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Challenges in Measuring Firearm Prevalence: A Test of Cook's Index Across The Rural–Urban Continuum

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CHALLENGES IN MEASURING FIREARM PREVALENCE: A TEST OF COOK'S INDEX ACROSS THE RURAL-URBAN CONTINUUM.

by

NOAH CYPHER

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ABSTRACT

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Before questions about the effects of firearm ownership can be answered, basic questions of relative prevalence must be established. There is very little hard data on this and most of the research relies upon proxy variables to measure firearm prevalence. Cook's Index is the most commonly used firearm proxy. This research uses New York's Pistol Permits to measure legitimate firearm prevalence and compare it to Cook's Index. In this study, Cook's Index predicted impossible values for several counties that together contained a clear majority of New York State citizens. Cook's Index was also shown to be unreliable across types of counties. Rural and Urban counties had significantly different ratios of Cook's Index to Pistol Permits in New York. The models show a general finding that the relationship between Cook's Index and legitimate firearm ownership varies depending on the Rural-Urban Continuum. A more precise and non-linear model is needed to estimate the prevalence of firearms. Finally, the way in which Rural and Urban culture affect the use of firearms needs further research.

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Chapter 1: Introduction

Firearms are tremendously important (and controversial) objects in the United States. Firearms are powerful but also simple; these are tools that have not seen significant technological advance in the better part of a century. But, the political fight over them is as relevant and modern as any issue in American political life. Historically, firearms were crucial in establishing the American colonies (Russell 1957), in breaking off from Great Britain (Cunliff 1968), and in the Westward Expansion (Kenne t& Anderson 1975). In the modern day they are an enduring and potent symbol of Americanism (Cunliff 1968, Khon 2004,Utter & True 2000, Kleck & Bratton 2009). Firearms are more than mere symbols however as Americans use firearms millions of times each year. Many of these uses are innocent (sport, hunting, and self-defense) but Americans also use firearms in thousands of violent crimes, murders, and suicides each year. It is these negative uses of firearms that spur the long running political fight over firearms in the United States.

The political controversy is both omnipresent and intractable, but one of the rare points of agreement in this argument is that the prevalence of firearms in America is of primary importance. There is a deep-seated disagreement over what the effects of more firearm ownership versus less firearm ownership are (Lott 2013, Bogus 2008), but both sides are arguing over the effect of firearm prevalence. Research in this area is mainly about the effects of increasing or decreasing firearm prevalence. As firearm prevalence cannot be experimentally manipulated, most of the research compares areas with high prevalence of firearms to areas with low prevalence while statistically controlling for other factors.

What is often lost in the debate over gun rights/control is that there is very little concrete data about firearms prevalence. Without high quality data on firearm prevalence there is no empirical reason to support either gun control or gun rights. There are philosophical reasons to support either position (Degrazia & Hunt 2016) but without high quality data, it is a philosophical debate masquerading as a scientific and empirical debate. The philosophy matters and affects how data are interpreted by both researchers and advocates, but a primary goal of research is to distill the facts upon which all sides can agree.

There have been only two[1] high quality national level surveys attempting to measure the prevalence of firearm ownership (Cook & Ludwig 1997; Hepburn, Miller, Azrael and Hemenway 2007). Additionally, only two well-known ongoing surveys (the Gallup Poll and the General Social Survey) ask any questions about firearm prevalence. These estimates vary dramatically from each other and will be explored in depth in the literature review. To give a preliminary illustration of how disparate these estimates are, consider that the 2014 GSS and Gallup estimates of firearm ownership disagree about whether 30 million individuals have access to a firearm or not. This is specifically the minimum number of Americans about whom the two studies disagree, there might be an even greater actual difference. As a percentage of total population that is roughly 11 percent of Americans which may or may not have access to firearms depending on which survey you prefer. It is worth noting that there are also a handful of other estimates available from studies which use specially commissioned phone surveys along with a few medical studies which use their own survey infrastructure. These outlying studies are

[1] Extensive searching and reading in the area by the author has revealed no other similar surveys. Further, other respected researchers compiling the well regarded international publication "Small Arms Survey" likewise rely on these estimates for their US numbers.

rare and idiosyncratic and so difficult to generalize from or to compare with other firearms research.

Because of the minimal (and conflicting) data on firearm prevalence from surveys, the vast majority of the literature relies on proxy variables to measure firearm prevalence. Using widely available data as a proxy also allows analysis at finer levels and in a consistent manner across studies. One measure has come to dominate the literature: Cook's Index (Azrael, Cook & Miller 2004). Cook's Index uses the proportion of suicides completed with a firearm to estimate firearm prevalence and this has become a standard measure of firearm availability. Much of the popularity of this measure follows from how readily available the data is and the many levels at which this data is available. Combined with a general claim of validity, it is no surprise that Cook's Index has become the standard measure.

This research is based on twin questions of validity for Cook's Index: First, the question of the general validity of the measure. The data which have been used for validation in previous research are sparse and highly variable. Researchers must have further validation of Cook's Index before they can rely on its validity. Second, this research identifies a specific factor (the Rural-Urban Continuum) which may be systematically biasing the proxy.

A widespread reliance on a single proxy variable means that issues of validity have far reaching consequences. Any issue of validity, or confounding variable which biases the proxy, undermines every study that utilizes that proxy. This can cause widespread re-evaluation of the literature which would be disruptive in and of itself. However, this particular literature is one that is drawn upon not just by social scientists but also by advocates on both sides of the gun control vs gun rights debate, by legislators, and by the national media. Any validity issue in this research

has the potential to influence a deeply felt issue of constitutional importance in an unscientific manner. Unscientific literature used in such a manner could seriously damage the credibility of any academic discipline involved in creating the problematic literature.

The main assumption of Cook's Index as a proxy measure is that it relies on the idea that the measured *use* of an object is directly related to the object's *prevalence* when the concepts of use and availability have a more complex relationship. Consider if you were to estimate the prevalence of fine china dining sets and treadmills by this same method. Although Americans commonly own both treadmills and china, they do not commonly use them, nor do all subgroups of Americans use them identically. An estimate of the prevalence of these items based on their use would severely undercount their actual prevalence. Conversely, if you were to estimate nationwide use of fine china dining sets and treadmills based on their prevalence an overestimate would be likely. Focusing on a criminal variable, the rates of murder using no weapons vary across national lines but no one argues that there is a difference in number of hands or feet (Messner and Rosenfeld 2001 pg 22). The questions of prevalence and use are indeed related, but they are distinct questions and researchers ought not conflate them. This is especially true with nontrivial objects like firearms.

The Rural-Urban Continuum (or RUC) is an understudied factor which may be biasing Cook's Index. The literature indicates that Rural, Urban, and Suburban areas are associated with differences in both firearms prevalence (Cook 1997; Hepburn et al 2007) and behaviors involving firearms (Hemenway 2006; Kleck & Kates 2001; Wiebe, Krafty, Koper, Nance, Elliott & Branas 2009; Wilkinson & Fagan 2001). Also relevant are the noted differences in suicide behaviors in rural and urban areas (Singh & Siahpush 2002) as well as social wellbeing and mental health generally (Peen, Schoevers, Beekman, & Dekker 2010). Taken together, these

findings raise issues with using suicide involving firearms as the means to estimate firearm prevalence. Cook's Index assumes identical use of firearms in suicide, regardless of each individual's location on the Rural-Urban Continuum. The limitations of using an indicator that varies across type of place, independently of the concept it is intended to measure, is largely unexamined in this context.

The research presented below explores the two questions using data from the State of New York. New York's comparatively strong gun control in the US allows a validity test that addresses the limitations of prior tests. This research compares the predicted handgun prevalence using Cook's Index to the measured legitimate handgun ownership in New York State using licenses. Second, because New York offers a wide cross-section of places (counties) along the Rural-Urban Continuum, the question of whether the proxy variable performs similarly across levels of the RUC (as is currently assumed) can be tested. Taken together, New York is optimally situated to test the validity of a key proxy variable for an important field of research.

Chapter 2: Literature Review

Background Caveats for Firearms Prevalence Research

The subject of firearm prevalence in the US is highly politicized and controversial both among the general public and among academics. There are excellent examples of science transcending politics, such as Wolfgang's (1995) praise of quality research even though he disliked the findings and implications. Unfortunately, this sort of interchange is not common. There are far more cases of the reception of research being driven by desirability of conclusions rather than the quality of the work. Consider Tom Diaz's book “Making a Killing” (Diaz 1999) which has been cited in the academic literature at least 67 times according to Google Scholar with all reviews found in Academic Search Complete unanimously positive (Gabor 2001; Petit & Bryant 1999; Lumpe 2000; Recent Publications published by Harvard Law Review 2000). Yet this highly cited book is an example of self-publishing by a representative of a gun control advocacy group not an academic book subject to peer review. The book seems fine at a glance but close reading reveals flawed (even self contradicting) arguments, questionable sources, and a very obvious bias. The book's acceptance cannot be based on the rigor of the argument and evidence. Rather, agreement with its conclusions has led to inadequate criticism of the book. Ultimately the academic acceptance of such poor research is indicative of how deeply polarizing this subject often is.

Because of its polarizing nature, the subject of firearms in America has left a convoluted and complex literature in which even the most dispassionate researcher can be led astray. While the Diaz book is clearly identified as self-published on the first page, other questionable research

has insinuated itself into the peer-reviewed articles and books, notably Bellesiles (2000) which won the Bancroft Price in History. Bellesiles claimed to show via historical documents that firearm prevalence was far rarer in the past than is generally believed. The book won the prestigious Bancroft Prize in history – essentially passing a second stricter level of peer review – and top researchers in the field gave positive reviews and blurbs for the book. Unfortunately Bellesiles fabricated data and misrepresented sources systematically in his book. These issues were first brought to light by an amateur historian (Cramer 2001; 2006) rather than in the process of peer review. In fact, the initial sourced criticisms were largely ignored. It was not until Professor Lindgrin echoed the critiques (Lindgren & Heather 2002; Lindgren 2002) that the prize was rescinded and the work denounced. Modern researchers, unless they are familiar with the subsequent literature around the book, could easily cite the book and perpetuate its factual errors while attempting to do unbiased research.

The issues with the firearms prevalence literature are found on both sides of the debate. John Lott's "More Guns Less Crime" (Lott 2013, 1st printing 1998) has been accused of pro-gun partisanship and even dishonesty. Lott claims to show that widespread prevalence of firearms has an inhibitory effect on violent crime, and the work is widely referenced by gun rights activists. Ayres and Donohue (2009) argue that the facts were made to fit the argument rather than vice versa in addition to their arguments against Lott's methodology and analyses. This book has been published multiple times and the debate over its merits continued for at least a decade after the initial publishing. For academics in sociology and criminology as well as the public at large, the emotional intensity of the debate over firearms smolders beneath the surface. This puts modern researchers in a difficult position as they must know controversies surrounding the publications rather than simply noting agreed upon findings in the literature.

Researchers must also be aware of the history and politics associated with schools of research, as some schools have been entangled in political battles —some still simmering — centering on firearms prevalence. In particular the medical research must be put into context. It is well known that there are current restrictions on the Center for Disease Control and Prevention's (CDC) research into firearm deaths; what is not well known is that these are due to a specific history with the Public Health school of research. The Public Health approach to smoking enjoyed a large measure of success and the research it generated was key in showing the dangers of smoking. This research not only convinced politicians to change laws, it convinced Americans to embrace significant social change around the behavior of smoking. On the heels of this victory, Public Health researchers tried to apply the same methods to cut down on firearm related deaths. In their excitement the solutions were offered before the research had been completed. High ranking officials made highly publicized statements that they wanted to be able to cast firearms as negative and dangerous as they had with cigarettes (Bell 2013). At the same time, the US Department of Health and Human Services published an official goal to reduce handgun ownership in the US (Fingerhut & Kleinman 1989 pg 6). This recommendation hinged on the argument that decreasing firearm ownership (decreasing the prevalence of firearms) would be a boon to public health and ought be pursued as a matter of governmental policy. This is a strongly political stance to take and one that attracted a lot of attention. Because many of these statements were made before the research was performed, the statements seemed to stem from a pre-existing political stance rather than from the results of research. The backlash from firearm owners and their advocacy groups culminated in congressional restriction of this research. That history, coupled with extensive evidence that public health has allowed advocacy to overshadow

detached objectivity (Kates, Schaffer, Lattimer, Murray, & Cassem 1994) has led to a degree of enmity between some firearms owners and some elements of the medical community.

The enmity between elements of the medical community and elements of the gun community directly affects some firearm prevalence estimates as firearm owners don't trust these researchers. This is more than historical trivia, these elements are still clashing over the issue. A recent example can be found in Florida in the case of *Wollschlaeger v Governor of Florida* (2014) referred to in the media as the "Docs vs Glocks" controversy. The concern over doctors asking whether patients owned firearms and recording these responses as a matter of routine led to the state of Florida passing The Firearm Owners Protection Act (Fla. Stat. §§ 381.026, 456.072, 790.338), which was designed to prevent routine recording of this data. Various elements of the medical community joined with Florida Dr Wollschlaeger to challenge the statute but the law has been upheld in the 11th Circuit court of appeals. The Court held that doctors could not routinely ask (and centrally record) whether a patient owned firearms. The court further held that this did not interfere with doctors offering advice for gun safety or asking about firearm ownership in cases where the patient exhibited suicidal or violent ideation. The heart of this controversy was about whether the medical community, by creating and keeping this data, was actually assembling a registry of firearm ownership (prevalence) in Florida.

