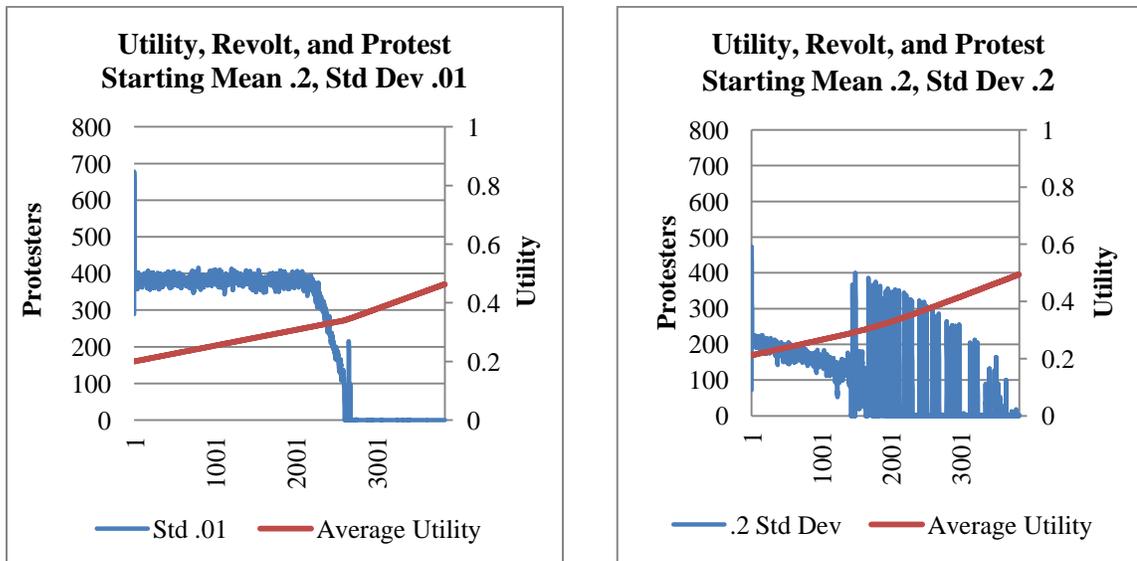
**Figure 17: Increasing Utility and Protest**

The higher magnitude and increased frequency of punctuated protest in larger distribution models is particularly interesting in that the magnitude of active citizens during periods of punctuated protest is higher than during the periods where revolt was observed. As can be seen in figure 17, for almost 1700 iterations in the model, the active citizen counts during punctuated protest exceed 200, the initial level of rebels during the period of revolt.

> Finding 6: Higher utility distributions have punctuated protests that take longer to quell

In addition to differences in the magnitude and frequency of protest, we find that higher distributions of utility amongst citizens lead to longer periods of punctuated protest. Again, figure 17 serves to highlight this finding. As we observe, the level of citizen activity in the model run with a distribution of 0.20 standard deviation maintains levels of

100

punctuated protest through over 3900 iterations of the model, whereas in our other model we see that it subsides before the 2800th iteration. Recalling that in our earlier findings where distribution helped to stabilize a system experiencing revolt, we find the opposite holds true during periods of punctuated protest. At the citizen level, the larger distribution of utility means that both utility rich and poor citizens exist in mass. In low utility scenarios, the higher utility citizens would serve as a more stabilizing force, reducing the count of active citizens. However, once the rebellion is quelled, there still exist large numbers of utility poor citizens whose grievance remains high. Small changes to their risk perception (i.e. as cops move) are enough to change their behavior potentially setting off large waves of protest. The larger distribution therefore necessitates more utility for all citizens such that a vast majority of our individuals' grievance is reduced to the point where the peer effect of other citizens is minimized.

*The Negative Growth Utility Model: Declines in Utility and Protest*

We now have a relatively good idea of how our model performs starting from a relatively low level of utility as it grows over time. We discussed how the initial equilibrium of revolt transforms to a period of punctuated protest and is eventually quelled over time. We also identified that the magnitude, frequency, and rate of change to active citizens in the model is correlated with both distribution and to the level of utility in the system. In this section of the chapter, I continue to explore the dynamics in the model by beginning from a relatively higher level of utility and then decrease it by an interval over time. As with our previous experiments, I rerun this simulation at varying values of utility

distribution. I conduct this experiment to both replicate results achieved earlier, as well as to understand how a system is disrupted from a seemingly stable status.

The series of experiments run in this section of the chapter I referred to as the Negative Utility Growth Model. This model generates three major findings. These findings are:

1) Decreasing average utility over time leads to punctuated protest followed by the outbreak of revolt;

2) Decreasing average utility associated with *higher magnitude and frequency* of protest;

3) Higher initial utility distribution leads to *earlier* punctuated protest;

These findings discussed in detail in the chapter are similar in nature with observations in the Utility Growth Model. This result is not surprising as the methodology is similar, different only in the initial position and the direction of utility growth. However, the advantage of testing the model from an alternate direction, allows us to concentrate on the emergence of active citizens in a stable system. This approach helps in the analysis of initial instability leading to greater punctuated rebellion followed by the emergence of continuous rebellion.

Finding 1: Decreasing average utility over time leads to punctuated protest followed by the outbreak of revolt

This finding is similar to the first finding of this chapter. The introduction of negative utility growth over time introduces three phases to our model. The first phase is one with no active citizens observed. The second phase, marked by punctuated protest, emerges with some citizens choosing to protest at greater intensity only to be suppressed by

security forces. Finally, punctuated citizen activity gives way to revolt as cops are unable to suppress active citizens in the system. The three phases are not homogenous as we do see differences in magnitude and frequency as distribution changes; however, the transition of the model from one phase to the next remains constant across all simulations.
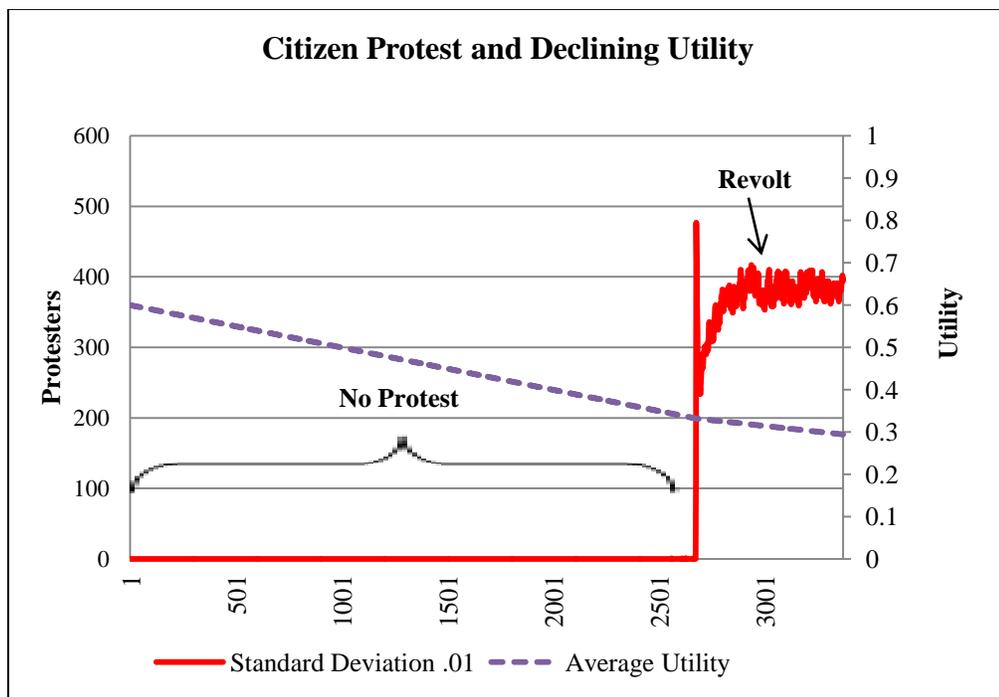


**Figure 18: Citizen Protest and Declining Utility, Std Dev .01**
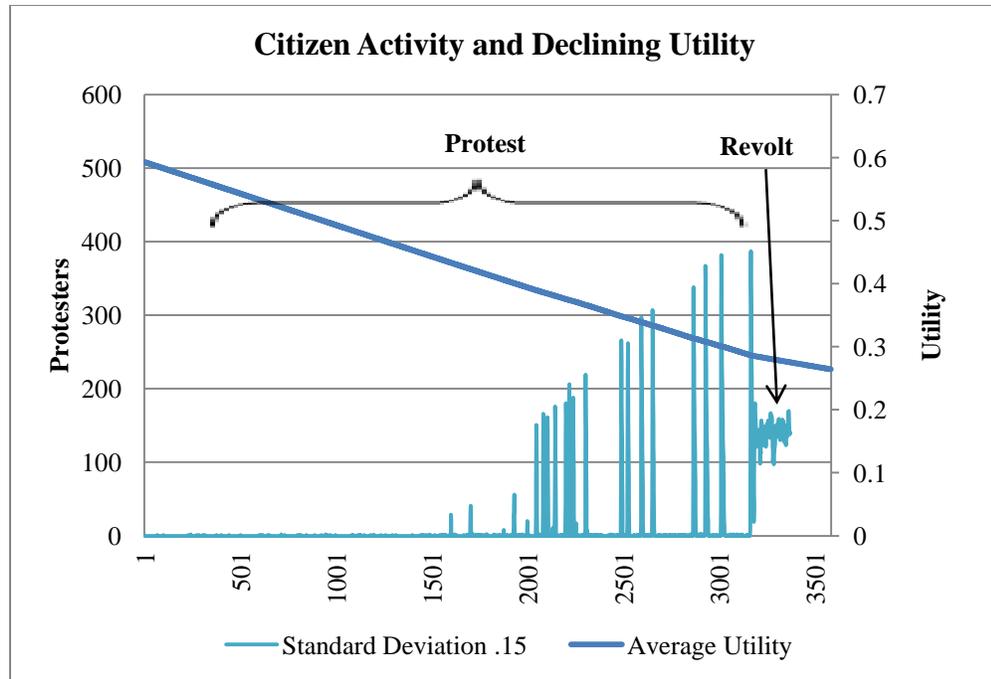
**Figure 19: Citizen Activity and Declining Utility, Std Dev 0.15**

In both figures 18 & 19, we see the transition from stability, to punctuated protest, and finally to citizen revolt. The magnitude, frequency and the speed from one phase to the next are correlated with changes to the utility distribution (e.g standard deviation of utility).

Finding 2: Decreasing average utility associated with *higher magnitude* of protest

When we reduce utility across all citizens by 0.0001 utiles per model iteration, average utility is in turn lowered. As we move from higher average utility levels to lower levels of utility, we begin to introduce instability as grievance levels increase among citizens. The increase in grievance introduces both higher magnitudes of violence as well as increasing

frequency of initial punctuated citizen activity, followed by revolt. We see this pattern

demonstrated in Figure 6, where over time the magnitude and frequency of active citizens

increases both in punctuated protest and revolt.  More specifically, we see the increasing

intensity of protest and revolt in declining utility environments in Table 8.

| Events by Utility Levels Averaged across all Distributions | | | | | |
|---|---|---|---|---|---|
| **Events Categorized by Protester Counts** | **Utility 0.5** | **Utility 0.4** | **Utility 0.35** | **Utility 0.3** | **Utility 0.2** |
| **1-25** | 100% | 89.8% | 65.5% | 20.9% | 0.4% |
| **26-50** | 0% | 3.9% | 4.2% | 2.6% | 0.0% |
| **51-75** | 0% | 1.9% | 4.0% | 2.3% | 0.0% |
| **76-100** | 0% | 2.1% | 4.6% | 3.1% | 0.0% |
| **101-125** | 0% | 1.1% | 4.3% | 3.5% | 0.0% |
| **126-150** | 0% | 0.8% | 4.0% | 2.7% | 0.9% |
| **151-175** | 0% | 0.5% | 3.5% | 3.5% | 12.7% |
| **176-200** | 0% | 0.0% | 3.5% | 18.0% | 6.3% |
| **201 +** | 0% | 0.0% | 6.3% | 43.5% | 79.7% |

Table 8: Events by Utility Level

At an average utility level of 0.50, all events are small in scale with 100% of protests

containing fewer than 25 active citizens in the system. Whereas in a low utility

environment, more of the events become large scale events (e.g.  79.7% for utility level

of 0.20). This pattern repeats throughout the data, with low intensity events dominating in

high utility environments, and with high intensity violence associated with low utility environments.

Finding 3: Higher initial utility distribution leads to *earlier* and more frequent punctuated protest

As utility levels are decreased over time, punctuated protest occurs earlier and more frequently with higher distribution levels. In figures 20 & 21, we see that an initially stable system moves to a period of punctuated protest followed by the emergence of citizen revolt.
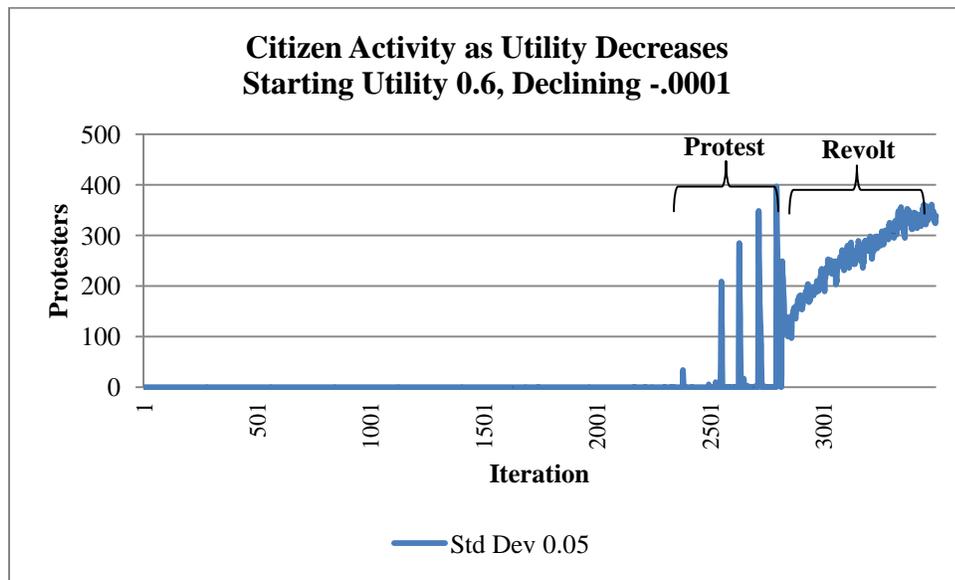


**Figure 20: Citizen Activity as Utility with Distribution of 0.05 Declines over Time**

The onset of punctuated protest does differ however as we change distribution of utility among citizens. We can visually check this in the two figures. Our simulation with a standard deviation of 0.15 begins seeing punctuated protest around model iteration 1604,

while in the smaller distribution of 0.05 we do not see this activity until model iteration

2384.

**Citizen Activity as Utility Decreases
Starting Utility 0.6, Declining -.0001**
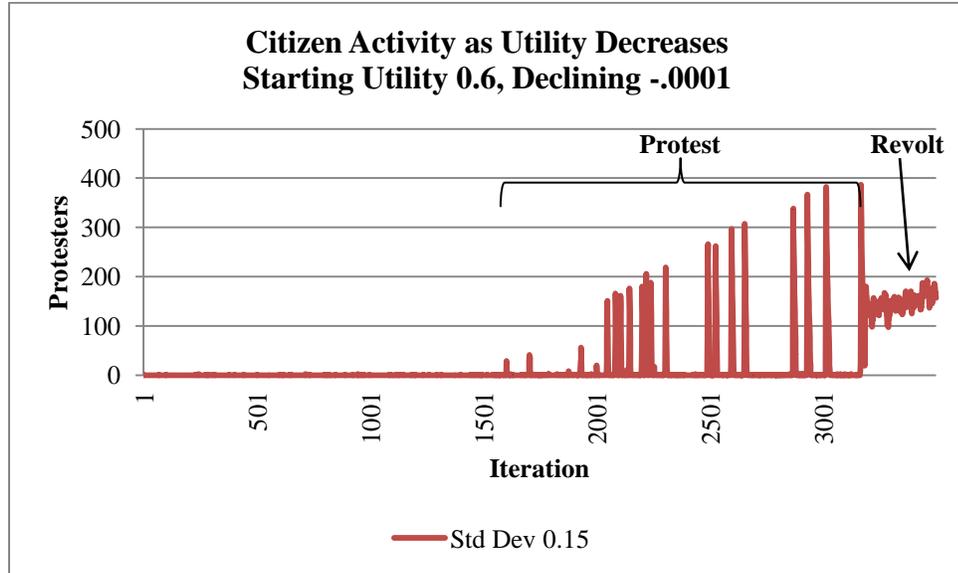
**Figure 21: Citizen Activity as Utility with Distribution of 0.15 Declines over Time**

Moving beyond visual analysis, we can see the onset of punctuated protest across all

tested distributions in table 9. There is a general trend of earlier punctuated protest onset

as we increase distribution. The one exception to this finding is for a distribution of 0.20.

In this case, we do see earlier episodes of protest, but the magnitude of the events are

under the 25 citizen definition. It is interesting that although we do not see the earlier

onset of larger events, the presence of significant numbers of lower magnitude events

portend an increasingly unstable system.

| Distribution | Punctuated Protest >25 (Model Iteration) | Revolt (Model Iteration) |
|---|---|---|
| 0.01 | *No Punctuated Rebellion | 2678 |
| 0.05 | 2384 | 2819 |
| 0.1 | 2137 | 3055 |
| 0.15 | 1604 | 3167 |
| 0.2 | 2047 | 3495 |

**Table 9: Start of Rebellion by Distribution and Model Iteration**

Thus far, we have observed that the magnitude of punctuated protest appears correlated

with the distribution of utility among citizens in our system. However, we also find that

in addition to the earlier onset of punctuated protest, revolt among citizens also appears

more frequent in systems with a wider distribution of utility. We observe in Figure 21

over 14 episodes in a system with a standard deviation of utility of 0.15, whereas in

Figure 20 we find only four major episodes tied to a distribution of 0.05.

*Conclusion*

In this chapter, we explored the dynamics of the modified Brookings Model as we

allowed utility to change over time. Change to utility, and thereby hardship, both in its

level and distribution provided decidedly distinct results from the Brookings model.  The

magnitude, frequency, and onset of protest and revolt are affected by the distribution of

utility amongst citizens within the system. The change to activity in three phases of

citizen behavior, stability, punctuated protest and revolt inform us to how selection and peer effects in the model influence the outbreak and sustainability of revolt.

The results discussed in the chapter have provided insight into possible relationships that are observed in empirical data seen in conflict datasets. Specifically the relationship between utility levels, their distribution and the impact to protest/revolt frequency, onset, and magnitude provide verifiable postulates, which if supported would allow us to better understand how the symptoms of discord work together in a broader context.

# Chapter 6: Policy Considerations and Areas for Future Research

**"When the fabric of society is so rigid that it cannot change quickly enough, adjustments are achieved by social unrest and revolutions."**

**-John Boyd Orr**

Human expression of grievance can evolve from the angst of single individual into a broad movement demanding the removal of a central authority. The manner in which protest stems from the economic condition of the individual and his peers is the focus of the dissertation. The characteristics of a protest, specifically the onset, magnitude, and frequency of civil unrest is explored by expanding on the Brookings Model. The results of the simulation lay out specific relationships between protest and changes to the average level of utility, its distribution, and rate of change of utility in a system of agents.

This approach is distinctly different from most research in civil conflict as it avoids statistical modeling and instead utilizes an agent based computational approach. This method allows us to develop a coherent theory of how individual motivation transforms into group behavior and allows us to analyze both multi points of equilibrium as well as states of disequilibrium. Our results from this effort provide coherent, consistent, and in some cases surprising conceptual results that expand our understanding of the dynamics of protest. These results suggest that the level and distribution of individual utility play important roles in how mass protest emerges and develops in a system of agents. The importance of citizen's economic well-being therefore becomes an important policy concern as governments and international agencies evaluate the efficacy of reform

programs. While economic interests in the long-term are served by substantial subsidy reform or decreases in state supported employment, the short-term consequences to social stability are important factors that should be considered.

Most research into civil conflict and violence has utilized either case study or econometric modeling that utilize large datasets to draw inference between variables and the outbreak of civil conflict. In the second chapter of this paper, we discussed major themes in the field of conflict study of the past several decades. The most recent research in the field has focused on the relationship between determinants of political grievance or macro-economic condition on the emergence of civil conflict. Some studies suggest economic conditions, specifically the amount of primary commodities as a percentage of GDP, provide incentive for rebellion to ensue as purely a function of the net benefits individuals receive from rebellion. Other supporters of this view, while skeptical of the primary commodities argument, look to macroeconomic indicators as a reflection of the weakness of central authority to repress any potential uprisings, and not to the microeconomic condition of individuals as a motivator for protest against the state. They point specifically to measures of national income and economic growth as proxies for the relative strength of the central authority and its ability to field security forces large enough to deter or quell any potential uprising. Primarily citing statistical correlation between income measures and the outbreak of civil conflict, these researchers are largely ignoring economic-grievance determinants of emergent violence. While some researchers point to the robustness of these independent variables on the onset of civil conflict, the lack of detailed local data blunts the ability of statistical analysis to delve deeper into possible economic grievance motivators for conflict. Is it possible that the statistical

correlations between income, growth and the outbreak of civil conflict are not strictly explained as a proxy of government strength or of the benefits of rebellion, but are in fact tied to the grievance of individuals who are not able to support themselves or their families?

This dissertation has taken a different approach to the problem of understanding how mass protest emerges in society. Instead of conducting an econometric analysis testing independent variables against large datasets of conflict data, agent based modeling techniques are utilized to help conceptualize how measures of individual utility relate to emergence of mass protest and possible revolt. This effort builds on an earlier framework of emergent protest that allows us to explore how changes in the average utility and its distribution in a system of adaptive citizens affect an emergent outcome of civil unrest. The third chapter details this effort to modify the Brookings Model by focusing in three specific areas. First, we can change average level of utility in a system of citizens removing the uniform distribution used in the original model. The introduction of a normal distribution severs the constraint imposed by a uniform distribution allowing for changes to both the mean and standard deviation. Second, the introduction of a modifiable standard deviation allowed for testing at various intervals allowing us to examine changes in utility variation in the system of citizens. This change lets us examine how distributional affects among citizens affects adaptive behavior. Lastly, the introduction of time into the model provides an opportunity to witness changes to utility in citizens at some regular interval.

How do the changes we introduce to the Brookings model affect emergent phenomenon? These changes are discussed at length in chapter 4 & 5 and are broadly grouped between

findings resulting from our exploration of a static model (non-time dependent) and dynamic simulations that explore changes to utility over time. In chapter 4, the central findings are:

- Lower levels of average utility are correlated with <u>higher magnitude</u> protests, regardless of utility distribution;

- Lower levels of utility are associated with <u>greater frequency</u> of protest, regardless of distribution;

- Variance of utility  is associated with the <u>earlier onset</u> of protest;

- In high average utility models, higher variance <u>increases</u> magnitude and frequency of protest; lower utility models with higher variance <u>lowers</u> magnitude and frequency of protest; and

- Lower utility citizens are associated with higher instability.

Of these results, the fourth finding is the most surprising. While we could surmise that lower levels of citizen utility are associated with higher grievance thus leading to bouts of aggression (e.g. the bread riot), the bifurcated result discussed in finding four offers a significantly different conceptualization of the relationship between  inequality and civil unrest.