The law's passage and subsequent challenge are evidence of the tension between significant numbers of firearm owners and significant portions of the medical community. It is safe to say, then, that some firearm owners' ambivalence or opposition to medical based inquiry over their firearms still retains potency twenty years later. This longstanding state of distrust and ambivalence challenges the accuracy of firearm prevalence estimates from medical researchers.

The people most important to the research (gun owners) are the very group who are inclined to distrust the researchers because they distrust both the motivations of the researchers and what will be done with the data afterwards. Whether this distrust leads to misleading answers or increased likelihood of opting out of the research entirely, the utility of the estimate suffers as a result.

Focusing so intently on these aspects of the firearm literature may seem combative, but it is unavoidably important for researchers studying firearms. Researchers in this field must use a higher level of scrutiny than is normal in peer reviewed research. They must be aware of findings that have been invalidated but may still be cited in the literature. They must be aware how the failings of research have affected funding and current research restrictions. They must be aware how this history may be affecting respondents in current research. Finally, they must be aware that all social science findings will be used (and misused) in the political fight over firearms. While a firearm registry may be the most methodologically sound way to measure how firearms are used in the United States and calculate relative risk rates, the political fight in the background makes the creation of such a thing politically dangerous. Researchers must be aware of the political realities that pertain to this subject. Ultimately, the only answer available for researchers is to hold the research to the highest standards. Researchers must ensure that the research can withstand the closest scrutiny that either side may, and probably will, bring.

Types of Data for Firearms Prevalence Research

Because of the issues with firearm prevalence research it is important to examine the data directly. Unfortunately there is actually very little data and much of the literature is simple re-analysis and re-interpretation of that data. What little data is available concerning firearms is best

at the national level. State level estimates, and all analyses using those estimates, are rarer and more methodologically questionable.

Nationally there are two single instance surveys designed to measure firearm prevalence and two ongoing surveys about firearm prevalence. A third source of research has recently become available from Pew (2014, 2017) and is actually a pair of estimates, much like the single instance surveys but their methodology is weaker. The single instance surveys about firearm prevalence and ownership were conducted in 1994 and 2004 respectively. There are a total of two ongoing surveys that include questions about firearm ownership — one available at the regional level of the US and the other strictly national level. Again it is necessary to note that there are handful of other surveys that ask about firearms in an incidental manner. However, these surveys are not designed to measure the prevalence of firearms and instead focus on physical health.

Finally, there are some ongoing data collected by the Bureau of Alcohol Tobacco Firearms and Explosives (BATFE, or more commonly ATF) which is the main source of non-survey data available to researchers. The types of data available, their benefits and drawbacks, will be explored. Unfortunately, it will be shown that this non-survey data is of little utility to researchers. It is useful in estimating a minimum number of firearms in the US and the majority of newly produced/imported firearms to the US. Any other applications of the data are highly questionable.

Beyond this, there is very little data left in the literature. The remaining studies (a significant percentage of the literature) are actually based on proxy variables for firearm prevalence. Researchers use proxy variables when the desired data are unavailable. If the proxy

is well correlated with the desired data (that is, if the proxy variable is valid) then this has minimal risk. The issue this runs into is that validation of a proxy is difficult. If it was easy to get the desired data, researchers would simply use it, in which case why even think about using a separate variable that you hope is closely enough related that it can be substituted for the desired data? Ultimately, the proxy variables must be tested against the desired data. In the case of firearm prevalence this means they are all tested for validity using the available — and strikingly sparse — data.

Surveys

First, I will examine some known confounding issues with Firearm Surveys. In validating proxy variables, researchers are most interested in how well the validating measure corresponds with reality; therefore, known weaknesses of firearm prevalence surveys must be noted. Second, I will look at the firearm-focused single instance surveys, examining both the methodological concerns and the findings of each survey. Third, I will briefly consider a relevant single instance survey that incidentally covers firearm ownership and prevalence. I will also analyze the ways in which these three single instance surveys relate to each other.

Next, I will consider the ongoing surveys to see their attendant methodological differences and how they compare with each other. Then, I will compare the one-shot surveys with the ongoing surveys and incorporate the findings from research that does not neatly fall in either camp. Following that I will consider the non-survey data. Finally, I will suggest reasonable inferences from the available data sources. The comparisons in this literature review are very detailed and include some minor statistical calculations. This is because a simple reading of any

of these sources is misleading. It is only by carefully considering all three types of data that the issues confronting firearms prevalence research become clear.

Known Issues for Firearms Surveys

Ultimately, survey and interview data about firearms must be treated with care. Firearms are powerful symbols with multiple and conflicting meanings. As a result, survey answers about firearms are likely to be less accurate than survey responses on other topics. Asking a 17-year-old boy if he could access a firearm is somewhat like asking if he has had sex. We know that many of them can honestly say 'yes', but we also know that many will say 'yes' when it is not true because teenagers like to imagine themselves and present themselves as socially connected and powerful. Ruddell and Deker (2005) compared firearms confiscated from teenagers with their self-reported access to firearms. They concluded that the youths had been exaggerating their involvement with firearms generally and with the nebulous "assault weapons" in particular. The finding that teenagers claimed greater access to more powerful firearms than they are known to have is a cautionary tale about taking their claims at face value. Moreover, interviewing those convicted of offenses with firearms presents typical problems often encountered when interviewing any social deviants about their deviancy. Even normative firearm owners may be inclined to mislead researchers due to fears about how the information will be used, not just personally but also in lobbying for policy changes that will affect them personally.

Even given cooperative respondents and well-worded questions, there are still reasons to view survey data skeptically. It is well-established that framing effects, the context created by all the questions in the battery as well as specific wording, are exceptionally strong with questions about firearms (Haider-Markel & Joslyn 2001). An excellent example can be seen in surveys

asking whether respondents would support an "assault weapon" ban. In 2012, Public Policy Polling and Gallup both ran surveys to find the level of national level support for an "assault weapon" ban. These two well-respected sources had slight differences in wording but were substantively similar in methodology and sample size. The results were quite different with a crucial 20-percentage-point difference in the level of support. This difference meant that the Public Policy Polling found a majority in favor of the ban while Gallup found a majority against (Nir 2012; Gallup 2015). In short US survey data about firearm use and access, or even public opinions on firearms, must be approached cautiously and with some skepticism.

Single Occurrence Surveys Concerning Firearm Prevalence

Only two national level surveys aimed at measuring firearm prevalence appear in the literature. The most methodologically sound estimate was done in 1994 at the behest of the National Institute of Justice and was a national level survey of firearm prevalence in the US (Cook & Ludwig 1997). This survey had a non-response rate between 44 and 59 percent and the 2,568 respondents were weighted to estimate the owning habits of approximately 262 million Americans. Weightings were used to correct both for the purposeful oversampling of minorities and sample differences from the general population. The next national level survey was done by Hepburn et al. (2007) from a survey completed in 2004. This survey had a non-response rate of between 86 and 88 percent, a significantly larger non-response rate. The 2,770 responses were used to estimate the owning habits of approximately 290 million Americans. This second survey used a sample that was importantly distinct from the national population with respect to several demographic variables, resulting in extensive use of weightings in the estimate. In both cases nonresponse rates were very high which must make researchers critical. Nonresponse rates

almost invariably weaken the foundational assumption of randomness. If the people who do not respond differ from those who do, even assuming good data from the sample, there are immediate concerns about generalizability to the population as a whole.

The 1994 survey indicated that 35% of households have a firearm on the premises and approximately 25% of citizens personally own at least one firearm. The 2004 survey indicated that 38% of households have a firearm on the premises and approximately 26% of citizens personally at least one firearm. These estimates are very close to each other in results despite being separated by a decade. However, there are a few reasons to approach the second estimate with more caution.

The Hepburn et al (2007) estimate has several weaknesses compared to the previous Cook (1997) study. The Hepburn et al (2007) study had significantly greater non-response than the previous study, approximately twice the rate of non-response. Indeed, the refusals (a subset of non-response) by themselves were twice the size of Hepburn et al's final sample. The second estimate also had an association with Harvard School of Public Health which is problematic due to bad blood between public health and gun owning groups. Additionally, the single demographic that Hepburn et al (2007) note as being most likely to own a firearm in their data is the very demographic they note was significantly under-sampled (males between the ages of 18 and 34). Both of these surveys use weightings and neither is particularly forthcoming about what those weightings were although the Cook (1997) survey mentions purposeful oversampling of minorities while the Hepburn (2007) does not. This should incline a researcher to trust the Cook (1997) survey more, as they have more data to winnow and the gathering was undertaken with an eye towards weighting. The Hepburn (2007) in contrast gives the impression of weighting being

used as a band-aid for a less than optimal final sample. Taken together, there is good reason to be cautious using the 2004 survey data.

A final national level survey has only recently been made available by Pew research. Initially, an incidental aspect of Pew's (2014) research into political polarization included a question about firearm ownership. This yielded an estimate of 34% (plus or minus 2.3 percentage points) of American households had a firearm in their home, which is a lower percentage than the two surveys specifically designed to measure this phenomenon. Though its coverage of firearms was incidental, this research sample totaled 10,013 participants, a sample size approximately four times the sample size of the previous surveys. A decade separates each of these three surveys and each survey employs less methodological rigor than the one preceding it. And yet these are the three best national surveys in existence. The latest estimate is almost identical to the estimate from 1994 (1 percentage point lower) which makes one consider whether these represent samples from a stable gun owning population.

There are some other survey data concerning firearms in the Behavioral Risk Factor Surveillance System but these are from a public health surveys. This means that not only do researchers run into the issues with medical researchers and gun owners, but also that the survey was designed to measure primarily health outcome and lifestyle data rather than firearm prevalence. The firearm question was not asked consistently either across time or across states. Further, the wording varied when it was asked so even the same state asked consecutive years does not yield interpretable comparisons due to the strong framing effects of wording. At the same time, because the battery included questions about medical health the medical or public health focus of the research was accessible to the respondents. Accordingly, these surveys aren't

included here. For single instance surveys, this leaves two national surveys primarily concerned with firearms, and one survey that is incidentally interested in firearms.

Ongoing Surveys Concerning Firearm Ownership

Moving from single-instance national surveys to ongoing surveys, only two national level ongoing surveys ask about firearm ownership: Gallup and the General Social Survey (GSS). Statistical analysis of the GSS numbers irrefutably show that the instrument is undercounting gun ownership and has both gender and regional response issues on the firearms questions (Legault 2008). Additionally, while the GSS has trended slightly down over time, the Gallup polls have shown variation up and down and do not show a clear trend (Gallup 2014). The current Gallup and GSS polls show a 10-point difference, with the GSS being lower (Ingraham 2015), despite both attempting to measure national firearm ownership by household. Neither of these can provide state level patterns; the GSS covers regions of clustered states and Gallup covers only national level data. Gallup estimates that between a high of 51% (measured in 1994) and a low of 34 % (measured in 1999) of households with a firearm on the premises. The GSS shows a steady decrease from 47 to 31% of households had a firearm on the premises from 1973 to 2014. The latest estimates from these sources indicate that either 41% of US households (Gallup) or 31% of US households (GSS) have firearms on the premises.

Contrasting Different Survey Type Results

Contrasting the two single instance firearm prevalence surveys with the same year's GSS and Gallup estimates gives some insight into how little we can safely infer. The Cook (1997) estimate took place in 1994 and while the Cook number is "35 percent (plus or minus 1.3

percent)" (pg 1), the GSS estimate for that year is 40.6% (plus or minus 2.9%) and the Gallup estimate for 1993 is 51% with no given margin of error. So while Cook may say " [t]his estimate may be somewhat off the mark but not by much" (pg 1), two other surveys exist well beyond the margins for error. The Standard Deviation for Cook is 0.65% and the point estimate is 35%. The GSS estimate for that year lies 8.6 standard deviations away from Cook. Gallup's estimate of 51% lies 24.6 standard deviations away from Cook's number. Even taking a look at the more forgiving confidence intervals and assigning less importance to the point estimates, the GSS and Cook are outside each other's margin for error.

Turning to the second estimate, the Hepburn et al (2007) estimate was taken in 2004 and estimated 38% of households had at least one firearm (plus or minus 1.86%). That same year Gallup estimated 43% and the GSS estimated 34% (plus or minus 3.27%). Again, the single instance survey and the GSS estimate are outside each other's margin for error, although this time the GSS is below the single instance. While the GSS and the single instance have changed position, the Gallup estimate remains much higher than both.

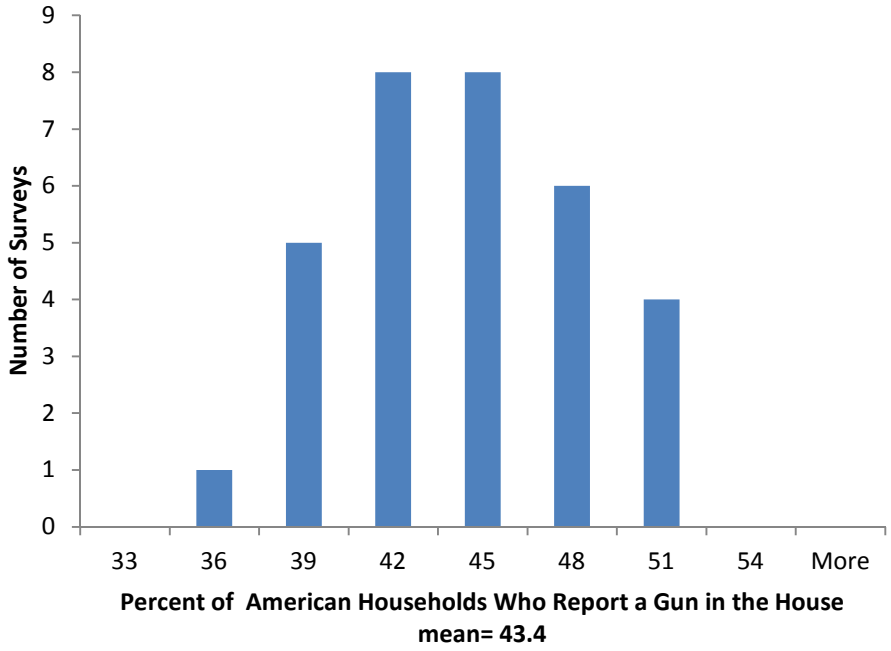
Contrasting the consecutive surveys with the two single instance surveys, the first single instance estimate is far below the running estimates, and the second single instance estimate is between the two running surveys. The relationship between these single instance surveys and ongoing surveys has simply not been established, to say nothing of the actual validity of any of them. The GSS downward trend may be indicative of decreasing ownership. Alternatively, the face to face aspect of the GSS may be leading firearm owners to demur and mislead about their status. That the Gallup numbers' lack a clear trend, despite an enduring and high-profile reputation of the firm, indicates that the other numbers may be conservative. Indeed, plotting the

Gallup estimates results in a graph that is suggestive of a bell curve (Figure 1), which is what statisticians would expect if Gallup was in fact taking multiple estimates from a stable gun owning population.

A final piece of evidence that can be added to this analysis is the expanded Pew research. This research, which Pew released in 2017, is different from either the ongoing or single instance surveys as Pew used a panel recruited from previous national random surveys. Pew recruited panelists, weighted the panel to represent Americans as a whole, and from these subjects Pew published an in-depth investigation into American attitudes to firearms. This research estimated a 30% rate of personal ownership of firearms, and a household estimate of 42%. It is noteworthy that this estimate is more in line with Gallup's ongoing estimates while being significantly higher than Pew's own incidental estimate in a true single instance survey. This might be an indication that single instance surveys by their nature return different results than ongoing data collection methods.

Pew also had an insightful follow-up question where participants were asked whether they were open to owning a gun in the future. A possibility with this question is that gun owners who are unwilling to identify as gun owners may be willing to identify as being "open" to becoming a gun owner. It is widely speculated and claimed that gun owners mislead researchers and this question was an excellent work around. On this measure, about half of self-reported non-firearm owners indicated an openness to owning firearms. Put another way, a total of 66% of Americans are either firearm owners or are open to becoming firearm owners. The remaining third of Americans neither own firearms nor are open to firearm ownership. Either way, Pew's

Figure 1.
Histogram Of Gallup Firearm Prevalence Estimates 1959-2015 (32 surveys)



research indicates that 2/3 of Americans is a reasonable upper limit estimate for firearm ownership in the United States.

Summary of Survey Data Sources

The survey data about firearm prevalence is both sparse and questionable. Survey data about firearms is highly influenced by framing variables (Haider-Markel & Joslyn 2001) to the point where slight wording difference can cause a 20 point swing to a majority (Nir 2012; Gallup 2015). Further, for at least one subpopulation in which corroboration was possible, subjects have been found to mislead researchers (Ruddell and Deker 2005). Beyond the framing issues, there seem to be significant differences between single instance survey results and other research results even when conducted by the same agency (Pew 2014, Pew 2017). Further, ongoing surveys from high quality research instruments do not agree with each other (i.e., Gallup and the GSS).

The challenges in survey data about firearm prevalence mean that their use as a validation measure is questionable. In other words, what researchers care about is how well a proxy variable tracks with reality. If survey data is known and demonstrated to have reliability issues between and among surveys, then by itself survey data is inadequate to declare a proxy variable valid. Cook's Index, the most common proxy variable for firearm prevalence, relies entirely on survey data as the validation measure. Even good correlation of the proxy measure and the validation measure in this case is not entirely convincing as neither has been demonstrated to correlate with the real variable of interest. Better, or at least more, validation tests are required of this measure.

Non-Survey Data

A non-survey source of data worth considering comes from the ATF. The ATF has three sources of data: (1.) New firearms added to the US yearly (2.) Raw numbers of background checks run in each transfer from a Federal Firearm Licensee (FFL, licensed firearm dealers) (3.) Metadata about traces the ATF has run. This data is freely available but is of doubtful utility even to the most careful researcher. All three of these forms of data are created in the manufacture/import process, the transfer of a firearm to a citizen, or in the aftermath of a crime involving a firearm. During the manufacture or import process the ATF requires documentation of the firearm, this process can only completed by a specialized version of a FFL which includes greater than normal scrutiny and ATF oversight compared to a standard firearm dealer. Following manufacture or importation the firearm cannot be transferred without a background check as any transfer of a firearm from an FFL to a citizen requires background checks and the request for a background check is likewise logged by the ATF. Additionally, any transfer of a firearm across state lines or to an out-of-state resident requires the involvement of at least one FFL, more often it requires two. In this way, the ATF can trace the chain of possession of a given firearm from its original date of importation or manufacture to the last transfer from an FFL. In the aftermath of a crime involving firearms, the ATF will "trace" the firearm to establish the chain of ownership from its point of origin to the citizen to whom the FFL transferred the firearm. Any firearm traced in this manner yields a record of the State of last FFL transfer, the State the firearm was recovered in, and the time between the two events.

The trace data are not useful for firearms prevalence research. Citizens are not required to keep documentation of private sales — with exceptions in a handful of individual states and as a

result the paper trail linking every firearm from manufacture or import to current holder can be incomplete, with no way of knowing when an illegal peer-to-peer transfer was made. The longer the time between last sale from an FFL to the date the ATF traces the firearm, the more nebulous the history is. How many times was it legally transferred before it entered the black market? Once in the black market, how many times was it transferred? Since the ATF data only covers sales that include an FFL, to determine the chain of possession between the last transfer by an FFL to the firearm's involvement in a crime is something that must be manually investigated by law enforcement. As a result, little is known about the process by which these firearms go from the legal to illegal markets. Additionally ATF traces must be requested by local law enforcement and the decision to ask for a trace is idiosyncratic between agencies. The aggregate trace data, then, are not representative of any population other than "the population of firearms recovered in crimes for which a particular law enforcement agency requested a trace from the ATF."

The background check numbers available from the ATF are similarly flawed. While National Instant Criminal Background Check System (NICS) checks correspond to some degree with legal firearm sales involving FFLs, they have no direct relationship with firearm availability or the firearm market as a whole. There are simply too many possible outcomes after a NICS check for the scan to have anything more than a weak association with firearms sales. For example, a background check could be completed but not accompanied by a transfer due to a changed mind by either party or the FFL refusing the transfer due to suspicious circumstances, as they are required by law to do. Even where the NICS scan and a transfer do have a true correspondence, multiple firearms can be transferred with a single NICS check. Further distorting the relationship between NICS checks and transfers is the fact that transfers from an FFL to a concealed carry licensee in some states does not require a NICS scan. In this case

because the state has already conducted background checks, they exempt the license holder from further background checks while the license is valid.

State-by-State laws can also add noise to any attempt at correlating NICS scans and firearm commerce. One such oddity can be found in the state of Nebraska, where a license is required to purchase firearms. This license is valid for a defined period during which the holder is not required to submit to further NICS checks. This weakens a direct relationship between NICS checks and legal firearm sales and makes the NICS numbers from Nebraska substantially different from the rest of the US. Even more noise is added because the citizen may choose not to buy a firearm, but the NICS check was already run. At the other extreme, there are States such as California which require all citizens to involve an FFL in any transfer of a firearm. While all citizens are prohibited by federal law from transferring a firearm to a prohibited possessor, not all States require citizens to transfer firearms solely through an FFL. A result of this is that what would be legal private transfers in most States become associated with a NICS check in States like California. So, while there is some correspondence between firearm transfers from FFLs and NICS checks, the strength of this relationship is unknown and varies by state.

Even the state based manufacturing data from the ATF is largely useless to researchers. In one of the many ironies concerning the subject of firearms in the United States, the Northeastern US has become a locus of strong gun control at the State level despite being the historical cradle of the firearms manufacturing industry. For example, while Connecticut is one of the leading firearms manufacturers, those firearms are sent out of the state to other FFLs (a transfer which requires no background check as both parties hold federal licenses). All that can

be said with confidence is that the citizens of Connecticut are probably not the owners of most of the firearms produced there.

The ATF production and importation data simply does not tell us where the newly manufactured firearms go, nor do the estimates consider attrition of firearms from the stock, and how this affects firearm prevalence. This is an incredibly complicated subject as a well-cared for firearm from the late 1800s can still be safely fired today with off-the-shelf ammunition. On the other hand, some firearms from that era are chambered in cartridges no longer produced which may mean they are unable to function as a firearm. Other much more modern firearms wear out, are destroyed through abuse and neglect, are destroyed following use in crime, destroyed by an official at a gun buyback program, or have been removed from the civilian market without being destroyed. The FBI, in particular, has thousands of firearms once used in crime that are being stored in Washington, D.C. Firearms are also lost while camping, hunting from a boat, or moving. Some firearms can pass from a collector who would never fire it to an enthusiast who fires it regularly — and vice versa. All together this makes the task of estimating firearm attrition, and how that affects firearm prevalence, all but impossible.

A final factor confounding the use of ATF data to estimate US firearm population is the fact that it is entirely legal for citizens to manufacture their own firearms for personal use if that person may legally possess a firearm. Personal manufacturing of a firearm is specifically allowed in the National Firearms Act (1934) as long as it is not manufactured for sale or distribution. Thus, even adding the ATF numbers to a national level estimate would not yield an accurate count of firearms in the US. Such an estimate would not encompass all the new firearms in the

Table 1 Specially Commissioned National Level Estimates of Firearm Prevalence						
Year	Commissioning Agency	Polling Agency	Response Rate	Sample Size	Household ownership Estimate	Personal Ownership Estimate
1994	National Institution of Justice sponsored National Survey of Private Ownership of Firearms (NSPOF)	Chilton Research Services	44-59 %	2,568	35%	26%
2004	Harvard School of Public Health	Fact Finders	14-18%	2,770	38%	25%

Table 2	Ongoing National Level Estimates of Household Ownership					
		Highest Estimate		Lowest Estimate		
	Trend	% households	year	% households	year	2014 Estimate
Gallup	No Trend	51%	1994	34%	1998	41%
General Social Survey	Declining	50.40%	1977	31%	2014	31%

population nor would it accurately account for attrition. It would also be entirely dependent on the accuracy of the starting estimate which as we will see in the next section is a dicey prospect.

Inferring From the Data

Tables 1 and 2 present the best sources of data currently available to researchers. It is remarkable that these few sources represent the best possible attempts made to investigate firearm prevalence in America. Much research hinges on these surveys, so much so that when the Small Arms Survey estimates American firearm prevalence, they rely on the 1994 NIJ commissioned survey to which they add ATF production numbers. As shown earlier, when considering the ATF production numbers this is an exceptionally weak methodology, which the Small Arms Survey (2007; Chapter 2 Annexe 3, pg 7) does acknowledge in passing. Various other numbers represented as an estimate can be found in the literature but most of these are either proxy variables (which will be considered in a following section), are based in the sources represented in those tables, or are not sourced. Even the excellent history by Kennet and Anderson (1975) commits the sin of omission by mentioning an estimate of 200 million firearms in the US (a number that places the per capita rate at 1 per person) but they fail to provide a source. This is the rule rather than the exception with firearms research: the analyses are many but the data are few. With that in mind, the challenging task of inferring from the data (not proxy variables) can begin.

- It seems safe to infer that that there is at least one firearm per person in the US and this has been a longstanding situation.

Firearm owners commonly own more than one firearm and both national surveys as well as the Kennet and Anderson (1975) history all put the estimate of a total number of firearms in US as one per person. The Kennet and Anderson number is unsourced but the overall caliber of their history is very high. They also use some colonial production and importation numbers for their historical estimates, a methodology that, for colonial American history, is much sounder than it has become today. This, and importantly its agreement with later sourced estimates, leads me to keep their estimate in this review. There is also another specialized datum from the ATF via the Government Accountability Office that indicates that there must have been more than 252,433,229 firearms in the US in 2016 (GAO-16-552, 2016). There are several reasons why this is a gross underestimate and correspondence to both manufacturers involved in the program and the ATF has been unanswered on this question. Nevertheless, it puts the lowest estimate close to the oft-repeated estimate of one firearm per person.