Traditionally, scholars have theorized that inequality is directly correlated with increased civil unrest. The line of reasoning being that as the masses have less relative  to the wealthy, angry protest ensue against the inequity of distribution of income. Yet despite well articulated arguments, and in some cases specific examples of a correlation, broad based econometric analysis has not been able to find any linkage between the two. The

model proposed in this paper, conceptually demonstrates a bifurcated result that is both utility and threshold dependent. *At some point, increased equality of citizens in a system ceases to be stability maximizing and instead introduces extreme volatility in the system.* For example if we have two societies, each with perfect equality amongst its populace, one that is wealthy and meets all of the needs of its populace, the other poor. In the first case, the entire populace has a home, food, and is able to live a meaningful life. In this society it is unlikely we see unrest due to financial hardship as individuals have what they need to survive. In the second case however, the entire society is below some threshold of subsistence. While all individuals are equal, they are all equally starving.

In chapter 5, we expanded our work on the Brookings model to account for inter-temporal changes. By adding time to our analysis, we induce adaptive changes by citizens in the system allowing us to examine how protest emerges or collapses in our model. This effort produced nine key findings that include:

- Increasing average utility over time leads to quelling of revolt followed by periods of punctuated protest;
- Increasing average utility over time associated with lower numbers of rebels in revolt;
- Higher initial utility variance associated with lower number of rebels in revolt;
- During revolt, increasing the utility variance affects the rate of change of active citizens in the system;
- Higher utility variance associated with higher magnitude and frequency of punctuated protest in systems in system with increasing levels of average utility;
- Higher utility distributions have punctuated protest that take longer to quell;

114

- Decreasing average utility over time leads to punctuated protest followed by the outbreak of revolt;

- Decreasing average utility associated with *higher magnitude and frequency* of protest; and

- Higher initial utility distribution leads to *earlier* punctuated protest;

These results have provided useful concepts in understanding how the form of protest emerges in systems of decreasing utility, how its distribution affects frequency and magnitude, and finally how seemingly intractable revolt collapses into protest. The results presented are useful conceptual findings that draw on inference from individual behavior that provide coherent and plausible emergent phenomenon in social systems. Assuming that these results are supported by additional empirical work they provide useful guidance to researchers for future empirical work and provide insight for policy making in societies that might be at risk for civil conflict.

*Implications for Public Policy*

Understanding how protest emerges from individualized grievance and how it progresses to a coherent and large-scale movement in a society remains an important goal for policy makers eager to address issues that help to forestall significant social upheaval. The recent protests, revolts, and rebellions of the Arab Spring serve as an enduring reminder to the speed and magnitude of social unrest in seemingly stable countries. The findings in this study demonstrate that the level of utility, its distribution, and rate of change can matter substantially. While we have focused on expanding a conceptual model of protest in a system of agents, the findings can provide useful insight into how protest forms,

evolves, and expands. Therefore understanding these dynamics is useful to policy makers who are concerned about state stability while in a period of economic transition and reform.

While the speed and severity of Arab Spring protests served to highlight to much of the world the problem of civil conflict, significant research on the subject has been ongoing. The most recent work has explored socio-economic, geographic, and demographic variables deemed to be important determinants of civil conflict. Chief among these findings are that measures of income and economic growth are found to be strong correlates with outbreaks of civil war. Yet while some of these results have been accepted into the orthodoxy of civil conflict research (e.g. measures of income per capita), they tend to interpret the behavior of rebels as a form of rent seeking behavior or as an indicator of central state weakness not as a form of individual grievance as motivator to protest, revolt, and eventually rebellion. While this might be good at explaining quasi criminal conflicts in Sierra Leone or in the drug producing regions of Columbia, they are less successful in explaining the origins and evolution of political protest found in the Arab Spring, where individual action lead to protest, growing in size and intensity. If individual condition remains an important factor in social stability, leaders in weak states should consider the impact policy changes have on its most vulnerable citizens.

*Implications for Subsidy Reform*

International organizations and central authorities expend a great deal of effort in understanding the complexities of underperforming economies, developing reasonable action plans, and finally managing the process of economic reform. The objective of both

organizations and their government partners is to boost national income. Often part of the strategy is to reform subsidy programs to help foster faster growth leading to increasing incomes for citizens. These reform efforts often call for removal of state support of common household staples such as cooking gas or bread. These reforms reduce government expenditures on price supports, that can then be used in areas that are more productive. In the end, the economy grows as the government allocates resources more efficiently. These efforts are well intentioned and serve to solve the larger structural problems in the economy, but they largely ignore possible short-run social stability concerns. The removal of state subsidies on highly demand inelastic goods such as cooking fuel, reduces household income as individuals are unable to substitute away from these goods. While wealthy or middle class households are unlikely to suffer significantly under this type of reform, low income households might find it more difficult to survive. If stretched enough, an individual or group might see no alternative but to voice their discontent.

*Increasing Individual Deprivation: Jordanian Subsidy Reform*

On February 4th 2011, an explosion destroyed a pipeline to Israel and Jordan, significantly disrupting fuel supplies to both countries. This was the latest in a series of attacks against pipelines since the Arab Spring uprisings in Egypt forced Hosni Mubarak from power.[14] This attack forced Jordan to import its energy by other means, significantly increasing the cost of energy in the Kingdom. The Jordanian government maintained state subsidies to help insulate the populace from increased prices, but at the cost of

---

[14] http://www.nytimes.com/2012/02/05/world/middleeast/egyptian-pipeline-supplying-israel-is-attacked.html?ref=sabotage&_r=0

increasing central government expenditures on fuel subsides in 2011 and the first half of 2012. Prime Minister Fayez al-Tarawneh estimated that the additional cost to the budget had reached roughly 2.5 billion Jordanian Dinars by mid 2012.[15]

Facing a yawning budget deficit and needing to reduce expenditures, the government announced on September 1st 2012 a modest 10% increase in fuel prices. The following day, Jordanians from Amman to the southern city of Ma'an rallied for the immediate resignation of Prime Minister Fayez al-Tarawneh in the face of increased prices.[16] The protesters were reported to be numbered in the thousands.[17] On September 3rd, the Jordanian King acquiescing to the demonstrators, announced a suspension to increased of fuel prices. While the King's announcement appeared for the moment to mollify the populace, political demonstrations returned on October 5th and reportedly attracted up to 10,000 people calling on the government to take up needed economic reforms.[18] After the October rally, street demonstrations appeared to ebb with the government raising the prospects of new elections to meet many of the protesters demands.

On November 13th , 2012 the cabinet announced that subsidy reforms would be carried out resulting in a increase in gasoline, cooking and heating gas. The Jordanian government indicated that without support payments from foreign partners, specifically Saudi Arabia, they were unable to keep the supports in place[19]. The reform was reintroduced as the budget deficit from increased fuel payments swelled above 3 billion

[15] http://jordantimes.com/per-capita-fuel-subsidy-compensation-set-tentatively-at-jd70-a-year-for-limited-income-households
[16] http://en.trend.az/regions/met/arabicr/2060982.html
[17] Ibid
[18] http://www.nytimes.com/2012/11/14/world/middleeast/jordan-faces-protests-after-gas-price-proposal.html?pagewanted=all
[19] http://jordantimes.com/jordan-reaches-out-to-wealthy-arab-states--for-urgent-financial-aid

dinar. Gasoline prices for 90 Octane increased from JD 0.70 per liter to JD 0.80. Diesel fuel increased from JD 0.515 to JD 0.685 per liter, a 33% increase. Gas for cooking increased the most rising from JD 6.50 to JD 10.00, a 54% in the price for a single gas cylinder.[20]

**Number of Protesters in Jordan**
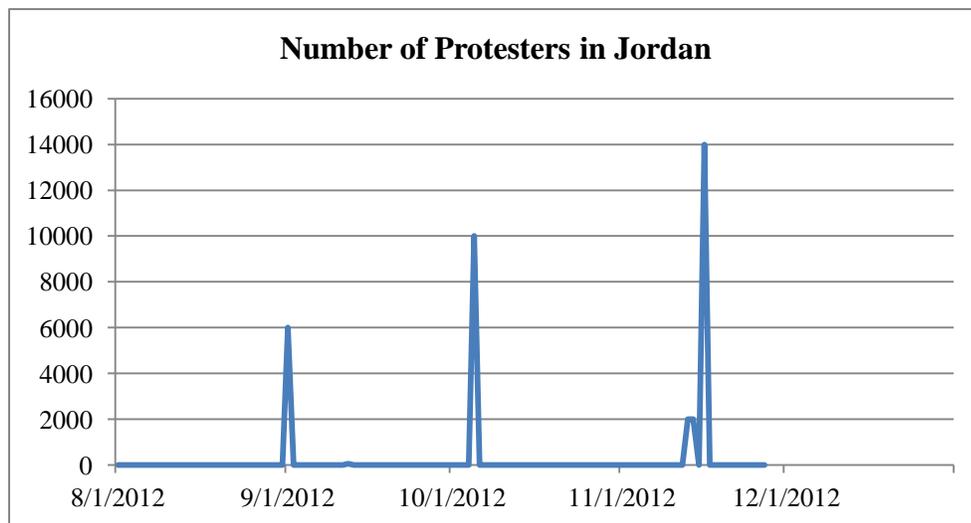
Figure 22: Protest Numbers in Jordan 2012

Once again, violent protests erupted from November 13th through the 15th with thousands taking to the streets in over 100 different demonstrations demanding the cessation of the subsidy reform program.[21] The government, previously willing to suspend the subsidy reform program, found itself unable to, primarily because of the increasing deficit being driven by the higher fuel costs. In a bid to soften the impact to poor households, the government introduced proposals to provide direct cash payments of up to JD 420 per

---

[20] http://www.albawaba.com/business/jordan-fuel-451968
[21] http://www.nytimes.com/2012/11/14/world/middleeast/jordan-faces-protests-after-gas-price-proposal.html?pagewanted=all

year for families whose income did not surpass JD 10,000.[22] At the time of the writing ,

it is not clear if the protests centered around energy subsidy reform in Jordan will

continue. However, what this particular example demonstrates is the sensitivity of

subsidy reform on households and the possible protest it can trigger. Although this is a

single case example, it nicely frames a core concept of this paper, the economic

conditions of the individual help to drive the emergence of protest, its magnitude, and

frequency. While each example of political protest, revolt, or rebellion is multi faceted

the role of grievance stemming from individual deprivation should be considered as a

significant determinant of political protest.

*Tying Subsidy Reform to the Growth Model*

The story of Jordanian subsidy is an interesting case study, but can it be tied to the model

presented in this paper to help us understand how emergent protest forms? The growth

model presented in Chapter 5 while purely conceptual does provide us a framework to

understand how changes to subsidy programs in Jordan can influence social stability. In

this section, I discuss the Jordanian subsidy case coupled with an extension to the

conceptual model in Chapter 5. This extension simply allows for differing growth to

utility among citizens in our model. To achieve variable growth, I simply allow the

amount of utility added to citizens to vary by a standard deviation greater than zero. This

allows us to examine average growth to citizens in the model, but varies the amount of

growth each individual citizen experiences. Therefore, if the *average* growth of utility is

.001 utiles per iteration of the model, but varies with a standard deviation of 0.005 we

---

[22] http://jordantimes.com/per-capita-fuel-subsidy-compensation-set-tentatively-at-jd70-a-year-for-limited-income-households

find that some citizens will add utility at a level greater than .001, while others experience negative utility growth. This action simulates inequality of growth in the model and is an important extension as we discuss how subsidy reform affects economic growth and social stability.

In Figure 22 we show the reported protests in Jordan before and after the announcement of fuel subsidy reform. Prior to the announcement on September 1st 2012, there were no protests reported as noted by no spikes in the graph prior to that date[23]. We can compare that initial condition with our model output represented in Figure 23. We have a initial system that has a level of utility of 0.5 (blue line) that remains constant through the first 500 iterations of the model. Beginning with iteration 501 we reduce the level of utility for all citizens by .01 for 10 periods.
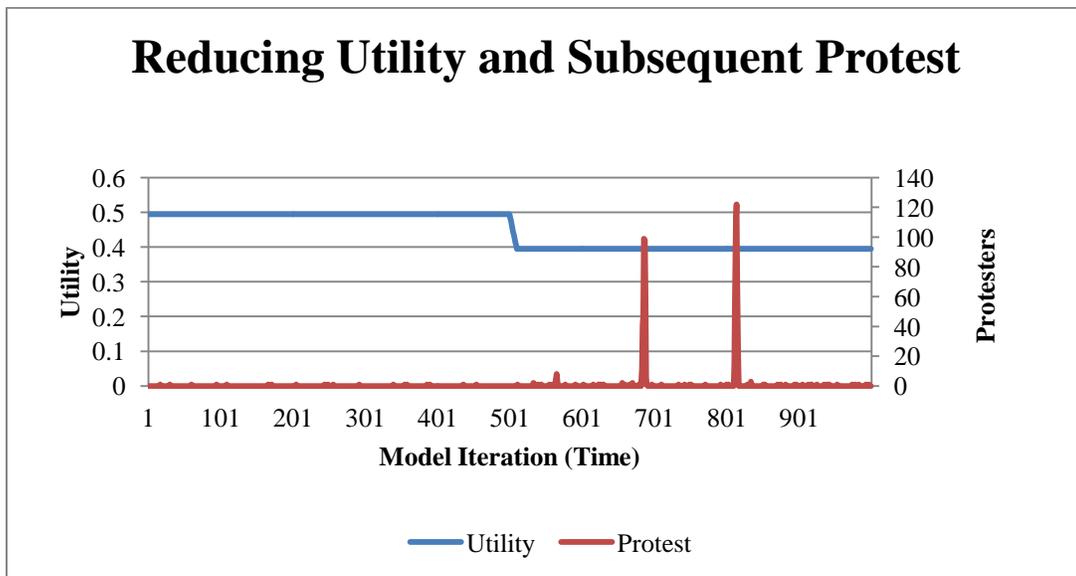


**Figure 23: Reducing Utility and Subsequent Protest**

---

[23] Earlier protests in 2011 were tied to general economic problems such as unemployment, but as this specific example is tied to subsidy reform I do not discuss them.

This serves to reduce utility by 0.1 to a new level 0.4. This is meant to simulate the reduction in citizen well-being stemming from the removal of subsides. In our Jordanian example, this would represent either the initial subsidy reform announcement on September 1st 2012, or the second announcement on November 13th 2012. We can see in Figure 23 that once we reduce utility punctuated protest forms around the 560th, 700th, and 800th iteration with the largest protest reaching around 120 active citizens. Do we see the same phenomenon in our real world example? If we again look at Figure 22, we see after the announcement on September 1st and again on November 13th large protests erupting in Jordan. While not an exhaustive analysis on the efficacy of the model, this simple example allows us to draw a linkage between real world events and our model presented in this paper.

The subsidy reform effort in Jordan was primarily aimed at reducing financial support to better off households who were receiving benefits at the expense of the central government.[24] By reducing inefficient subsidy support, along with other reform measures the International Monetary Fund seeks increase economic growth in the country and to improve its overall fiscal position.[25] However, if subsidy support is removed for all households in an attempt to generate long-term economic gains is there a risk for both short-term social instability even as the country is growing?

---

[24] https://www.imf.org/external/pubs/ft/survey/so/2012/int080312a.htm
[25] Ibid

## Subsidy Reform, Growth, and Protest
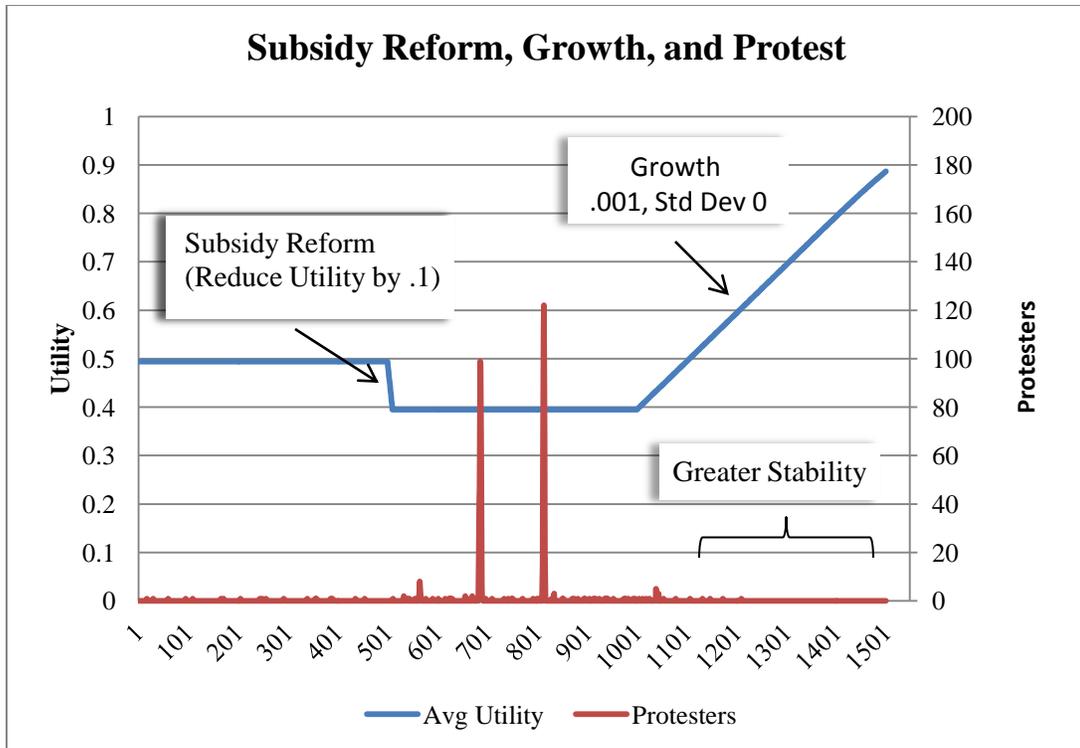


Figure 24: Subsidy Reform, Growth, and Protest

In Figure 24, we again revisit a model that shows a system that has a starting utility of 0.5, but introduces subsidy reform at iteration 500. The subsidy reform reduces average utility to 0.4 generating punctuated protest, something we predict from our discussion thus far. At iteration 1000 we introduce economic growth by adding utility to *every* citizen. Protest evaporates from the system leading us to conclude that although short-term instability is a real problem with subsidy reform, in the long-run stability returns with all agents becoming better off. Does this proposition hold when growth is uneven?

In the discussion above we stepped through how the model can help us understand protest dynamics associated with subsidy reform, however our analysis was limited to equal growth shared by all citizens. If we allow growth among citizens to vary do we get the same result?
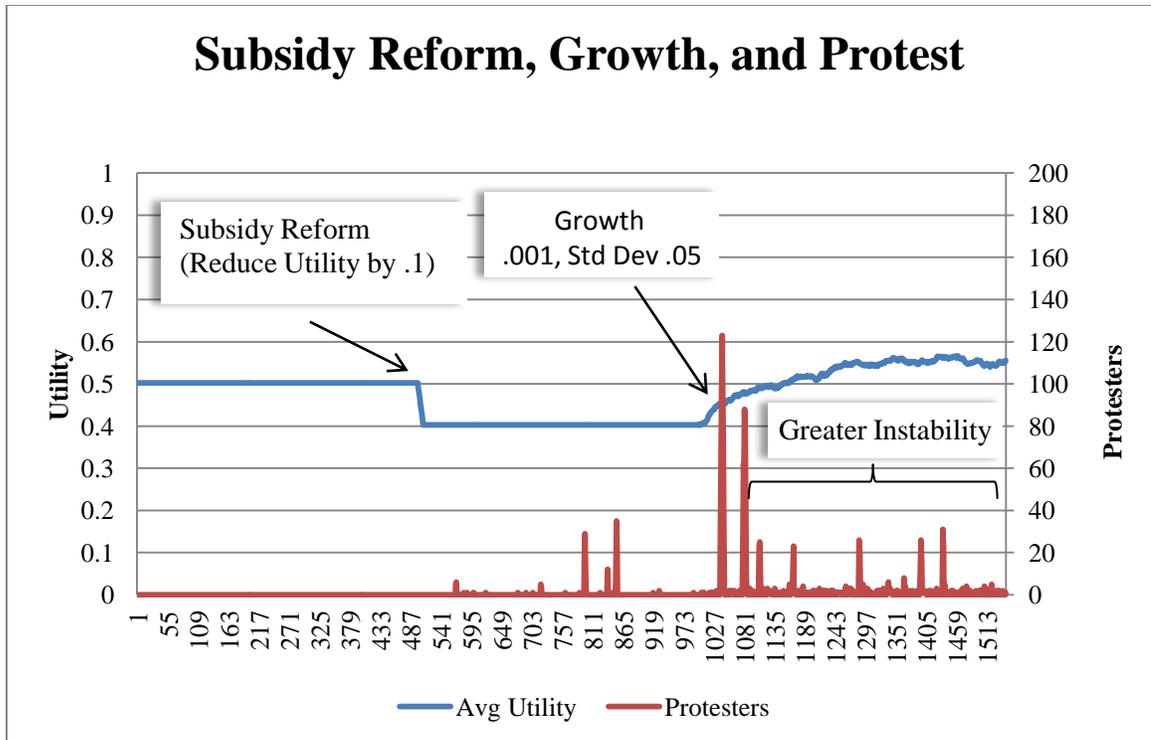
**Figure 25: Subsidy Reform, Growth, and Protest**

Figure 25 is similar to Figure 24 in that the system begins with the same initial utility

and is subject to subsidy reform at iteration 500, lowering average utility in the system by

0.1. However, while Figure 24 introduced economic growth for all citizens at iteration

1000, Figure 25 allows growth to vary among citizens. By introducing variable growth

we see a different result. Even through average utility increases overall for the system,

social stability erodes. If this model is to be believed, then while reform efforts might be

successful in increasing overall growth in a country, an unintended consequence might by

increased social instability for a longer period. This is an important issue for policy

makers and researchers as it highlights a deeper and more complex set of interactions

among citizens and the state. While I do not formally address this model variant in this

paper, leaving that exercise for future research, it is enough to highlight this model result

as an example of the usefulness of the ABM approach to understanding changes in economic reform policy.

*Areas for Future Research*

This paper discussed changes to a portion of the Brookings Model as a way to explore how changes in individual utility affect the emergence of protest in a system of citizens. The goal of this effort was to understand how these changes would affect the emergent behavior of citizens in the system. While changes to both the average level of utility and its distribution produced important conceptual breakthroughs for our understanding of how utility and protest relate, there remains additional work that would help expand on our results. These efforts include a renewed examination of large-scale statistical evidence utilizing the results of this paper as a series of testable hypotheses, additional work with specific case studies and micro level data on protest, and finally additional conceptual work that builds upon the simple changes made to the Brookings model.

Our results, while informative conceptually, need to be verified empirically either through case study or statistically. While some empirical research has supported the general viability of the Brookings Model, additional empirical work would help in supporting our conclusions about the relationship between individual economic condition and the emergence of civil unrest (Gulden 2004, Epstein 2010). To test the viability of the findings in this paper statistically, an effort that examines individual well-being (egg not only income) and civil unrest should be pursued. While beyond the scope of this paper, examining the role of poverty as a derivative of utility distribution would be helpful in supporting or refuting many of the results of this paper that identify low utility

125

citizens as a measurable determinant for the onset, magnitude, and frequency of protest. To achieve this, our measures of poverty cannot simply be income based, but must include the range of state supported services (e.g. state subsidy) that contribute to overall well-being. While some efforts to examine this relationship have shown some support to this conclusion, more research is needed to establish this link (Vadlamannati 2011).