- It seems safe to infer that firearms used in crime are not representative of the US stockpile as a whole. Firearms used in crime are neither a random sampling of available firearms nor the result of an understood selection process.

All the estimates agree that by some margin, long guns (rifles and shotguns) are more prevalent than handguns in the US. Despite this, firearms used in criminal homicide are significantly different, with handguns overrepresented (Cook 1997). The high prevalence of long guns goes back to our earliest estimates (Kennet & Anderson 1975) and these long guns unquestionably have more killing potential than a hand gun (Di Maio 1999*).* Despite this, the vast majority of homicides involve handguns not long guns (Planty & Truman 2013). This is more striking since a shotgun can be "sawn off" to pistol size in a few minutes with a common

hacksaw. Further, because a shotgun develops most of its power within the first few inches of barrel, sawing off the barrel to a pistol length does little to nullify the power. Long guns are also easier to access since any person with a clean record can buy one beginning at age 18 (instead of 21 as with handguns). The takeaway of all this is that a sawed-off shotgun would be cheaper, more effective, equally concealable, easier to access, and harder to trace forensically than any handgun and would be the logical choice for "most common murder weapon", but this has never been the case. In fact, until the mid-1990's, knives were more often used to kill than long guns (Cooper & Smith 2011). Firearms used in criminal homicide simply are not a representative sample from the US gun stock nor is the choice of implement for criminal use well understood.

- It seems safe to infer that the makeup of local firearm stock varies across places in the US. This difference is apparently connected to variation along the Rural-Urban Continuum.

All the estimates (except Gallup which is mute on this point) agree that firearm type and prevalence differ across place. Rural, Urban, and Suburban are associated with distinct levels of positive responses to ownership across surveys. The Pew (2014) numbers show this most starkly, with 25% of urbanites owning firearms, 36% of suburbanites, and 51% of rural residents owning firearms. Kleck and Gertz (1998) in their famous estimate on Defensive Gun Uses (DGU's) and firearm carrying habits likewise show differences in carrying habits across Rural and Urban.

Even researchers who rarely agree on anything do agree that urban and rural areas have different patterns of use and misuse (Hemenway 2006; Kleck & Kates 2001). Despite this agreement, there is a paucity of literature exploring this issue. What research has been done shows that poor black urban residents have far less access to firearms than black rural dwellers, but black urbanites have a firearm homicide rate many times their rural counterparts (Kleck &

Kates 2001; Johnson 2014). Additional evidence can be found in the research by Wiebe, Krafty, Koper, Nance, Elliott and Branas (2009), who found that geographical effects of gun shops on crime vary markedly across the RUC. Wilkinson & Fagan (2001) likewise note that the RUC is associated with wholly separate types of adolescent misuse of firearms. These are striking findings but they have received little attention and even less follow up investigation.

These three simple inferences based on the best available data about firearms bring up a couple of issues with studying prevalence of firearms generally, as well as issues with validating proxy variables generally. First, the sparse nature of what can be reasonably inferred presents difficulties in demonstrating that a proxy variable corresponds with reality. At the very least it demonstrates a need to validate with measures beyond simple survey data. Second, if what little information available indicates that both use and availability of firearms vary along the RUC, then accounting for this factor is important in future research.

Cook's Index

Ultimately, firearms research relies almost exclusively on proxy variables to assess firearm availability and prevalence. The dearth of hard data has left researchers with few options but to try increasingly tenuous proxy variables. Each proxy variable has been an attempt to leverage accessible data to meaningfully describe the situation of firearms in the US. For Criminal Justice researchers, homicides perpetrated with firearms was the logical starting point but firearm homicide does not correlate well with telephone survey estimates of firearm prevalence; indeed, it is among the poorest predictors (Azrael, Cook, & Miller 2004). Further, as noted previously, firearms used in criminal homicide are significantly different from the firearms in the US as a whole (Cook 1997). Attempting to use other criminal acts with firearms as proxy

is an even worse prospect. When a crime such as robbery is committed with a firearm, unless the firearm is actually fired, the question of whether the firearm was real or a realistic replica is an open one. Victim testimony or security camera footage cannot fully resolve the question, as it is known that crimes have been committed while brandishing replica weapons. To find a variable that is related to firearms prevalence and can be accessed by researchers many proxy variables have been used: hunting licenses issued (Krug 1967), the circulation of firearm specific magazines (Duggan 2001), disagreements over which of the several published firearm magazines ought be used (Plassmann & Lott 2004), and plethora other study specific proxies that are various combinations of the existing proxies. Of the many proxies tried one has come to stand head and shoulders above the rest: Cook's Index (Azrael, Cook, & Miller 2004).

Cook's Index was originally a composite measure calculated using both the ratio of firearm suicide to all suicide and the ratio of firearm homicide to all homicide. It correlated with survey responses better than previous proxies, and, if not better than some of its competitors, it did use easily accessible data with minimal transformations and thus quickly became standard in firearms research. Since its original formulation many attempts have been made to increase its validity. Some have restricted the ages of decedents for suicide, arguing that an older man taking his own life with the family shotgun is importantly distinct from a younger man buying a firearm to kill himself. Others have restricted ages based on whether the perpetrator (when known) could have legally bought the firearm, arguing that illegally held firearms are a distinct subset of firearms. Similarly, some have weeded out rifle and shotgun suicides, as these weapons are rarely involved in crime and their prevalence may be unrelated to handgun prevalence. Specifics on the many modifications and proxies can be found in Kleck (1997) and Azrael, Cook, & Miller (2004). The latest attempt to contrast all common proxy variables, but particularly the common

variations of Cook's Index, led to the conclusion that the simple ratio of suicides with firearms divided by the total suicides was the most valid proxy, inferior to telephone survey but superior to other proxies (Azrael, Cook, & Miller 2004).

Azrael, Cook, and Miller (2004) give the most recent review of Cook's Index and provide a thorough analysis concluding that percentage of suicide committed with a firearm is a robust proxy for cross-sectional analyses. However, their glowing review suffers from methodological flaws that require further investigation. Azrael, Cook, and Miller (2004) ultimately rely too strongly on the General Social Survey (GSS) as their main measure of validity, even going as far as calling it "the gold standard". But, as was noted earlier, it has been demonstrated that the GSS has significant errors with respect to firearm ownership responses (Legault 2008). Further the GSS shows a clear downward trend in ownership that does not agree with the other data available. This disagreement means that even if Cook's Index and the GSS surveys correlate perfectly, other methodologically sound surveys show different findings and do not show a clear trend. More validation is necessary given that the utility of the GSS is in question.

Underlying Assumptions of Cook's Index

Cook's Index has a handful of fundamental assumptions built into it and these assumptions should be explored theoretically and empirically. The most important assumption is the assumption that there is a direct link between availability of firearms and their use in suicidal behavior. Cook's Index assumes that availability of firearms and use in suicide are simply associated, but how does this apply to availability of other suicide methods? Worldwide, hanging is the dominant method of suicide (Ajdacic-Gross et al 2008). While it is true that even the poorest humans have access to some form of cordage, the poorest humans also have access to

sharp edges (be they metal, glass, ceramic, or even wood) that are capable of opening arteries. The difference is not one of potential for killing nor is it a choice based on perceived suffering since strangulation takes minutes of agony awhile exsanguination, in general, takes less time and is less painful. Ultimately, the choice of suicide method has to be influenced by something more than simple access.

This should not be surprising. It is true that many people will accept that a long string of preliminary behaviors necessary to take a particular action can influence people against choosing to take the action. This is the logic behind easing voting requirements, if there are fewer tests and forms to fill out, more eligible people will vote. At the same time, everyone has equipment of one type or another that was bought to accomplish a behavior or to reduce excuses for not doing something. Procuring this equipment did not on its own change the behaviors exhibited. The number of relevant examples here is quite high. From hobby equipment to professor's office hours, the extent to which human beings use what they have access to varies markedly. Even when it is in their own self-interest (office hours) or in line with their own desires (hobbies), access alone is inadequate to explain behavior. Easy access can, but does not always, increase the probability of use.

Cook's Index also assumes that all places (in the US at least) are equivalent in choice of suicide implement. The importance of this assumption can be seen by considering swords instead of firearms and then considering them across Eastern and Western culture. The Japanese had a widespread practice of Seppuku, a highly ritualized form of suicide which utilized a sword. The use of a sword to accomplish a suicide is also known in the West (the Biblical King Saul used this method) but this method of suicide never achieved the cultural dominance there that it did in

Japan. If one were to measure availability of swords by their use in suicide, one would conclude that European nations had fewer swords simply because Europeans did not die by suicide in the same manner. It is difficult to have a clearer example of culture having an effect on suicide method, but this difference was also a difference across place.

These theoretical explorations show some of the weaknesses and exceptions that exist to the underlying assumptions of Cook's Index. These assumptions are not explicitly dealt with in the literature, rather, the emphasis is placed on how Cook's Index correlates with surveys. Regardless, the assumptions are there and need to be explicitly dealt with if this is to continue to be a way to measure and model firearm prevalence in the US.

Empirical Studies on Variation in Cook's Index

A unique study by Silveira, Wexler, Chamberlain, Money, Spencer, Reich, and Bertone-Johnson (2016) provides the foundation for a preliminary test of the logic of Cook's Index. Silveira et al (2016) studied suicide behavior in rural Alaska among a group in which "Almost every household has access to guns and ammunition"(pg 36). They found that "[f]irearms accounted for only 10% of all suicide behavior" (Silveira et al 2016:pg 38) despite 100% access. These data include suicide attempts, not just completed suicide, but the disconnect between means used in suicide behavior and the availability of firearms is still striking and at odds with the logic of Cook's Index. This population had universal access to firearms but chose to use other methods for the overwhelming majority of their suicidal behavior.

The Silveria et al (2016) study provides the data necessary to complete a preliminary test of Cook's Index. A researcher can take the suicide rate observed where 100% access to firearms

exists and then apply that suicide rate to estimates of American households with firearms. If the logic of Cook's Index applies to the gun owning population as a whole, then the rate with 100% access to firearms ought to be the rate for all firearm owning households, as these households by definition have access to firearms. To be as generous as possible to Cook's Index, it is posited that all the completed suicides in Silveira et al's (2016) study were committed with a firearm. Substituting the percentage of households believed to have firearms and number of people in each household should give an estimate of suicide that is comparable to what is actually observed. The suicide rate with firearms taken from the Silveira et al (2016) study is 6.667 per 100,000 per year. Two estimates were made: one using the percentage of households with firearms according to the most recent one-shot survey measuring firearm prevalence (Hepburn 2007), the other uses the most recent GSS (the lowest estimate of firearm prevalence). Taking the Census Bureau's estimates of households in the US and their concurrent estimate of average number of occupants per household along with our estimates of household prevalence, there should be approximately 63,165 firearm suicides per year using the lower GSS estimate and 77,428 using the Hepburn estimate. However, in the US between the years 2000 - 2014 the national number of suicides with firearms has ranged from 16,586 to 21,334. The derived estimates using the logic of Cook are more than three times greater than the number of measured suicides. Further, the suicide rate yielded from Silveira et al (2016) gives us a suicide rate of 6.7 per 100,000 which is comparable to the firearm suicide rate of the US as a whole, but that would be evidence that going from a 100% households with firearm to between 30-60% of households having a firearm exhibits no change in the final numbers.

This simple back-of-the-envelope math is enough to give pause. If not fatal to Cook's Index it is a powerful argument that place matters with respect to suicide, as this is from a rural

area. If Cook's Index is to continue to be used it must account for these significant differences across place.

Three important pieces of disconfirming evidence counter the logic of Cook's Index: The German experience with Black Powder firearms, Eastern European preference for hanging, and the US gendered experience with suicide by firearms. Each of these pieces of evidence is directly at odds with what should be observed if the assumptions of Cook's Index are sound. Together with the theoretical explorations and the Alaskan example, the need for additional tests of validity for Cook's Index is strong.

Cook's Index attempts to take cultural differences into account by using the percentage of suicides involving firearms. Thus, while two cultures may have distinct suicide rates, Cook's Index argues that the proportion of each culture's suicides involving firearms will be directly, and linearly, related to firearm availability. However, increased ownership and ease of access to Black Powder firearms in Germany has *not* been associated with an increase in suicide involving these Black Powder firearms (Hartwig, Tsokos & Byard 2009). A rise in use for suicide was predicted because of the proposition that ease of access correlates with use in suicide, but the data do not support this conclusion. The authors point to complexity of loading as a possible reason for the failure of use, but those familiar with black powder firearms (or firearms history in general) know that though these are older technology (16^{th} -19^{th} century), loading a single round takes far less than a minute and they are more than adequate as a suicide weapon. In short, they are firearms and should be subject to the same use, but the data found are in conflict with the logic of Cook's Index.

The second piece of disconfirming evidence is seen considering the prevalence of suicide method in Eastern Europe. Ajdacic-Gross et al (2008) find that the highest rate of hanging occurs in Eastern Europe where 80% of females and 90% of males use that means of suicide, yet Eastern Europe has a higher rate of firearms ownership than Western Europe does (SEESAC 2006). With higher firearm availability, why do they not figure more prominently as a means of suicide? The low rate of suicide involving firearms is in direct opposition to what Cook's Index would predict and is further evidence that choice of suicide method, and the rate at which it is used, varies across place.