While econometric research utilizing large datasets has been useful in identifying apparent causal links, they are unable to reach consensus about the role that grievance factors play in civil unrest (Sambanis 2004). The large datasets used by researchers aggregate measures of political systems, economic, and social condition and therefore cannot provide the localized data required to understand civil unrest at a sub national level. Localized conditions have been shown to produce strikingly different conclusions from common casual explanations of civil violence that rely on macroeconomic data (Jones 2007). The results in this paper are characterized by changes to the onset time, magnitude and frequency of punctuated protest that lend itself to localized data analysis to support its results. In fact the recent spate of protest in several countries during the Arab spring are characterized by growing punctuated protest, with some evolving into civil war (e.g Libya and Syria) while others exhibiting on-going peaceful protest (e.g Jordan). Each case while part of the collective phenomenon of the Arab Spring remain distinct in the formation and evolution of protest, therefore requiring individual treatment by researchers.

While this paper has advanced our understanding of the dynamics of political protest, it does not portend to have constructed a final version of such a model. While the effort of

126

this research has extended the Brookings Model, it has not attempted to incorporate some additional elements we might deem important. Some of these might include:

- As utility changes over time, do citizens change their perceived legitimacy of the central authority? If so how does it affect punctuated protest?

- As protest levels increase, how are changes in central regime response modeled?

- If protesters are killed vice imprisoned, is there a substantial change in our results?

- How do changes to period weights affect the sensitivity of utility changes over time?

Future efforts to expand on this work are likely to identify additional elements that are also relevant in our analysis of how economic conditions, government legitimacy, and security affect emergent mass protest.

*Conclusion*

Through the course of this paper, we have explored a conceptual approach to understanding the emergence and evolution of political protest. By using an agent based model approach and extending earlier work we find that the level, distribution, and rate of change of utility affects the onset, frequency, and magnitude of political protest in a system of agents. This approach is markedly different from analysis that has utilized case study or statistical models to draw correlations between variables and the onset of civil war. While these studies have been useful for identifying some determinants of increased probability of civil violence, they are limited in their function. Our agent based modeling

approach allows us to explore multiple iterations providing a conceptual framework that yields consistent and coherent results that should and could become the starting point for additional empirical analysis.

The protests, revolts, and revolutions of the Arab spring serve as a reminder of the importance of understanding the underlying causes of social instability. Seemingly isolated acts of desperation can have profound geo-political consequences. With the speed and breadth of modern telecommunications ideas and social upheaval can move faster and further than ever before. This requires a deep understanding of the determinants and evolution of conflict so that reasonable policies can be put in place to address grievance before social instability manifests itself and moves beyond our control. By addressing the underlying concerns of people yearning for a better life, we help maintain our own.

# Appendices

*Appendix I: NETLOGO Code for the Modified Rebellion*

;; Core rebellion codeset wriiten by Uri Wilensky. Modified by Charles Harry to include modified measures of starting mean utility, and standard deviation. Also modifies to allow for the ability to change utility over time.


 breed [agents agent]

 breed [cops cop]


;;;;;;;;;;;;;;;;;;;;;;;Defining Varibles;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

 globals

[

  k              ;;factor for determining arrest probablity



  ;;;;;;;;;;;;;;;;;;;;Slider Variables;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

  ;; Threshold is by how much must G > N to make someone rebel?

  ;; Copy Density is how many copy is the field you want to deploy

  ;; Agent Density is how many agents you want in the field

  ;; movement? is a true or false variable that allows for movement

  ;; income-variability is a variable to add to Utility in present period to account for changes in income.

 ]


 agents-own   ;; defining variables for agents

[

risk-aversion      ;; R, fixed for the citizen's lifetime, ranging from 0-1 (inclusive)

perceived-hardship ;; H, a function of utility   H(utilityn)

utilityn          ;; Utility in period N

utilityn-1         ;; Utility in period n-1

utilityn-2         ;; Utility in period n-2

utilityn-3         ;; Utility in period n-3

utilityn-4         ;; Utility in period n-4

utilityn-5         ;; Utility in period n-5

active?           ;; if true, then the agent is actively rebelling

jailterm          ;; how many turns in jail remain (if 0, the agent is not in jail)

personallegitimacy ;; agents personal legitimacy

shadowutilityn     ;; Utility without stimulus intervention

shadowutilityn-1   ;; Utility without stimulus intervention period n-1

maxutility        ;; Maximum Utility level




]


patches-own   ;; defining variable for patches

[

  neighborhood      ;; surrounding patches within the vision radius

  ;vision          ;; value of vision

]


;;;;;;;;;;;;;;;;;;;;;Begining Setup Procedure;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

to setup

  ca             ;; clear the model

```
set k 2.3        ;; set arrest probablity to 2.3


ask patches

[

  set pcolor gray - 1   ;; sets the patches background color to dark gray

  set neighborhood patches in-radius vision   ;; cache patch neighborhood

]


create-cops round (initial-cop-density * .01 * count patches)  ;; Creating cops

[


  move-to one-of patches with   ;;move a cop to a random patch "where the following
exists..."

  [

    not any? turtles-here      ;;no citizens exist in this patch

  ]


  display

]


create-agents round (initial-agent-density * .01 * count patches)   ;;creating agent


[

  move-to one-of patches with  ;; move a agent to a random patch "where the following
exists..."

  [

    not any? turtles-here      ;; no citizens exist in this patch
```

```
  ]


    set heading 0                              ;; heading of the turtle

    set risk-aversion random-float 1.0         ;; sets a random number for the citizens risk
adversion

    set perceived-hardship random-normal mean-strt-income stddev-strt-income  ;; sets a
random number for percieved hardship

    set utilityn perceived-hardship                        ;; sets hardship and utilityn as
the same

    set utilityn-1 utilityn                                ;; sets the previous periods utility
to the same

    set utilityn-2 utilityn                                ;; sets the previous periods utility
to the same

    set utilityn-3 utilityn                                ;; sets the previous periods utility
to the same

    set utilityn-4 utilityn                                ;; sets the previous periods utility
to the same

    set utilityn-5 utilityn                                ;; sets the previous periods utility
to the same

    set active? false                                      ;; sets the flag for active to false

    set jailterm 0                                         ;; sets inital state of jailterm to 0

    set color blue                                         ;; sets color of agent blue

    set personallegitimacy government-legitimacy           ;; sets individual
legitimacy based on change to income

   display

  ]


  ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;Calculating the Starting Hoover Index for
Inequality;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

  ask agents

  [
```

```
let utilitymax max [utilityn] of agents                    ;; Set Max Utility

let utilitymin min [utilityn] of agents                    ;; Set Min Utility

let utilitydiff utilitymax - utilitymin                    ;; Defining the Utility
Difference

let quintilesize utilitydiff / 5                    ;; Calculating the Quintile Size

let quintile-1 utilitymin + quintilesize                    ;; Calculating the upper
bound of Quint 1

let quintile-2 quintile-1 + quintilesize                    ;; Calculating the upper
bound of Quint 2

let quintile-3 quintile-2 + quintilesize                    ;; Calculating the upper
bound of Quint 3

let quintile-4 quintile-3 + quintilesize                    ;; Calculating the upper
bound of Quint 4

let quintile-5 quintile-4 + quintilesize                    ;; Calculating the upper
bound of Quint 5

let utilitysum sum [utilityn] of agents                    ;; Sum total Utility for the
system

let agentcount count agents


if utilityn >= utilitymin and utilityn <= quintile-1                    ;; Calculating the Sum
and count for the quintile 1

[


set utilitysumquint1 sum [utilityn] of agents

set countquint1 count agents


]


if utilityn > quintile-1 and utilityn <= quintile-2                    ;; Calculating the Sum
and count for the quintile 2

[
```

```
    set utilitysumquint2 sum [utilityn] of agents

    set countquint2 count agents

  ]


  if utilityn > quintile-2 and utilityn <= quintile-3              ;; Calculating the Sum
and count for the quintile 3

  [

    set utilitysumquint3 sum [utilityn] of agents

    set countquint3 count agents

  ]


  if utilityn > quintile-3 and utilityn <= quintile-4              ;; Calculating the Sum
and count for the quintile 4

  [

    set utilitysumquint4 sum [utilityn] of agents

    set countquint4 count agents

  ]


  if utilityn > quintile-4 and utilityn <= quintile-5              ;; Calculating the Sum
and count for the quintile 5

  [

    set utilitysumquint5 sum [utilityn] of agents

    set countquint5 count agents

  ]


  set hooverindex ( 0.5 * ( abs ( ( utilitysumquint1 / utilitysum ) - ( countquint1 /
agentcount )) + abs ( ( utilitysumquint2 / utilitysum ) - ( countquint2 / agentcount )) + abs
( ( utilitysumquint3 / utilitysum ) - ( countquint3 / agentcount )) + abs (( utilitysumquint4
/ utilitysum ) - ( countquint4 / agentcount )) + abs ( ( utilitysumquint5 / utilitysum ) - (
countquint5 / agentcount ))) )
```

]


  ;; update plots                          ;; plot inital state of the system

   end




;;;;;;;;;;;;;;;;;;;;;;;;; Start of the Go Procedure ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;



 to go

   ask turtles                              ; All Turtle Specific Commands

  [

    if (breed = agents and jailterm = 0) or breed = cops   ; If it is a agent not in jail or a
cop

      [

        Move                              ; Move Procedure -- Rule M

      ]

    if breed = agents and jailterm = 0                  ; Rule A: Determine if each agent sould
be active or quiet

      [

        determine-behavior

      ]

    if breed = cops                          ; Rule C: Cops arrest a random active agent
within their radius

      [

        enforce

      ]

  ]

```
ask agents                              ; Only Agent Breed Commands
[
  if jailterm > 0                       ; If Jailterm is greater than 0 then
  [
    set jailterm jailterm - 1           ; Reduce Jailterm by 1
  ]
]


ask agents
[
  display-agent                         ; Updates the agent disply


]
ask cops
[
  display-cop                           ; Updates the cop display
]


tick                                    ; Advance the clock
update-plots                            ; Update all Plots




end
```

;;;;;;;;;;;;;;;;;;;;;;;;Agent and Cop Behavior & the Move Procedure;;;;;;;;;;;;;;;;;;;;::

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

;;;;;;;;;;;;;;;;;;;;;;;;;  Start of Move Procedure;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

to move

  if movement? or (breed = cops)                    ; If movement? is on or the breed is a cop


  [

   let targets neighborhood with                  ; set local variable "targets" to neighborhood
where

        [

           not any? cops-here and all? agents-here     ; there are no cops and there are
agents with all agents here have a jailterm > 0

             [ jailterm > 0]

        ]

   if any? targets                          ; If any targets move to one of the targets

        [

          move-to one-of targets

        ]

  if breed = agents


  [


   if shock = true  and ticks  >= start-of-shock and ticks <= end-of-shock

137

```
    [

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

    ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;; Sets the following conditions if ticks are in the range of
a crisis;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;


;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

    set utilityn-5 utilityn-4                                               ; Sets Utility
in N-5 as Utility in N-4

    set utilityn-4 utilityn-3                                               ; Sets Utility
in N-4 as Utility in N-3

    set utilityn-3 utilityn-2                                               ; Sets Utility
in N-3 as Utility in N-2

    set utilityn-2 utilityn-1                                               ; Sets Utility
in N-2 as Utility in N-1

    set utilityn-1 utilityn                                                 ; Sets Utility
in N-1 as Utility in N

    set utilityn utilityn  + random-normal mean-income stddev-income - Period-Utility-
Loss-During-Shock          ; Shocks the agent with a loss of utility based on the user
defined variable


    if utilityn > 1                    ; If Utilityn is larger than 1


    [

      set utilityn 1                   ; sets Utilityn as 1 (Bounds Utility to 1)

    ]

    if utilityn < 0                    ; If Utilityn is less than 0

    [

      set utilityn 0                   ; sets utiltyn to 0  (Bounds Utility to zero)
```

138

]


]


;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;  Sets the following conditions if the ticks are NOT in the range of a crisis;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;


;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;


    set utilityn-5 utilityn-4                                              ; Sets Utility in N-5 as Utility in N-4


    set utilityn-4 utilityn-3                                              ; Sets Utility in N-4 as Utility in N-3


    set utilityn-3 utilityn-2                                              ; Sets Utility in N-3 as Utility in N-2


    set utilityn-2 utilityn-1                                              ; Sets Utility in N-2 as Utility in N-1


    set utilityn-1 utilityn                                                ; Sets Utility in N-1 as Utility in N


    set utilityn utilityn + random-normal mean-income stddev-income              ; Sets Utility in present as previous plus some random number within a distribution of mean and std dev

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;; Determines if it is the period before the start of stimulus and then sets the shadow utility variable;;;;;;;;;;;;;;;;;;;;

   if ticks = start-of-stimulus - 1

   [

     set shadowutilityn utilityn

   ]


   ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;; Determines if and when the stimulus should begin ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

   if stimulus = true and ticks >= start-of-stimulus and ticks <= end-of-stimulus and income-limit <= .25

   [


     set utilityn utilityn + Stimulus-gain


   ]


   ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;Determines end of stimulus period and then removes all of stimulus provided;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

  if stimulus = true and ticks = end-of-stimulus

  [

    set utilityn shadowutilityn

  ]


   if utilityn > 1                        ; If Utilityn is larger than 1

   [

     set utilityn 1                       ; sets Utilityn as 1 (Bounds Utility to 1)

   ]

```
  if utilityn < 0                        ; If Utilityn is less than 0
  [
    set utilityn 0                       ; sets utiltyn to 0  (Bounds Utility to zero)
  ]


  ]
  ]



  end
```

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;Agent Behavior;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;


;;;;;;;;;;;;;;;;;;;;;;;;;; Start of the Determine-Behavior Procedure;;;;;;;;;;;;;;;;;;;

```
to determine-behavior

set active? (grievance - risk-aversion * estimated-arrest-probability > threshold) ; Uses
formula to determine activity


end
```

;;;;;;;;;;;;;;;;;;;;;;;;;;;Set Grievence Reporter;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

```
to-report grievance
```

report ( 1 - (U-Period-N * utilityn + U-Period-N-1 * utilityn-1 + U-Period-N-2 * utilityn-2 + U-Period-N-3 * utilityn-3 + U-Period-N-4 * utilityn-4 + U-Period-N-5 * utilityn-5  ) ) * ( 1 - government-legitimacy )   ; Determines the Grievence value used in the rebellion determiniation

end


;;;;;;;;;;;;;;;;;;;;;;;;;;;Set estimated-arrest-probability Reporter;;;;;;;;;;;;;;;;;;


to-report estimated-arrest-probability

let C count cops-on neighborhood                         ; Counts the number of cops in a neighborhood

  let A 1 + count (agents-on neighborhood) with [active?]     ;

report 1 - exp (- k * floor (C / A))                     ; Arrest Probaility calculation


end


;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;Cop Behavior;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;


;;;;;;;;;;;;;;;;;;;;;;;;;;;; Start of the Enforce Procedure;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

to enforce

  if any? (agents-on neighborhood) with [active?]           ; If any agents on a neighboorhood are active


  [

   ;; arrest suspect

    let suspect one-of (agents-on neighborhood) with [active?] ; set local variable suspect as one of the active agents in the neighborhooh

```
  ask suspect [

    set active? false                          ; set active? variable back to false

      set jailterm random max-jailterm                ; set jailterm as a random variable
upto the maximum jailterm specified

  ]

    move-to suspect  ;; move to patch of the jailed agent      ; moves a cop to the patch of
the jailed agent

  ]


end



;;;;;;;;;;;;;;;;;;;;;;;;;; Start the Display-Agent Procedure;;;;;;;;;;;;;;;;;;;;;;;;;;
to display-agent
  ifelse visualization = "2D"            ; Reads the chooser button
    [ display-agent-2D ]               ; If the dropdown is listed as 2D it runs this procedure
    [ display-agent-3D ]               ; If it is false it runs the 3D procedure


end



to display-agent-2D  ;; agent procedure
  set shape "circle"
  ifelse active?
    [ set color red ]
    [ ifelse jailterm > 0
       [ set color black + 3 ]
       [ set color scale-color green grievance 1.5 -0.5 ] ]
end
```

```
to display-agent-3D  ;; agent procedure


  set color scale-color green grievance 1.5 -0.5
  ifelse active?
   [ set shape "person active" ]
   [ ifelse jailterm > 0
      [ set shape "person jailed" ]
      [ set shape "person quiet" ]
   ]


  end


;;;;;;;;;;;;;;;;;;;;;;;;;; Start the Display-cop Procedure;;;;;;;;;;;;;;;;;;;;;;;;;;;
to display-cop
   set color cyan
  ifelse visualization = "2D"
   [ set shape "triangle" ]
   [ set shape "person soldier" ]
end



;;;;;;;;;;;;;;;;;;;;;;;;;;;Start the update-plots Procedure;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;; PLOTTING


to update-plots
  let active-count count agents with [active?]
  let jailed-count count agents with [jailterm > 0]
```

144

let average-utility mean [utilityn] of agents

let average-general-discontent mean [grievance - risk-aversion * estimated-arrest-probability] of agents

let count-of-about-to-rebel count agents with [grievance - risk-aversion * estimated-arrest-probability > .1]

let count-of-low-income-agents count agents with [utilityn < .25]

let inequality sum [ ( 1 / initial-agent-density ) * (utilityn - average-utility) ] of agents

let count-of-low-mid-income-agents count agents with [utilityn >= .25 and utilityn < .5]

let count-of-mid-high-income-agents count agents with [utilityn >= .5 and utilityn < .75]

let count-of-high-income-agents count agents with [utilityn > .75]


file-open "output.txt"                              ; Write to output file


 file-write average-utility file-write average-general-discontent file-write count-of-low-income-agents file-write count-of-low-mid-income-agents file-write count-of-mid-high-income-agents file-write count-of-high-income-agents file-write count-of-about-to-rebel file-write active-count file-print " "

 file-close


set-current-plot "Active agents"

plot active-count


set-current-plot "All agent types"

set-current-plot-pen "active"

plot active-count

set-current-plot-pen "jailed"

plot jailed-count

```
        set-current-plot-pen "quiet"

        plot count agents - active-count - jailed-count


        set-current-plot "Average Utility and Discontent"

        set-current-plot-pen "Utility"

        plot average-utility

        set-current-plot-pen "Discontent"

        plot average-general-discontent


        set-current-plot "Agent Sentiment"

        set-current-plot-pen "Rebelling"

        plot active-count

        set-current-plot-pen "About to Rebel"

        plot count-of-about-to-rebel

        set-current-plot-pen "Low Income Agents"

        plot count-of-low-income-agents



end
```

## Appendix II: Average Number of Active Citizens

| Average Number of Citizens During Protest | | | | | |
|---|---|---|---|---|---|
| | **Standard Deviation** | | | | |
| | | **0.01** | **0.05** | **0.1** | **0.15** | **0.2** |

| | | **0.01** | **0.05** | **0.1** | **0.15** | **0.2** |
|---|---|---|---|---|---|---|
| **Mean Utility** | **0.9** | 0 | 0 | 0 | 0 | 0 |
| | **0.8** | 0 | 0 | 0 | 0 | 0 |
| | **0.7** | 0 | 0 | 0 | 0 | 0 |
| | **0.6** | 0 | 0 | 0 | 0 | 0 |
| | **0.5** | 0 | 0 | 0 | 1 | 1 |
| | **0.4** | 0 | 2 | 2 | 4 | 14 |
| | **0.35** | 1 | 30 | 56 | 51 | 43 |
| | **0.3** | 383 | 195 | 115 | 77 | 95 |
| | **0.2** | 382 | 382 | 318 | 232 | 169 |
| | **0.1** | 382 | 382 | 377 | 340 | 294 |

*Appendix III: Peak Number of Citizens During Protest*

| Peak Number of Citizens During Protest | | | | | |
|---|---|---|---|---|---|
| | | Standard Deviation | | | |
| | | **0.01** | **0.05** | **0.1** | **0.15** | **0.2** |
| **Mean Utility** | **0.9** | 0 | 0 | 0 | 0 | 0 |
| | **0.8** | 0 | 0 | 0 | 0 | 0 |
| | **0.7** | 0 | 0 | 0 | 1 | 1 |
| | **0.6** | 0 | 0 | 0 | 1 | 2 |
| | **0.5** | 0 | 0 | 1 | 5 | 17 |
| | **0.4** | 0 | 4 | 21 | 60 | 169 |
| | **0.35** | 1 | 182 | 248 | 247 | 247 |
| | **0.3** | 668 | 472 | 382 | 345 | 347 |
| | **0.2** | 644 | 646 | 594 | 487 | 434 |
| | **0.1** | 667 | 673 | 649 | 630 | 580 |

*Appendix IV: Period of Time with Protest*

| Period of Time with Protest | | | | | |
|---|---|---|---|---|---|
| | **Standard Deviation** | | | | |
| | **0.01** | **0.05** | **0.1** | **0.15** | **0.2** |
| **0.9** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **0.8** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **0.7** | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% |
| **0.6** | 0.0% | 0.0% | 0.0% | 0.2% | 0.3% |
| **0.5** | 0.0% | 0.0% | 0.4% | 5.7% | 10.8% |
| **0.4** | 0.0% | 0.5% | 6.8% | 13.9% | 33.6% |
| **0.35** | 0.3% | 14.6% | 35.6% | 30.5% | 34.6% |
| **0.3** | 100.0% | 98.5% | 57.4% | 44.9% | 63.9% |
| **0.2** | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| **0.1** | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

Mean Utility (row label, left side)

*Appendix V: Number of Low Income Agents*

| | | Standard Deviation | | | | |
|---|---|---|---|---|---|---|
| **Number of Low Income Agents (<.25)** | | | | | | |
| | | **0.01** | **0.05** | **0.1** | **0.15** | **0.2** |
| **Mean Utility** | **0.9** | 0 | 0 | 0 | 0 | 1 |
| | **0.8** | 0 | 0 | 0 | 0 | 2 |
| | **0.7** | 0 | 0 | 0 | 4 | 7 |
| | **0.6** | 0 | 0 | 0 | 6 | 32 |
| | **0.5** | 0 | 0 | 2 | 31 | 57 |
| | **0.4** | 0 | 1 | 54 | 107 | 182 |
| | **0.35** | 0 | 19 | 109 | 200 | 222 |
| | **0.3** | 0 | 125 | 236 | 285 | 310 |
| | **0.2** | 762 | 639 | 543 | 506 | 453 |
| | **0.1** | 762 | 761 | 718 | 630 | 586 |

*Appendix VI:  Number of Low-Mid Income Agents*

| Number of Low-Mid Income Agents (0.25-0.5) | | | | | |
|---|---|---|---|---|---|
| | **Standard Deviation** | | | | |
| | | **0.01** | **0.05** | **0.1** | **0.15** | **0.2** |
| **Mean Utility** | **0.9** | 0 | 0 | 0 | 2 | 19 |
| | **0.8** | 0 | 0 | 1 | 25 | 49 |
| | **0.7** | 0 | 1 | 25 | 84 | 136 |
| | **0.6** | 0 | 42 | 142 | 213 | 239 |
| | **0.5** | 638 | 445 | 417 | 361 | 344 |
| | **0.4** | 762 | 748 | 615 | 483 | 370 |
| | **0.35** | 762 | 741 | 600 | 456 | 380 |
| | **0.3** | 762 | 637 | 508 | 422 | 336 |
| | **0.2** | 0 | 123 | 217 | 246 | 259 |
| | **0.1** | 0 | 1 | 44 | 129 | 163 |

| | | Standard Deviation | | | | |
|---|---|---|---|---|---|---|
| **Number of Mid-High Income Agents (0.5-0.75)** | | | | | | |
| | | **0.01** | **0.05** | **0.1** | **0.15** | **0.2** |
| **Mean Utility** | **0.9** | 0 | 6 | 70 | 126 | 160 |
| | **0.8** | 0 | 160 | 255 | 281 | 282 |
| | **0.7** | 0 | 684 | 523 | 430 | 298 |
| | **0.6** | 762 | 720 | 579 | 444 | 329 |
| | **0.5** | 124 | 317 | 341 | 346 | 292 |
| | **0.4** | 0 | 13 | 93 | 166 | 184 |
| | **0.35** | 0 | 2 | 53 | 104 | 140 |
| | **0.3** | 0 | 0 | 18 | 54 | 106 |
| | **0.2** | 0 | 0 | 2 | 10 | 49 |
| | **0.1** | 0 | 0 | 0 | 3 | 13 |