A third piece of disconfirming evidence is produced by comparing female and male suicide in the US. Household firearms are to some degree available to all members of the family. This fact is often used to stress the importance of safe storage in an effort to deny unsupervised access to firearms by minors. However, the implication that children have access but women do not is an untenable assumption. Firearm ownership is known to be more common among households with a married couple (Cook & Ludwig 1997), which means that, where there are firearms, generally, a male and female both have access. In cases where one parent stays home to provide childcare, the stay-at-home parent would in fact have more access than the working parent. Given similar access, why do women in America use firearms in suicide so rarely? In the US, female suicides perpetrated with a firearm make up approximately 30% of all female suicides, while the male percentage of suicide with firearms hovers around 60% (WISQARS 2015).

Similar, though starker, gender differences can be found in Switzerland. Though there are many important differences in the Swiss and American approaches to firearms, both societies

have relatively high firearm prevalence particularly when comparisons are restricted to Western European Nations. When considering the gendered differences in firearm use for suicide Ajdacic-Gross et al (2008; pg 728) note "only men used this method in Switzerland". This is an overstatement, but not by much. The raw data show that, over a four year period, 1,553 Swiss males used this method, a number that constitutes 33.5% of male suicides. Over the same four-year period there were 71 cases of Swiss females dying by suicide with firearms, constituting 3.5% of female suicides. There is even stronger finding that gender and suicide method vary with equally available means through Europe (Varnik et al 2008) and Asia (Ahn, Park, Ha, Choi & Hong 2012). The finding exemplified by the Swiss and the Americans, i.e., that males and females use different means even when they have equal access, is a concept ignored by Cook's Index but one that must affect its validity.

Important Factors Associated With Suicide That May Affect Cook's Index

Suicide is a complex behavior that has noted variation across religions, history, age, gender, and place. This section explores some of these known factors. Many of the factors associated with suicide are historically well known in the social science. Ultimately, because of the complex nature of suicide, its use as a simple barometer of firearm availability is brought into question.

When describing an overview of suicide as a phenomenon, Judd, Cooper, Fraser & Davis (2006) note that "generally, psychosocial stressors impinge on a vulnerable person to promote suicidal thoughts and behaviour that may have varying degrees of lethality and intent" (pg 209). This simple definition incorporates psychological and sociological factors as well as language that includes the comparatively new public health paradigm; "Psychosocial" encompasses both

individual and social factors while the term "vulnerable person" signals membership in a "vulnerable population", which is a public health concept. There can be conflict or overlap between factors within these frameworks. For example, a factor such as "age" or "sex" could be perceived as a defining characteristic of a vulnerable population in the public health paradigm, or it could be considered a psychological factor in how an individual thinks and behaves, or it could be conceived of as a social factor that has an effect on aggregated individuals' behavior. Care must therefore be taken when comparing studies from the three schools, as their respective underlying philosophies affect how the factor is modeled and defined. For the purpose of finding factors associated with suicide that affect estimates of firearm prevalence, however, description is sufficient rather than determining the underlying causes.

Religion or Religiosity and Suicide

Religious group membership is one of the first factors associated with distinct suicide rates. Durkheim's ([1897] 1951) seminal work on suicide found that Protestants had higher rates of suicide than Catholics and Jews. A later study of Switzerland presented an interesting case because cantons tend to be Catholic or Protestant; this study likewise found that Catholics had lower rates of suicide (Halbwachs ([1930]1978). Even a modern follow up study of Switzerland (Torgler & Schaltegger 2014) taking place at a time when Protestant and Catholic theological difference are less pitched and taking into account several non-religious factors, continued to show that Catholicism is associated with fewer suicides than Protestantism. This relationship is likewise found in the United States very strongly. Despite some variation, the relationship between Catholicism and lower suicide rate has been dubbed Sociology's "one law" (Pope & Danigelis 1981; Faupel, Kowalski, Starr 1987). Stack & Kposowa (2011) find in cross-national

research that membership in any of the "four major faiths" correlates with lower aggregate approval of suicide. Wu, Wang and Jia (2015) find in a meta-analysis that included both Western and Eastern religions that religion has a generally protective effect. And Gearing & Lizardi (2008) in their systematic review of religion and suicide find that in the US religion has a generally protective effect. They go on to offer clinical guidelines for how a subject's religiosity should affect his or her assessed suicide risk. Clearly then, religion is associated with differences in suicide phenomena which makes simple reliance on suicide as a proxy variable dicey. Further, as both the practice of religion and the American make up of religious affiliation are constantly changing, care must be taken when considering suicide data and even more care when it is being used as a proxy.

Gender

Another important factor is gender. Again, Durkheim ([1897] 1951) observed differences between suicide rates of men and women. The extent of the gender difference varies across nations, with Western Europe showing the greatest difference and certain Asian countries showing the least difference (Varnik et al 2008). However, even considering the lowest gender difference, males died by suicide at almost twice the rate of females (Ahn, Park, Ha, Choi & Hong 2012) which is far from a trifling difference. Ultimately, the male/female difference has been described as "almost universal "(Girard 1993, abstract) with males significantly more likely to die by suicide than females. Likewise, Mendez-Bustos, Lopez-Castroman, Baca-Garcia & Ceverino (2013) note that it is well established that women die by suicide less often than men even though women attempt suicide more often. In the US specifically, there is a 4:1 ratio of male to female suicides (Ahn, Park, Ha, Choi & Hong 2012). Clearly, gender matters to the

phenomenon of suicide but is variable in the magnitude of the measured effect. As noted previously, there are gendered differences in the use of firearms for suicide and observed stark differences between men and women. Differences in methods chosen for suicide are present even with the universally available method of hanging (Varnik et al 2008). While the reason for the gendered difference in rate, attempts, and methods utilized is subject to debate, what is not subject to debate is that the suicide phenomenon varies markedly according to gender both in the US and internationally. Any measure that does not account for the found differences in both suicide and attempted suicides across gender lines is ignoring an identified confound and one whose magnitude varies across place and culture.

Age

It is a consistent finding that suicide does not affect all age groups identically. This is a complex topic, but it must be included when considering the topic of suicide. In the US, the majority of suicides occur among males 45 or older (Parks, Johnson, McDaniel, & Gladden 2010). At the same time, medical literature often refers to "leading causes of death" for various age groups, and by this metric younger age groups have suicide listed as a higher leading cause of death than older people. This is not as contradictory as it seems. Consider that although American children ages 10-14 have suicide as the third leading cause of death (CDC 2015), their death rate as a whole is very low, standing at 10.4 per 100,000. This is compared to over 1,000 per 100,000 for each age group above 65 (Murphy, Xu, Kochanek, Curtin & Arias 2017 Table 3;pg 24). Younger people face fewer lethal threats than do older people. Ultimately, both in raw numbers and in rates, older age groups have the highest suicide risk.

There has been some research that finds that while suicide attempts go down with age, completed suicides go up (Hawton & Harriss 2008, Table 1). Internationally, the findings are complex, with some countries showing positive correlation, some showing negative and some showing no relationship between age and suicide risk, though there does seem regional clustering in these findings (Shah 2007). Using indicators of life-expectancy rather than simple age leads to more agreement internationally (Shah 2009). Similarly, some conceive of age differences as a marker for stage in life cycle, which is the important factor rather than age itself (Rich et al 2001; Mendez-Bustos, Lopez-Castroman, Baca-Garcia & Ceverino 2013). As suicide disproportionately affects older adults in the US, the concept of stage in the life cycle may be an important factor. Additionally, other factors that differ along the lifecycle may be involved in this risk difference. Again, failure to disaggregate suicides likely introduces significant measurement error, a fatal flaw for a for a proxy variable.

Suicide and Place

Finally, it is worth noting that there are wide variations in suicide rates across place. Not only is there noted variation in contrasting North America with South America, there is variation in comparing Asia with Europe and even in comparing Western Europe and Eastern Europe (World Health Statistics 2016, Fig A.10.2). The variation demonstrated within regions, such as Eastern and Western Europe is notable because the distinction between the two areas is far less stark than comparing continents. Nor is the variation across place merely a matter of comparing nations. Inside the US there are differences between states (Barkan, Rocque & Houle 2013). Australia, likewise, shows variation between areas of the country (Cheung, Spittal, Pirkis, & Yip 2012). It is again worth considering odd cases like Switzerland, where people in different

cantons speak different languages and have notable eating preferences and religious differences, but Switzerland itself has national trends distinct from neighboring countries in addition to its cantons' differences (Ajadeic-Gross et al 2005). From this it is obvious that place matters, but also that defining the boundaries of these places is difficult. Particularly for the present research, if US states have distinct rates and trends, using the same measure of suicide as a proxy is questionable. Further, many of these persistent factors in suicide are found to be associated with differences along the Rural-Urban Continuum.

Rural and Urban Places

An under-examined factor that may be influencing the accuracy of Cook's Index is a familiar but rarely studied one: The Rural-Urban Continuum. The importance of the different influences of the Rural and the Urban to human behavior is well understood. Indeed, the familiar story of the City Mouse and the Country Mouse teaches that there are major lifestyle differences between urban and rural areas, and this story is one of Aesop's Fables and dates to ancient Greece (Perry 1952). Thousands of years later, analysis of the international food supply during World War II shows that people in rural areas had more in common with rural people in other countries than they did with their urban countrymen (see Collingham 2012; esp. pages 224 and 262). Similarly, analyses of rural and urban law enforcement from both Britain and the United States show that inside each nation the rural and urban officers are very different from each other, but officers share striking similarities with their international counterparts along the Rural-Urban Continuum (Smith 2010, Capsambelis 2009). Even our mental health seems to vary along the Rural-Urban Continuum. Peen (2010) notes in his meta-analysis of advanced nations and

mental health that urban areas have significantly higher rates of mental disorders than rural areas, observed across multiple nations.

In America specifically, we can see that the urban has a special importance to criminological thought. The Rural Sociologists note that, going back to Durkheim and the Chicago School, the theories of crime have been largely focused on the city and related concepts. The former focused on urbanization and industrialization altering nations as a whole, while the latter conceived of the city as an organism, a view that left little room for the rural. Indeed, rural sociologists have argued for thirty years that criminology has a habit of ignoring the rural (Lyerly & Skipper 1981). Partially this is because the oldest data is from cities (Monkkonen 2000); however, even with much more data availability spanning decades, it remains a common methodology to exclude from analysis any county with fewer than 100,000 inhabitants (Plassmann & Lott 2004, pg 22), a state of affairs which can lead to extremely rural areas being left out of national analyses (see Lee, Bankston, Hayes & Thomas 2007 pg 258).

Despite this neglect of the rural as a subject, it often figures as a control variable in social science, though with little standardization. Weisheit, Falcone, & Wells (2006) note that "In our review of 90 studies on rural crime, most (62%) gave no explicit (i.e., measurable) definition of the term rural" (pg 201). The importance of this is easily missed but cannot be overstated. It is a rare article of agreement among many branches of study that the Rural vs Urban is an important factor for human behavior. It is even agreed that it matters internationally (Collingham 2012; Smith 2010). Yet it is poorly defined, poorly studied, and both its definition and importance are rarely examined closely.

Because the study of the RUC is as splintered and sparse as it is, it is necessary to explore the factor in depth before showing the challenges the RUC poses to Cook's Index. First, the challenge of chopping the continuum into meaningful categories. Next, a handful of differences that demonstrate the fundamental importance of the factor, especially to a criminological perspective (crime and policing), will be explored. Then, some measured differences across the RUC that are inextricable from Cook's Index will be shown. Specifically, the RUC and its relationship to suicide and firearms will be examined in depth. The relationship of firearms and the RUC is surprisingly varied; there are documented differences between rural, suburban, and rural populaces with respect to firearm prevalence, firearm use, attitudes towards firearms, political fights over firearm regulations, and history. Together these differences combine to place Cook's Index on perilous ground.

Categorization and Continuum- The Problem of the Suburbs

Acknowledging an urban pre-occupation in the criminological community and expanding the view to include the rural, while a step in the right direction, is ultimately too simplistic a solution. While it is true, and non-trivial, to state that New York City may be importantly different from Griegsville (the smallest town in New York State), to lump all the counties and cities as either like NYC or like Griegsville is to ignore the multiplicity of levels between the megalopolis and the backwoods. A better conception is not a rural vs urban dichotomy, but rather a continuum with the backwoods and the megalopolis as the extreme points: The Rural-Urban Continuum.

A simple rural-urban dichotomy would rightly note that a majority of US counties are rural and a majority of the population live in metropolitan areas (Donnermyer 2014). However, a

closer examination of RUC and population using Census Bureau data shows that only about 20% of the population lives in areas generally agreed to be rural and likewise only 30% in central cities (Hobbs & Stoops 2002). This leaves 50% of Americans as residents of a place somewhere in between the rural and urban poles on the RUC. This area between the rural and the urban may, with some degree of agreement, be called the suburbs. However, depending on the research, these people get added to either to the rural or the urban categories, making one category appear to be the clear majority when in fact the majority of the population is neither rural nor urban.