*Appendix VIII: Number of High Income Agents*

| Number of High Income Agents (>0.75) | | | | | | |
|---|---|---|---|---|---|---|
| | | **Standard Deviation** | | | | |
| | | **0.01** | **0.05** | **0.1** | **0.15** | **0.2** |
| **Mean Utility** | **0.9** | 762 | 756 | 692 | 634 | 582 |
| | **0.8** | 762 | 602 | 506 | 456 | 429 |
| | **0.7** | 0 | 77 | 214 | 245 | 321 |
| | **0.6** | 0 | 0 | 41 | 101 | 162 |
| | **0.5** | 0 | 0 | 2 | 24 | 69 |
| | **0.4** | 0 | 0 | 0 | 6 | 26 |
| | **0.35** | 0 | 0 | 0 | 2 | 20 |
| | **0.3** | 0 | 0 | 0 | 1 | 10 |
| | **0.2** | 0 | 0 | 0 | 0 | 1 |
| | **0.1** | 0 | 0 | 0 | 0 | 0 |

*Appendix VIV: Average Protest by Utility and Variance*
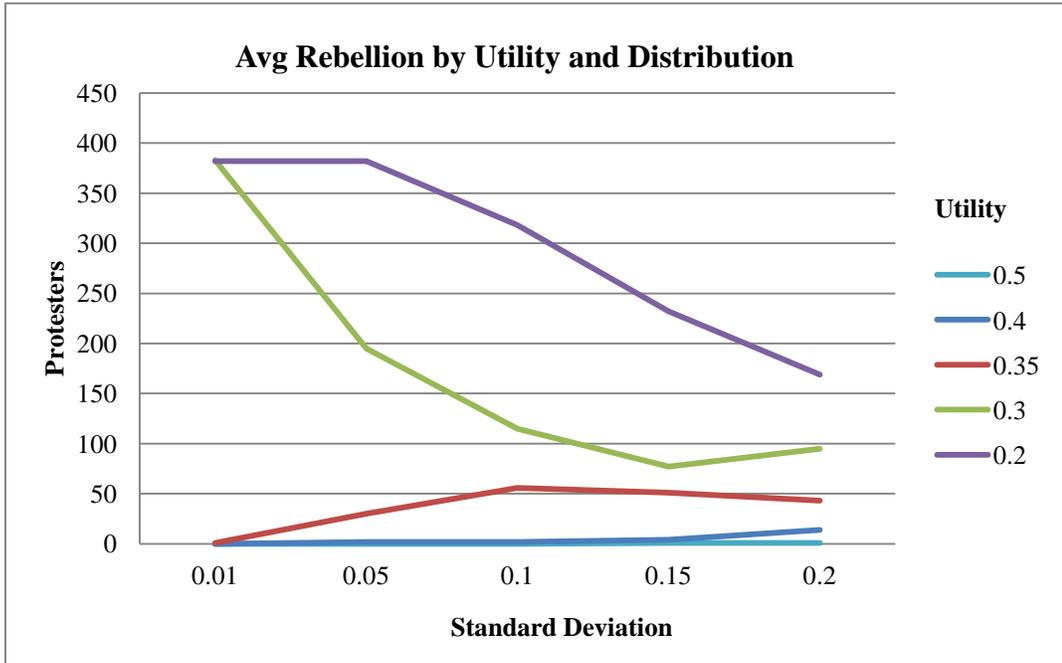


*Appendix X: Peak Protesters by Utility and Variance*
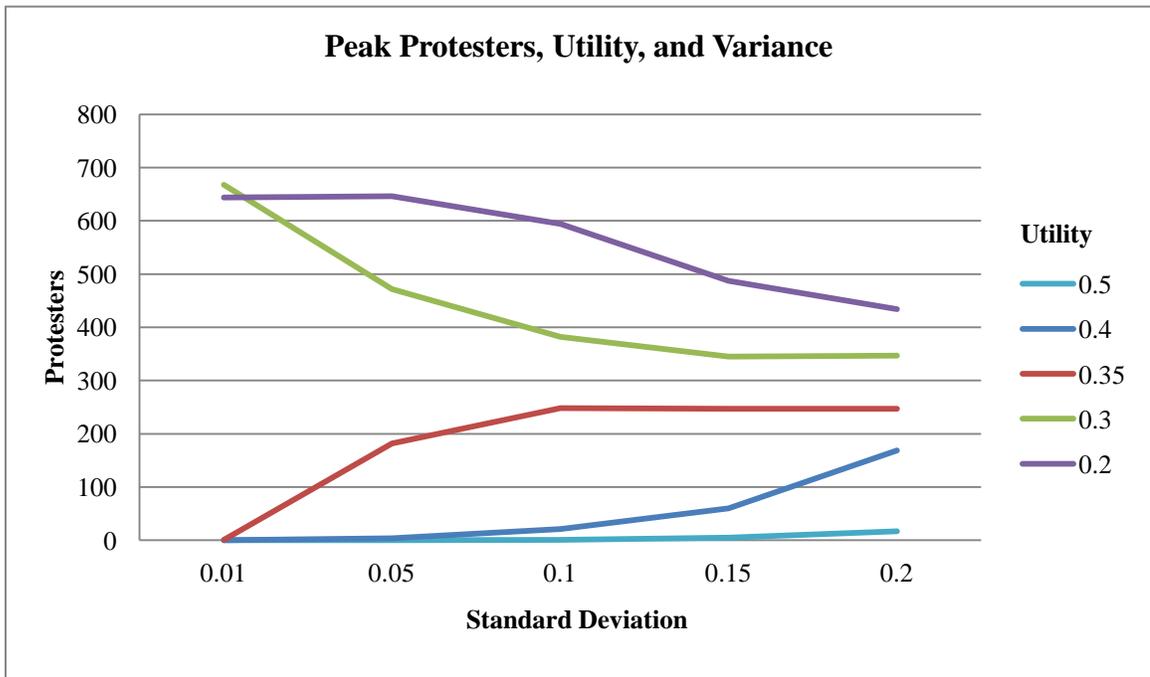
*Appendix XI: Histograms of Citizen Utility (Mean 0.3)*

**Number of Citizens by Utility Category**
**Mean Utility 0.3 Std Dev 0.10**

Number of Citizens (y-axis: 0–800)

Categories (x-axis): 0-.24, .25-.49, .50-.74, .75-1

Legend:
- Number of Low Income Agents
- Number of Low-Mid Income Agents
- Number of Mid-High Income Agents
- Number of High Income Agents

**Number of Citizens by Utility Category**
**Mean Utility 0.3 Std Dev 0.20**

Number of Citizens (y-axis: 0–800)

Categories (x-axis): 0-.24, .25-.49, .50-.74, .75-1

Legend:
- Number of Low Income Agents
- Number of Low-Mid Income Agents
- Number of Mid-High Income Agents
- Number of High Income Agents

*Appendix XII: Histograms of Citizen Utility (Mean 0.2)*

**Number of Citizens by Utility Category**
**Mean Utility 0.2 Std Dev 0.10**



**Number of Citizens by Utility Category**
**Mean Utility 0.2 Std Dev 0.20**



156

**Declining Utility and Protest**

**Declining Utility and Protest**

**Declining Utility and Protest**
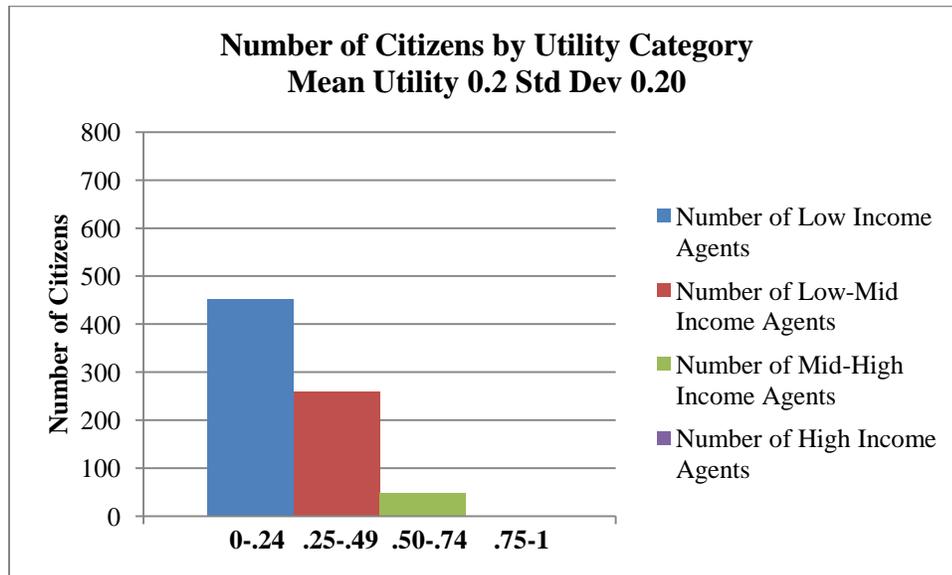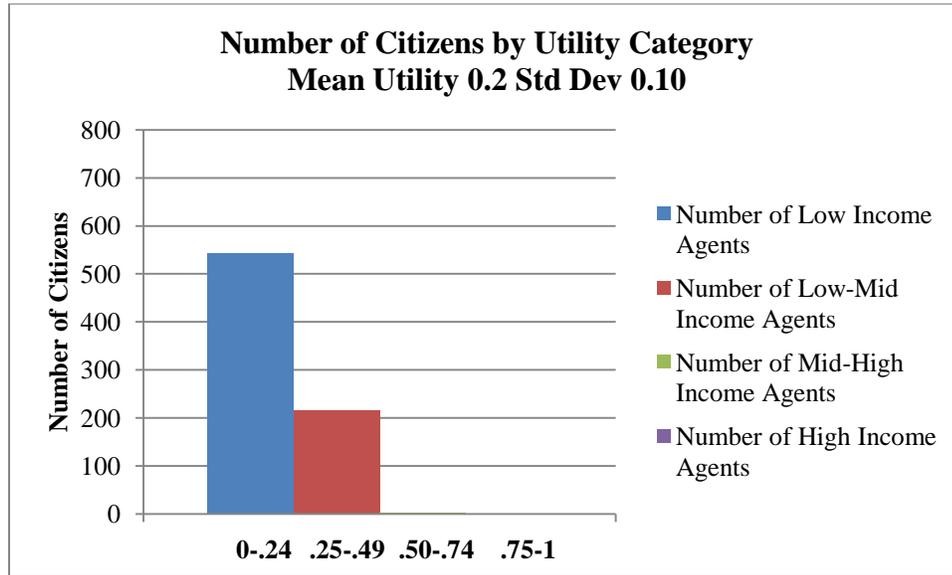
*Appendix XVII: Utility and Protest with Starting Utility of 0.6, Standard Deviation of .2*
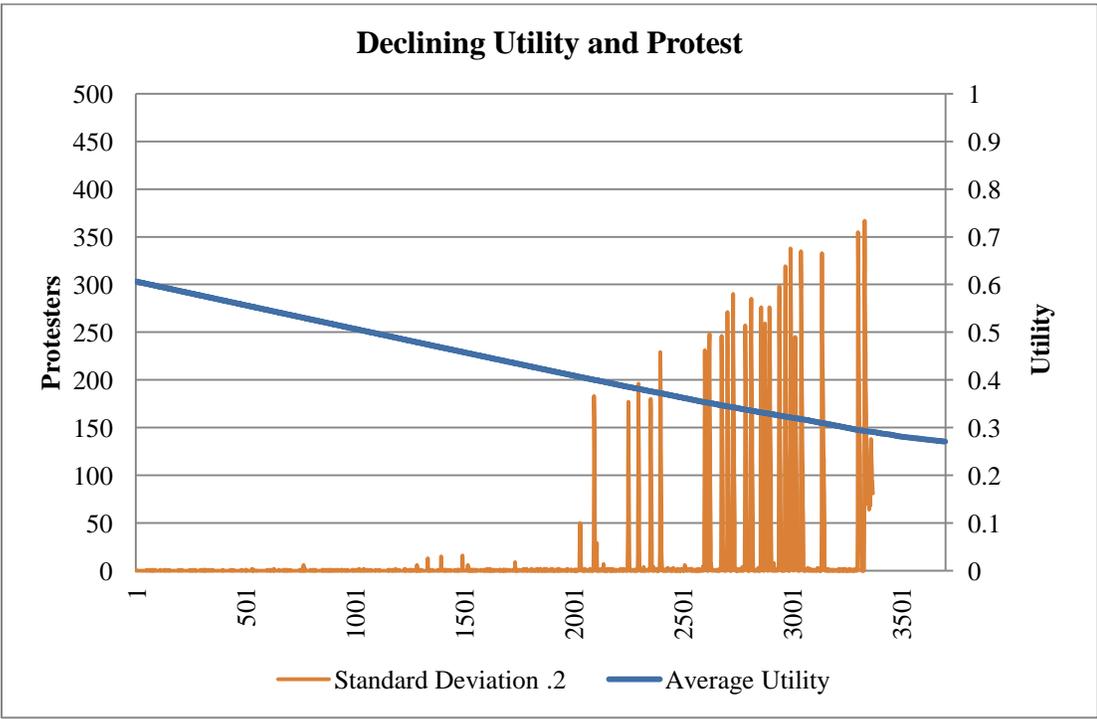
# Bibliography