The Suburbs are important for many reasons, not least of which is that the distinction between the urban and the suburban is a strong one. Rury & Saatcioglu (2011 pg 311) note:

> The Urban-suburban divide was historically established with communities proximate to city limits by powers of exclusion in contradistinction to the urban core in sociocultural and political terms to varying degrees.

Yet this important legal and social distinction between the urban and the suburban, just as important as the urban and the rural, receives even less research than the rural areas. The result is that the definition of the suburbs in Social Science is unclear, even though the category seems intuitive to most Americans.

Because there is so little suburban-focused research, the majority of this literature review will focus on the Urban and the Rural. Ultimately, this review will stress the differences along the continuum and the fact that the people between the extremes of the continuum are just as important as those on the extremes. However, it is also true that differences are most starkly seen by comparing the extremes. Any criticisms or improvements to Cook's Index would incorporate

the entire RUC, suburbia included, and so bring attention to a tangential, but nonetheless important, question of how the suburbs fit in the continuum.

Non-Urban Violent Crime — Less of it More Poorly Explained

Violent crime is the first measured difference along the RUC to consider. The findings in this area challenge many of the research findings about crime in general. The clear implication here is that if criminology's most enduring findings do not apply to non-urban places, the assertion that proportional representations of firearm suicide to suicide changes only with respect to firearm availability becomes more difficult to hold.

Because of the importance of this claim, much attention should be given to the specific claim that rural areas have much lower and more stable patterns of crime than urban areas and that the suburbs fall in between. Any discussion contrasting rates of violent crime must touch on the issue of measurement, and this is especially true in the case of differences along the RUC. If a part of living in rural places involves dealing with things informally (Özalp & Karakilic 2007; Capsambelis 2009), there is the question of whether this will affect officially reported crime. If it does have an effect, in what direction is the effect?

The effects of a close knit community on crime reporting and categorization patterns have not been empirically studied, leaving this inquiry squarely in the realm of theory. Without objective measurement, all that is left is theoretically plausible conjecture and the interpretations on both sides must be entertained. Certain influences that may affect certain pronouncements of "cause of death", like life insurance, are found in both rural and urban areas alike. The most

relevant process involved in this question is the ability of law enforcement to find and categorize crime.

The issue of investigative ability shows no clear advantage to rural or urban law enforcement. Urban areas have large well resourced police forces and surveillance devices. Rural areas, for their part, have a high degree of knowledge of each other's business and patterns (Slama 2004) where both presence and absence are noted by the community. Both of these are strong means of knowing what crime is occurring in the community. For both rural and urban locations, their particular situation has advantages and disadvantages for crime reporting and categorizations. A tight knit community may know more about crimes like domestic abuse but that may not translate into official reporting. In a less connected urban area, that abuse may be completely unseen. Without strong evidence, one way or the other, there is no reason to prefer either rural or urban reports of crime.

All forms of data about crime show quite clearly that violent crime is importantly distinct along the RUC, and has been over the last century. Violent crime (with and without firearms) is far more prevalent in urban areas compared to rural ones whether considered in per capita or raw count (Donnermeyer 2014). Rural areas also show far less variation in crime rate over time than their urban counterparts. While urban areas show the much-discussed crime wave in the 1970's and the 1980's as well as the subsequent decline in the 1990's, rural areas instead show a much lower rate that remained stable throughout the time period. This finding remains constant regardless of whether the data come from law enforcement agencies through the Uniform Crime Report or if the data are surveys of victims in the National Crime Victimization Survey

(Weisheit, Falcone & Wells 2006, pg 60 figures 3.1 and 3.2). Indeed, when considering the magnitude of the difference across the RUC, Donnermeyer notes (2014, pg 4):

> it is clear that larger places have much higher rates (per 100,000 persons) of "official" crime. For some crimes, such as robbery, the rates are more than 20 times higher. In general, however, the overall rates for both violent crime and property crime are anywhere from about 4 times higher to about 25 times higher.

Because the majority of the population is located in non-rural (suburban as well as urban) areas, the distinctions are even more striking put into raw numbers and as a percent of total crime. Put bluntly, the vast majority of murders occur in non-rural areas. Similarly, though per capita measures offer a milder contrast, rural areas trail far behind the urban and the suburban with respect to murder.

The point that violent crime is more common in an urban area can be illustrated further through consideration of a different exposure variable. The use of rates to express violent crime incidents includes an assumption that the exposure variable for crime is population density. However, since violent crime also requires proximity, one can also conceive of a geographic exposure variable (e.g., crimes per square mile). If one uses a geographic exposure variable, cities appear to be death traps. In plain language: in the city one is rarely more than a handful of miles (or blocks) from murder on a fairly regular basis. In the country, murders occur with much less frequency and are likely to be further away from a given citizen on average.

Beyond there being distinct patterns of crime, the criminological models are inadequate to explain this phenomenon. Weisheit & Wells (2005) show clearly that as observation moves from urban to rural the amount of variation in crime explained by criminological models drops

markedly. They take great pains to show that this cannot be due to statistical or methodological concerns. Sampson (1986) similarly acknowledged that rural areas' crime rate is poorly explained by the main models in criminology. Indeed, variables model differently—even oppositely—along the Rural-Urban continuum. Rural areas have higher levels of poverty, but this does not predict their crime well. When poverty does predict crime, the relationship between poverty and property crime is in opposite directions for rural and urban areas (Wells & Weisheit 2004). Likewise, gang violence predictors are different, and opposite, in rural areas compared to urban ones (Weisheit, Falcone & Wells 2006; pg 69).

RUC and Law Enforcement

The RUC is associated with distinct law enforcement practices. The different practices of law enforcement demonstrate that one of the strongest subcultures in the social science literature is substantively different across the Rural-Urban Continuum. And, if the RUC has this effect on such a strong subculture and how they enforce the law, what effect is it having on the average citizen? The evidence is strong that that culture varies along the RUC and thus that RUC may be associated with effects measures in multiple behaviors in these places, including suicide.

Research with New Jersey law enforcement across the RUC (Barrett, Haberfeld, & Walker 2009) clearly shows that officers enforcing the same state laws, all having received the same training and graduated from the same police academy, show marked differences depending on their RUC work assignment. Given identical hypothetical situations, the rural, suburban, and urban law enforcement show marked differences in their approach, behavior, and use of force. Indeed, rural officers are warned that the expectations of rural officers can be quite different

from those in urban or suburban areas (Capsembelis 2009) as are the situations they will likely face (Payne, Berg, & Sun 2005).

The attunement of Law Enforcement behavior along the RUC is an important finding for any research touching on crime or firearms. An excellent example of the importance of the RUC, independent of state, can be seen in both the states of Colorado and New York in the aftermath of the Sandy Hook Tragedy. In both states, prominent city police chiefs were part of the call for stricter gun control. Once the new regulations were passed the same police chiefs publicly praised the new laws and took steps to enforce them actively. Sheriffs serving more rural areas were not part of the lobbying effort for more gun control and once the laws were passed, the sheriffs gave much more tempered and even obstinate responses in both states (Goode 2013). That law enforcement behavior differed so starkly across the RUC concerning firearm legislation, with both sides involved with media lobbying, is striking. Also striking is the fact that this split was mirrored in these very different states from different regions of the country. There is even peer reviewed research where public health advocates note that "sheriffs may be less helpful than police chiefs as colleagues for public health campaigns to reduce firearm trauma" (Thompson, Price, Khubchandani & Dowling 2011; abstract). Even the well documented similarity of law enforcement officers shows a distinct variation across the RUC.

The importance of the RUC to policing is in fact an international finding. In both Britain and the US, it is argued that local law enforcement is distinct and more connected to the community in rural areas compared to urban areas (Capsembelis 2009; Smith 2010). Even Turkey, an Eastern European nation rarely included among comparisons of “advanced” nations, notes that in rural areas law enforcement handle issues more informally than law enforcement in

more urban areas (Özalp & Karakilic 2007). Note the similarity to Capsembelis (2009) warning US officers that, while making a lot of arrests may be seen as evidence that you are doing your job in urban areas, in rural areas it can be seen as a failure to handle things informally and to the community's satisfaction.

The RUC and Suicide

The RUC has a substantial impact with suicide behavior generally. This is important because if the RUC is affecting suicide generally, it may also be affecting choice of implement in the process of suicide. The following sections build on the evidence in the previous section to show that the RUC matters internationally, with rural like rural and urban like urban. Together, these sections clearly demonstrate a rational basis for believing that the RUC is an important factor associated with robust differences in many topics of research, but especially for firearm prevalence and Cook's Index specifically.

One retrospective analysis of suicide and the RUC covered more than fifty years of data (Singh & Siahpush 2002) and shows that 50 years ago, male suicide rates were comparable across rural and urban areas, but female suicide rates showed a marked difference. As time passed, this difference was reversed, so that currently male suicide is higher in rural areas than urban ones, while female rates across the RUC are comparable. This is particularly interesting because the geographically isolated nature of the rural has not changed and a corollary to this is that medical assistance is further away for rural residents than urban ones. Indeed, this rural medical disadvantage has been suggested to be part of the reason for the higher frequency of fatal car accidents in rural areas (Weisheit, Falcone & Wells 2006). Despite this permanent medical disadvantage in rural areas, the pattern of suicide by gender across the RUC has changed

over time. What changed in those fifty years to affect the pattern of suicide is unknown, as is the reason it affected males and females differently.

The importance of the RUC to suicide is far more than an American phenomenon. Not only does the RUC seem to matter overall (Singh & Siahpush 2002), but subgroup analysis attempting to control for factors like medical and mental health availability still find a rural affect (McCarthy, Blow, Ignacio, Ilgen, Austin, & Valenstien 2012). The importance of the RUC has also been found in Finland (Pesonen, Hintikka, Karkola, Saarinen, Antikainen, & Lehtonen 2001) where there is a difference in prevalence but also a difference in the profile of suicide victim; factors that are protective in urban areas are not necessarily protective in rural areas. In Taiwan, Chian, Lee, Yen, Wu, Lin, Hurng, & Chang (2013) noted differences in outcomes but also in ideation, stressors and risk factors between the Rural and the Urban. Chen, Kwok, Yip & Wu (2013) in their study of Taiwanese suicides found that the Rural and Urban utilize distinct methods to die by suicide, even when means were equally available. In Austria, Kapusta, Zorman, Etzersdorfer, Ponocny-Seliger, Jandl-Jager & Sonneck (2008) found that the RUC was associated with different levels of risk, and that this was increasing over time. While in India (despite some issues with sample selection), Kattimani, Sarkar, Menon, Muthuramalingam & Nancy (2016) found that the suicide process differed between urban and rural. And in Australia, the difference between rural and urban suicides persists even when attempting to control for social factors, leaving Judd, Cooper, Fraser, & Davis (2006) to conclude that factors associated with rural places were involved.

It is also worth returning to the previously mentioned social differences between rural and urban when considering their distinct suicide phenomena. Philip, Ford, Henry, Rasmus, &

Allen (2016) found that for rural youths the close-knit community—something alternately lauded and lamented as a rural characteristic—had a protective effect on suicide risk. Story, Kirkwood, Parker, & Weller (2016) note that a wider range of community figures participated in mental health education programs in rural compared to urban areas. In other words, rather than a seminar on suicide risk factors being attended mainly by mental health professionals, as is common in urban areas, in rural areas pastors, coaches, and parents attended. The programs were community rather than specialist events. At the same time Law, Snider and Leo (2014) found that social deprivation does not affect urban and rural areas the same way; instead the factors can lose significance or change direction of effect (pg 1927).

Other strong factors of suicide have been found to vary along the RUC as well. Dudley, Kelk, Florio, Howard, Waters, Haski & Alcockl (1997) found that the gender difference in suicide was different across the RUC in Australia. Wilkinson & Gunnel (2000) found that age patterns varied across the RUC. Torgler & Schaltegger (2014) found that urbanization had an effect on the well established difference of suicides between Protestants and Catholics. It has even been argued that the RUC might be related to the seasonal patterns of suicide (Coimbra et al 2016). While the exact mechanisms are not established, the importance of the RUC to the phenomenon of suicide is clear.

The RUC in the History of Gun Control

Evidence of the RUC's special relationship to firearms can be found in the historical fights over gun control legislation. The first national firearm regulation in the United States was The National Firearms Act of 1934 (NFA), which regulated short barreled shotguns and rifles, silencers, and all automatic weapons. Earlier, unenacted versions of the NFA had included all

handguns and revolvers in the group of weapons upon which “near-prohibitory controls” (Carter 2002 pg 545) were sought. Kennet & Anderson (1975; pg 209) show a fascinating glimpse of the debate leading to the passage of the National Firearms Act:

> Senator Copeland was even more incensed:
>
> "The Impression has been sent all over the country that we are trying to embarrass the farmer so that he cannot use a revolver or shotgun, or leave one with his wife, or take a pistol along in his automobile."

The implication is that farmers, and those in rural areas generally, were not the targets of the legislation, because their behaviors with firearms were acceptable. Whether this was Copeland backpedaling because of the political pushback over the NFA or an honestly held view, either way the rural relationship with firearms is demonstrated and rural use of firearms endorsed. This clearly shows that the rural-urban split was evident in firearm ownership in the 1930s.

More evidence of the RUC's historical relationship to firearms comes from the legal reviews of the firearm legislation fight. Justice Breyer noted in his dissent in *District of Columbia et al v Heller* (2008 pg 4) that urban areas, rather than rural areas, had some of the first firearm control laws and have a unique situation with respect to firearms compared to other areas of the country. Winkler (2013) likewise points to black powder storage laws as an early urban example of gun control and extends the analysis to include laws in the old west, specifically in frontier towns, as the origin of modern gun control. All of these laws implicate the urban in the genesis of gun control.

The early laws are not as simple to interpret as Breyer and Winkler think they are. Prohibitions on black powder storage may be understood instead as a hazardous material/fire

regulation due to the unstable and combustible nature of early gun powders – something importantly distinct from firearm regulation. Similarly, prohibitions against discharging firearms within city limits, which Breyer also cites, can be viewed as analogous to regulating pulling a fire alarm as gunshots were used to raise “a hue and cry”.

Winkler's (2013) use of the urban firearm laws of Tombstone, Arizona is likewise contentious. Although the law did prohibit carrying firearms, it also specifically provided that written permission could be granted allowing the free carry of firearms in town – a situation much more akin to modern Concealed Carry Licenses. Additionally, the law as written could have had no impact on residents having firearms in their homes or places of business, as this was not "carrying". It is also inescapable that in order for nonresidents to check their firearms with the sheriff they had to carry them to the sheriff's office inside town. Regardless of whether these were meant as "gun control" in the modern sense, they are claimed as a beginning by current gun control advocates and they all show an urban genesis.

As time went on, a more strident anti-gun view came from the Urban centers. Goss (2004) notes that gun control unabashedly has an urban heritage. Kennett & Anderson (1975) likewise note the urban origin as they point to New York City's increasingly strict gun control as an origin of the twentieth century gun control movement. In fact, Kennett & Anderson (1975) describe the more extreme gun control proposals (still being proposed in Bogus 2008) as cosmopolitan in flavor and bringing the urban in conflict with the rest of the RUC. They characterize the debate in the mid-twentieth century over gun control as that of "cosmopolitan" versus "bedrock" America:

Shortly after Robert Kennedy's assassination Gunnar Myrdal reportedly said that if the

> Constitution allowed such indiscriminate ownership of guns “then to hell with the Constitution”. Cosmopolitan American would have found this food for sober reflection; bedrock American, without reflection, would have said: “To hell with Gunnar Myrdal” (Kennet & Anderson pg 255)

Doubtless, urban people today rarely have opportunities for legitimate and legal use of firearms beyond self defense. Contrasted to rural areas where recreation with firearms is more common and feasible, it is easy to see why urban areas, bearing the brunt of firearm misuse and benefitting from fewer of the legitimate uses of firearms, were the cradle of the gun control movement.

The modern gun control movement continues to have an urban base. It is no coincidence that the cases which recognized an individual right to firearms in the second amendment *(District of Columbia et al v Heller* 2008*),* and then incorporated it to apply to the states *(McDonald et al v City of Chicago Illinois* 2010*)* had cities as the defendants. In both cases, the city councils enacted explicit bans on handguns until they were overturned by order of the Supreme Court. Another example of the urban support for gun control can be seen in a series of lawsuits in the 1990's. The series of lawsuits brought against firearm manufacturers had an admitted intent of simply trying to put gun manufacturers out of business with court costs, and many of the plaintiffs were mayors and municipalities (Burnett 2001). Similarly, when former mayor of New York City, Michael Bloomberg, was advocating for gun control in other states and at the national level, he funded a group of city mayors to make the push. In more academic realms, De Leeuw, Ho, Kim, & Kotler (2009) argue that municipalities must be allowed to have stronger restrictions on firearms because of the unique dangers of firearms in an urban environment. Bogus (2008)

takes this further and argues that, due to the issues with firearms affecting the city, national level restrictions are necessary and justified. And, as was mentioned previously, rural sheriffs and city police chiefs have been at odds in this fight as well. Kleck & Bratton (2009) ultimately cast part of the cultural battle over firearms as one in which the characters are urban effete sophisticates versus irresponsible rednecks, and a similar casting is available from public health sources (Branas et al 2004). While the back and forth over firearms legislation is a complex subject spanning at least 100 years of history, one clear thread that emerges throughout it is that the Rural-Urban Continuum has been an important factor.

The RUC and Attitudes to Firearms

While the urban currently comes down on the gun control side of the spectrum, the urban had its own history of firearms. Personally owned firearms featured prominently in urban environments during 4th of July celebrations up to and including the 19th century (Kennet & Anderson pg 137). Further, during the height of the volunteer militia movement just prior to the Civil War, the volunteer militias (and their attendant military grade firearms) were mainly an urban phenomenon (Cunliffe 1968). Both firefighter "brigades" and some urban police forces were originally volunteer urban militias. Over time these organizations shed firearms from their activities and uniforms but often retained the military ranks inside the organization.

It also seems that that firearm ownership among regular citizens was traditionally common in urban areas. The New York Tribune (22 February 1878) noted “a very fair percentage” of New York City residents carried firearms and stated:

> "Let a mad dog, for instance, take a turn around Times Square, and the spectator is astonished to see the number of men who will produce firearms from some of the multitude of pockets with which man, as constructed by the tailor, is endowed"

Similarly, in some towns in the Old West, handguns were simply a normal part of everyday dress similar to a pocket watch (McGrath 1987). Firearms were not simply rural instruments, however there was increasingly a split between the Rural and Urban in their attitudes to firearms. By the time of the American Civil War, the difference in attitude towards firearms was established and is perhaps best exemplified by a curious incident involving then-President Abraham Lincoln.

President Lincoln was originally from a rural area and his use of firearms in Washington DC (an urban area) caused an incident during the Civil War that neatly illustrates conflicting Rural-Urban attitudes. Lincoln was something of a firearm aficionado and was personally testing the new repeating firearms. DC law enforcement was going to arrest the man who was illegally shooting within city limits until they realized that the man doing the shooting was the President of the United States (Stoddard 1890; pg 43). There is no evidence that the firearms were being used in an unsafe manner, but that is irrelevant in the urban context; the prohibition was against any discharging of firearms, regardless of safety. Lincoln's use of firearms in DC was consistent with the rural attitude he carried towards firearms. This transportation of the rural approach towards firearms into an urban locality caused a conflict that illustrates the emerging differences between the rural and the urban with respect to firearm use.

More of this tension in attitude towards firearms can be seen in the origins of the National Rifle Association (NRA). The founders of the NRA sought to encourage marksmanship after its members observed that many northern urban soldiers did not have the same skill with firearms as

soldiers from rural areas (See Winkler 2011, pg 65). Whether true or embellished, this story is used as a narrative. That this resonates and is retold enough that it wound up included in an academic work tells us that this difference along the RUC is something that is generally seen as reasonable.

Modern research likewise indicates that the RUC is associated with distinct attitudes towards firearms. Where an individual lives along the RUC during adolescence may be important for lifelong relationship to firearms (Legault 2008). And firearm ownership (or at least people willing to admit to firearm ownership) continues to be highest among college-educated people in "rural small town America" (Cook 1997, pg 2). Clearly the RUC has come to be associated with distinct attitudes towards firearms.

The RUC and Firearm Use

Moving to the question of whether firearms are used differently across the RUC, one finds little direct evidence, but the scant evidence points to an unambiguous "yes". Whitney clearly mentions that the use of firearms differed along the RUC starting in colonial times (2012 pg 9). Toch and Lizotte (1991) state bluntly that:

> [T]he fact that national patterns show little violent crime where guns are most dense [rural areas] implies that guns do not elicit aggression in any meaningful way. Quite the contrary, these findings suggest that high saturations of guns in places, or something correlated with that condition, inhibit illegal aggression (pg 234).

This is not to say that guns are not used to kill in rural areas. Branas, Nance, Elliott, Richmond, & Schwab (2004) found the per capita rates of intentional firearm death (a composite of suicides and homicides involving firearms) are about equivalent comparing the rural and the urban. What

differs is the composition; most of the urban deaths are homicides, while most of the rural deaths are suicides. At the same time, it is worth noting that the risk posed by firearms overall is fairly low. Baker (2009) noted after his extensive analysis that "the case for criminalizing gun possession on basis of general dangerousness is extremely weak." (pg 191).

Despite a comparatively low risk overall, the types of misuse of firearms varies importantly along the RUC. Wilkinson & Fagan (2001) argue that levels of urbanization are associated with different patterns of firearm use among adolescents. Specifically, they note that adolescent-involved shootings varied along the RUC such that "nonurban shootings during this time were often multiple victim homicides, a sharp distinction from the predominantly single victim shootings in the cities" (pg 125).They further note the importance of the RUC to both the type and predictors of misuse:

> [There is an] extremely low rate of shootings by adolescents outside of cities. A direct link between inner-city and nonurban homicides would predict higher rates and more frequent events outside the cities. The easy access to rifles and other guns outside cities would support higher rates of gun violence. But this was not the case. (Wilkinson and Fagan 2001:129)

They also note that the predictors for firearm violence are fundamentally different comparing the rural to the urban.

Another piece of evidence for the importance of the RUC to firearm use can be found in academic criticism from Hemenway and research by Kleck, two prominent figures in the study of firearms who rarely agree on anything. While criticizing research that found a positive social

impact of firearms, Hemenway (2006) criticized the study for "comparing Cook County (Chicago) with downstate rural counties" because "the more relevant comparison is among the rural counties or among suburban areas." (pg 232). While comparing like with like is indisputably an important part of good research, the city of Chicago (and its attendant firearm misuse) had nothing to be compared to and the city effectively disappeared from the study. Those points taken together take much of the force of the criticism away, but in order to make the criticism, Hemenway displays a belief that firearms are used differently in the cities compared to the rest of the RUC. Hemenway characterizes this as a confounder rather than a finding that bears further investigation. Kleck (2001 pg 63) likewise finds that the RUC affects how firearms are used, only with greater specificity, noting:

> young inner city black males have a homicide rate almost 1,000 percent greater their counterparts in rural areas.[...] The correlative fact is that rural blacks have this far lower murder rate despite having a rate of gun ownership and/or availability comparable to whites , ie, a rate far, far exceeding that of urban blacks."

This particular finding was echoed by Johnson (2014) more than a decade later in his exploration of the black history of firearms. This finding is particularly important because these comparisons take into account race and availability of firearms – the pertinent difference is one of the RUC.

Another fascinating exploration of the RUC's differences with firearms use focuses on Federal Firearm Licensees (FFLs). FFLs may be usefully thought of as gun shop owners, though this is a simplification. FFLs are specially licensed at the Federal level to conduct the business of selling firearms, a license that has been more difficult to acquire after the 1994 legislation on firearms. In part this stemmed from concern about "kitchen-table gun dealers" but this is mostly

a misunderstanding; while it is true that not all FFLs have a brick-and-mortar store location, they are all subject to the same restrictions when transferring firearms to citizens and in submitting to ATF oversight, including storage requirements and background checks.

When studying the relationship between FFLs and geography Wiebe, Krafty, Koper,Nance, Elliott & Branas (2009) found no overall association between prevalence of FFLs and crime rate. However, when sub-groupings of the Rural-Urban Continuum were used, FFLs were shown to be significantly associated with increased crime in large urban areas, decreased crime in smaller cities and suburbs, and have no relationship with crime in rural areas. (Wiebe, Krafty, Koper,Nance, Elliott & Branas 2009). What is interesting here is that without explicit consideration of the RUC there seemed to be no associated effects with FFL location. It was only by considering rural, suburban, and urban areas separately that significant patterns were seen. This is an extremely important finding that the RUC matters to how firearms are used.

Finally, a pair of studies by Altheimer neatly show the importance of the RUC to firearms at an international level. In the first study, Altheimer's (2010) international research was only able to use city data. He found a positive relationship between violent crime and firearm prevalence. In the second study, Altheimer and Boswell (2011) were able to use nationally representative data (from which it can be inferred that data across the RUC for each country was used). When this more complete data was used the simple relationship disappeared and the effect of firearms varied country to country. He ultimately argued that shared cultural tendencies in groups of nations were more important than simple prevalence of firearms in explaining the pattern of firearm use. Though international research focusing specifically on firearms and the

RUC is sparse and idiosyncratic, Özalp & Karakilic (2007) likewise note that in Turkey firearms are more prevalent and more embedded in the culture in rural areas compared to urban ones.

Summary

There are two simple and related arguments. First, that Cook's Index as a proxy for firearm prevalence in the US needs further validation studies. It has been prematurely declared valid without adequate testing that includes variables from different geographical areas, different characteristics of the firearm owners, or different uses of the firearms. Second, that the Rural-Urban Continuum may be biasing this measure as it has been separately associated with each of the three aspects of Cook's Index and firearm prevalence. Together these findings require further research.

This section began by showing some of the necessary caveats when delving into firearms prevalence research. It showed what data was available and what little could be safely inferred from that data. Then, it explored some preliminary evidence that indicated that place on the rural urban continuum mattered with respect to firearm prevalence and use. The literature shows that the limited data forced researchers to lean heavily on proxy variables. Of the variables that were tried Cook's Index became the standard way to measure firearm prevalence.