Brock, L. (1991). Peace through Parks: The Environment on the Peace Research Agenda. *Journal of Peace Research* , 407-423.

Brubaker, R., & Laitin, D. (1998). Ethnic and Nationalist Violence. *Annual Review of Sociology* , 423-452.

Collier, P. (2000). *Economic Causes of Civil Conflict and Their Implications.* Washington DC: World Bank.

Collier, P. (2000). Rebellion as a Quasi-Criminal Activity. *The Journal of Conflict Resolution* , 839-853.

Collier, P. (2007). Post-Conflict Recovery: How Should Policies be Distinctive? United Kingdom: Oxford University.

Collier, P., & Hoeffler, A. (1998). On economic causes of civil war. *Oxford Economic Papers* , 563-573.

Collier, P., & Hoeffler, A. (2002). Greed and Grievience in Civil War.

Collier, P., & Hoeffler, A. (2002). On the Incidence of Civil War in Africa. *The Journal of Conflict Resolution* , 13-28.

Collier, P., & Hoeffler, A. (2005). Resource Rents, Governance, and Conflict. *The Journal of Conflict Resolution* , 625-633.

Collier, P., & Hoeffler, A. (2006). Military expenditure in post-conflict societies. *Economics of Governance* , 89-107.

Collier, P., & Sambanis, N. (2002). Understanding Civil War: A New Agenda . *The Journal of Conflict Resolution* , 3-12.

Collier, P., Hoeffler, A., & Rohner, D. (2007). Beyond Greed and Grievence:Beyond Civil war.

Deraniyagala, S (2005). The Political Economy of Civil Conflict in Nepal. Oxford Development Studies, Vol. 33, No. 1, March 2005.

Deudney, D. (1990). The Case Against Linking Environmental Degredation and National Security. *Millenium* , 461-476.

Doyle, M., & Sambanis, N. (2000). International Peace Building: A Theoretical and Quantitative Analysis. *The American Political Science Review* , 779-801.

Elbadawi, I., & Sambanis, N. (2002). How Much War Will We See? Explaining the Prevalance of Civil War. *The Journal of Conflict Resolution* , 307-334.

Epstein J., (2002) Modeling Civil Violence: An Agent-Based Computational Approach, Proceedings of the National Academy of Sciences, vol 99, pp 7243-7250.

Epstein J, Steinbruner J, Parker M (2001) Modeling Civil Violence: An Agent-Based Computational Approach. Brookings Institution Working Paper No: 20

Epstein J, Klemens B, Hammond R, Raifman M (2010) Empirical Performance of a Decentralized Civil Violence Model . *Center on Social and Economic Dynamics* Working Paper No 56.

Fearon, J. (2004). Why do some civil wars last so much longer than others? *Journal of Peace Research* , 275-301.

Fearon, J. (2005). Primary Commidity Exports and Civil War. *Journal of Conflict Resolution* , 483-507.

Fearon, J., & Laitin, D. (1996). Explaining Interethnic Cooperation. *The American Political Science Review* , 715-735.

Fearon, J., & Laitin, D. (2003). Ethnicity, Insurgency, and Civil War. *The American Political Science Review, Vol 97* , 75-90.

Gates, Scott (2002). Recruitment and Allegiance: The Microfoundations of Rebellion *Journal of Conflict Resolution*, Vol 46, 111-130.

Gleditsch, N. (1998). Armed Conflict and the Environment: A Critique of the Literature. *Journal of Peace Research* , 381-400.

Goldstone, Bates, Epstein, Gurr, Lustik, Marshall, Ulfelder and Woodward (2010) . A Global Model for Forecasting Political Instability. *American Journal of Political Science*, Vol. 54, No. 1 pp. 190-208

Grimm, V., Berger, U., Bastiansen, F., Eliassen, S., Ginot, V., Giske, J., Goss-Custard, J., Heinz, S., Huse, G., Huth, A., Jepsen, J., Jorgensen, C., Mooij, W., Muller, B., Peer, G., Piou, C., Railsback, S., Robbins, A., Rossmanith, E., Ruger, N., Strand, E., Souissi, S., Stillman, R., Vabo, R., Visser, U. A Standard Protocol for Describing Individual-based and Agent Based Models. Ecological Modelling, vol 198, pp 115-26

Gulden, Tim (2004). Adaptive Agent Modeling in a Policy Context. *PhD Dissertation*. University of Maryland.

Gurr, T. (1970). *Why Men Rebel.* Princeton, NJ : Princeton University.

Gurr, T Historical Trends in Violent Crime: A Critical Review of the Evidence, Crime and Justice, Vol. 3 (1981), pp. 295-353

Gurr, T. (1993) Why Minorities Rebel: A Global Analysis of Communal Mobilization and Conflict Since 1945 . *International Political Science Review*, Vol.14, No. 2 (Apr., 1993), pp. 161-201

Gurr, T (2000) Ethnic Warfare on the Wane. Foreign Affairs, Vol. 79, No. 3 pp. 52-64

Hegre, H., & Sambanis, N. (2006). Sensitivity Analysis of Empirical Results on Civil War Onset. *The Journal of Conflict Resolution* , 508-535.

Hirshleifer, J (1994). The Analytics of Uncertainty and Information. Cambridge. Cambridge University Press.

Hirshleifer, J (2001). The dark side of the force: economic foundations of conflict theory . Cambridge : Cambridge University Press.

Jones, K (2007). The Dynamics of Political Protest: A Case Study of the Kyrgyz Republic, PhD Dissertation, University of Maryland.

Jones, K (2012). Micro-Level Analysis of Civil Violence: An Event Data Analysis of Kenya, Georgia-Russia, and Mexico. *CISSM Working Paper,* University of Maryland.

Levy, M. (1995). Is the Environment a National Security Issue. *International Security* , 35-62.

Lichbach M (1990). Will Rational People Rebel against Inequality? Samson's Choice. American *Journal of Political Science*, Vol 34, No 4, 1049-76.

Lichbach M (1994). What makes Rational Peasants Revolutionary?: Dilemma, Paradox, and Irony in Peasant Collective Action. *World Politics*, Vol. 46, No. 3, 383-418

Lu, L. , Thies C. (2011) Economic Grievance and the Severity of Civil War, *Journal of Civil Wars*, Vol 13 No 3 pp 215-231.

Maddox, J. (1972). *The Doomsday Syndrome.* New York: McGraw-Hill.

Miguel E & Satyanath S. & Sergenti E (2004) Economic Shocks and Civil Conflict: An Instrumental Variables Approach. *Journal of Political Economy,* Vol 112 No 4,725-753

Muller, E (1985). Income Inequality, Regime Repressiveness, and Political Violence. *American Sociological Review*, Vol 50, 47-61.

Muller, E., & Weede, E. (1990). Cross-National Variation in Political Violence: A Rational Action Approach . *The Journal of Conflict Resolution* , 624-651.

Nielsen, R. A., Findley, M. G., Davis, Z. S., Candland, T. and Nielson, D. L. (2011), Foreign Aid Shocks as a Cause of Violent Armed Conflict. American Journal of Political Science, 55: 219–232

Olson, M (1971) The Logic of Collective Action: Public Goods and the Theory of Groups. Harvard University Press. Second Edition

Olson, M (1982) The Rise and Decline of Nations: Economic Growth, Stagflation, and Social Rigidities, Yale University Press

Opschoor, J. (1989). North-South Trade, Resource Degredation and Economic Security. *Bulletin of Peace Proposals* , 135-142.

Ostby, G. (2006). *Horizontal Inequities, Political Environment and Civil Conflict: Evidence from 55 Developing Countries.* Oxford: Centre for Research on Inequality, Human Security and Ethnicity.

Oyefusi, A (2008). Oil and the Probability of Rebel Participation Among Youths in the Niger Delta of Nigeria. Journal of Peace Research, Vol 45, 539-555

Percival, V., & Homer-Dixon, T. (1998). Environmental Scarcity and Violent Conflict: The case of South Africa. *Journal of Peace Research* , 279-298.

Regan, P., & Norton, P. (2005). Greed, Grievence, and Mobilization in Civil Wars. *The Journal of Conflict Resolution* , 319-336.

Reynal-Querol, M. (2002). Ethnicity, Political Systems, and Civil Wars. Journal of Conflict Resolution. Vol 46, 29-54

Sambanis, N. (2001). Do Ethnic and Non-Ethnic Civil wars Have the Same Causes? A Theoretical and Empirical Inquiry. *The Journal of Conflict Resolution* , 259-282.

Sambanis, N. (2004). *Poverty and the Organization of Political Violence.* Washington DC: Brookings Press.

Sambanis, N. (2004). Using Case Studies to Expand Economic Models of Civil War. *Perspective in Politics* , 259-279.

Sambanis, N. (2004). What is Civil War? Conceptual and Empirical Complexities of an Operational Definition. *The Journal of Conflict Resolution* , 814-858.

Simon, J. (1996). *The Ultimate Resource 2.* Princeton, NJ: Princeton University.

Tarrow, S. (1994). Power in movement: Social movements, collective action and mass politics in the modern state. Cambridge. Cambridge University

Taydas Z & Peksen D (2012). Can States Buy Peace? Social welfare spending and civil conflicts. *Journal of Peace Research*. Vol 49, 273-287

Tilly, C (1975). Revolutions and Collective Violence. *Handbook of Political Science*. Reading Ma.

Tir, J., & Diehl, P. (1998). Demographic Pressure and Interstate Conflict: Linking Population Growth and Density toMilitarized Disputes and Wars, 1930-89 . *Jouranl of Peace Research* , 319-339.

Vadlamannati, K. (2011). Why Indian Men Rebel? Explaining armed rebellion in the northeastern states of India , 1970-2007. *Journal of Peace Research*. Vol 48, 605-619.

Walter, B. (2004). Does Conflict Beget Conflict? Explaining Recurring Civil War. *Journal of Peace Research* , 371-388.

Wenche, H., & Ellingsen, T. (1998). Beyond Environmental Scarcity: Casual Pathways to Conflict. *Journal of Peace Research* , 299-317.