Cook's Index was then examined carefully. The underlying assumptions of Cook's Index concerning access and use were theoretically explored, and this was shown to be a weaker foundation than expected. Second, a case study where complete access to firearms existed was applied to Cook's Index. This brief analysis indicated that Cook's Index had large scale errors when used to estimate figures nationwide. To this was added three important pieces of

disconfirming evidence for Cook's Index: One case where equal access did not lead to equal use, one case where large scale access to firearms seemed to be inconsequential to method of suicide, and one case where increasing access to firearms did not increase firearm suicide. All of these are directly at odds with the logic of Cook's Index.

There is theoretical and empirical evidence that the validity of Cook's Index may be being influenced by a number of factors. The complex phenomenon of suicide makes reliance on it as a simple proxy questionable. Suicide and factors associated with suicide vary differentially across geographical areas, which means that applying Cook's Index equally across all types of geographical areas may produce different results for different groups. Specific factors like gender, religion, and age inside each of those places are also influencing suicide and choice of suicide implement, which are then influencing Cook's Index.

In addition to potential issues in the use of suicide as a proxy for the prevalence of firearms, the importance of differences within the Rural-Urban Continuum is clear. Turning the focus to this specific factor, the evidence shows it may be strongly influencing Cook's Index, though the direction of this influence is unclear without further research. Bearing in mind the definitional difficulties, the RUC was shown to be a powerful and understudied factor. The RUC was not only associated with different amounts (in both raw and per capita measures) of crime; it was also shown that decades of research has not explained this. Indeed, the findings of criminology seem to be mainly applicable to urban areas with different and even opposite findings in non-urban areas. Even Law Enforcement appears to differ across the RUC.

The critical importance of the RUC as a factor was then shown to affect both fundamental processes involved with Cook's Index: Suicide and Firearms. The differences along

the RUC with respect to suicide were robust across time and were shown to be international. The RUC was also shown to have a long and storied history with respect to firearms not only in the decades of political fighting over firearms rights and control, but also in social attitudes and in how the objects are used. Modern evidence showing the importance of the RUC to firearm use (again an international finding) combines with the established history to place Cook's Index on perilous ground. Everything involved in calculating Cook's Index varies across the RUC.

Taken together there is substantial evidence to conclude that the Rural-Urban Continuum is associated not just with cultural differences and crime patterns generally, but also with how firearms are used. This has important ramifications regarding policy, as it indicates that a one-size-fits-all solution, in addition to being politically impractical, may not be empirically justified. More importantly, this finding, that citizens in rural areas use firearms differently from citizens in urban areas, raises grave doubts about the validity of a proxy measure that focuses on the use of firearms to measure their prevalence. Cook's Index, being on shaky ground from the start, now appears to have further threats to validity due to the Rural-Urban Continuum. With that in mind, I have formed the following hypotheses.

Hypotheses

Hypothesis 1: Cook's Index will moderately correlate with legitimate handgun ownership.

Hypothesis 2: The rural counties will have higher firearm prevalence but less firearm use in suicide.

Hypothesis 3: The relationship between Cook's Index and legitimate handgun ownership will be different across categories of the urban and rural.

Hypothesis 4: The majority of firearm suicides will have legitimate access to firearms.

Hypothesis 5: Long guns will be majority choice for suicide.

Chapter 3: Theoretically Grounding Firearm Prevalence and Use

The heart of this research is establishing whether there are differences along the RUC that are affecting the accuracy of Cook's Index to estimate firearm prevalence. Based on the literature review it seems likely that people in rural and urban areas use firearms differently, including in the use of firearms to commit suicide. The cultural theories in criminology offer a way of understanding why this hypothesized difference may exist. An application of this cultural explanation for differences between groups is already existent in the literature on the Southern Subculture of Violence (SSV). Even though the theoretical arguments over the SSV are not settled, the variation in incidences of violence along regional lines in the US was a worthwhile finding. Likewise, though the theoretical explanations of the differences along the RUC with respect to Cook's Index are unclear, the establishment of these empirical differences is itself an adequate beginning for further research. It is only once the facts are identified and agreed upon that competing theories can be adequately tested against the evidence.

Cultural Theories

The main theoretical grounding for this research is found in cultural theories of Social Learning Theory (Akers 1998) and in the related theory of Differential Association (Sutherland 1947). Not only are these very strongly supported criminological theories, these are also theories that tie into the larger biologically inspired theories of cultural evolution (Dawkins 1976, Richardson & Boyd 2005). There is disagreement about certain particulars among these theories but there is general agreement that information and strategies are accrued and refined over time by the group and that this forms the inextricable core of "culture". Culture is then spread via social learning to group as a whole. This family of theories would argue that differences in

culture (or subculture) along the RUC are the reason for the hypothesized differences with firearm use along the RUC.

The implication for the current research into Cook's Index and culture is perhaps best articulated as: “objects are always used in the context of culture.” This understanding allows for the fact that while objects have certain physical properties, those properties do not themselves determine how the objects are used in a society. For example, while the chemical makeup of alcohol is invariant, the ways which different countries use alcohol varies markedly. Multiple attempts have been made to examine these cultural differences with regard to alcohol consumption, including the well-known “wet” and “dry” cultures in Europe (Room & Makela 2000), but at the extreme there are also Islamic countries which forbid alcohol entirely. The laws differ – but so do the behaviors, even without complete compliance with the law, the behaviors differ across these cultures. And even the laws must be socially learned and therefore fall within the definition of culture.

The importance of culture to the adoption and use of technology should not be underestimated. Even in situations where more effective technology – whatever that may be – is universally acknowledged to be a priority, an inferior technology may have cultural value which confounds adoption of the better technology. In other words, the process of cultural evolution occurs with only tangential reference to physical reality even when the focus is on the physical reality. This is the power of culture in the evolutionary view.

There is no better example of culture trumping physical reality than in the case of adopting weapons for war. If there is one place where we could expect simple superiority of technology to drive change, it is in warfare. The stakes are too high to tolerate inferiority of

equipment and yet Britain was slow to give up its long bow in favor of superior firearms (Phillips 1999). The cultural value of the bow outweighed the physical reality of its antiquation. Similarly, the United States sold off its Spencer repeating rifles after the Civil War (Adler 2011 pg 173) despite their proven value in battle (arguably responsible for the Union victory at Gettysburg). Notably, these repeating rifles were sold to private citizens while the army retained single-shot muzzleloaders. These muzzleloaders were eventually altered into breech loading single shot rifles but they were not repeating firearms. In both these cases the cultural value of the older weapon outweighed the objective value of the superior technology. Even where sheer technological ability would seem to be of most importance, it is in fact culture that remains king. It is culture that decides what we do with what.

Applied to the rural-urban questions, the cultural argument states that even if both rural and urban had identical access to technology, how they use it could vary simply due to the cultural variation. If rural groups, suburban groups, and urban groups are insulated to some degree from each other, then cultural evolution is occurring inside each of those groups and the resulting cultures could be quite different from each other. These ideas have started appearing in the social science literature especially in social network analyses, which ultimately rest on biological and evolutionary foundations (Bright & Delaney 2013).

Differential Association and Social Learning Theory

The previous section considered culture in its most general conceptions, this section considers specific conceptions by two of the best known theories in criminology: Differential Association (Sutherland 1947) and Social Learning Theory (Akers 1998). Both theories argue that culture is perpetuated through individuals' learning from groups. Even in cases where

institutions are explicitly considered to be the teachers of behavior to individuals, it is not the organization itself that teaches. It is always individuals within the organization who transfer the knowledge of how to act. Both Differential Association and Social Learning Theories are concerned with the transmission of behavior in the context of groups.

Sutherland's (1947) Differential Association Theory is mostly concerned with the process of how individuals associate themselves with other individuals and small groups. Sutherland focuses on these associations, as this is where he believes learning of behavior occurs, and argues that it is possible for groups to develop which teach different and even deviant behaviors compared to the normative culture. Sutherland argued this process also transmits values and thoughts rather than just behaviors. This idea has been influential since Sutherland introduced the theory, and the idea of subcultures with distinct values was carried forward in Anderson's (2000) the Code of the Streets where differential association was observed in American inner cities.

The relevance of Sutherland to the question of Cook's Index is the fact that even small groups can have their own culturally determined behavior with objects. A crescent wrench is simply a tool to most Americans, but to the biker gang Hell's Angels, it may be understood to be a weapon and may be carried primarily as a weapon. Similarly, while a simple newspaper may seem an almost useless weapon to American eyes, to an English “football hooligan” it may be carried to a game with main intent of being folded into a “millwell brick”: a surprisingly effective blunt force weapon. Again, the emphasis has to be placed on culture in order to understand these different behaviors. For Sutherland it is through the process of association with individuals and groups that understanding is shared, culture is created, and behaviors are exhibited.

Akers' Social Learning Theory (1998) is an updated conception of Differential Association (Sutherland 1947). Akers likewise recognized the importance of groups to the study of behavior and sought to integrate Sutherland's insight with the psychological findings concerning reinforcement of behaviors. For Akers, crime, like any behavior, is learned through interactions with other people. Ultimately, humans learn from those closest to them, their sub-groups, and individuals with whom they have personal interactions. Each time a person exhibits a behavior, that person receives reinforcement of some kind which makes repetition of that behavior more or less likely. This was an important attempt to have ties between the criminological and psychological literature and the resulting theory of crime is, empirically, one of the strongest theories in the criminological literature (Prat et al 2010; Cooper, Walsh, & Ellis 2010).

This view's impact on Cook's Index is that people learn to use firearms socially. Further, suicide as a possibility and the methods by which it may be accomplished are socially learned. Though relatively few people exhibit the behavior, humans learn how other humans die by suicide through social learning in a culture. Importantly, this behavior is not reinforced as suicide ends the possibility of reinforcement which leads back to more general social learning, differential association and cultural evolution. Suicide, and suicide involving firearms, are socially learned behaviors and may differ across the RUC if the social groups have variation in how this behavior is transmitted. If the urban or the rural subcultures have different measured uses of firearms, subcultural theories would contend that different behaviors have been performed and then spread via social learning in the groups.

Ultimately, any of the cultural theories can explain why differences across the RUC might exist. All humans are part of a culture that teaches us how to behave and how to use objects, including firearms. These theories all account for this idea and, if there is a demonstrated empirical difference across the Rural-Urban Continuum, all of these theories would argue that it is the cultural differences that drive the difference. The important conclusion is that the assumption that human beings are using firearms in the same manner across the RUC requires an assumption of homogeneity of culture across these very different places, an assumption which is disproven in the research on subcultures, social learning, and differential association.

The Southern Subculture of Violence

Perhaps one of the most well-known literatures in Criminology is the Southern Subculture of Violence literature. At the core of this theory is the agreed upon fact that there are differences in violence across Southern and non-Southern groups. The argument from the literature is that these differences are attributable to cultural differences. This literature is explored in depth because it is only as a whole that the relevant findings of this literature become clear. This literature shows the importance of establishing and measuring hypothesized differences even when there is not unanimous agreement among the researchers theoretically. Further, there are specific references to the Rural-Urban Continuum and crime which are relevant for this inquiry into Cook's Index.

The Southern Subculture of Violence (SSV) argues that the Southern area of the United States is culturally distinct from the rest of the United States and as a result its members are more violent than the US population in other regions. The origin of this subculture is argued to stem from the herding culture of the Scots-Irish (Fisher 1989; Lee and Ousey 2011) who came in large

numbers to live in the frontier regions of the South. Formal law enforcement was often unavailable (Cohen 1996; Cohen, Bowdle, Nisbett, Schwarz 1996) and so self-regulation through a culture of honor (Nisbett & Cohen 1996) that sanctioned comparatively more violence (but not pointless violence) evolved. This is argued to have mixed with Protestantism, particularly evangelical and fundamentalist Protestantism (Ellison, Burr, McCall 2003) and the result is a subculture in the US of surprising strength and longevity that is said to account for higher southern rates of violence.

Over a half a century of research and debate has not resolved the question of whether the cultural explanation for violence is compelling. Generally speaking, the models that successfully find an effect have low overall explanatory power with R square values (or equivalents) are, as a rule, under 20%. While the numbers shift somewhat depending on the methodological choices of the researchers, the SSV tends to leave most of the variance in violence unexplained. Lee & Ousey (2011), despite arguing for a new conception of the SSV, note that "empirical evidence backing the cultural argument is not particularly compelling" (pg 900). The relatively weak support for the SSV was shown more quantitatively by Anderson (1996) via a destructive testing methodology, where various competing explanatory variables were added to see if the significance of "southern" in the model could be broken. Anderson (1996) notes that the "effect was broken relatively soon in the destructive testing process. Indeed, because it was broken so soon, there was no need to further stress it by degrading [it] into its component parts" (pg 750).

Much of the perceived weakness in the SSV research can be attributed to the lack of standardization. Researchers cannot directly compare many of the studies to each other because the research questions and operationalizations of variables are so different in each study. While

many use the Census definition of “southern”, some argue that “former confederate states” ought to be used (Hackney 1969), others use some sort of index of southernness (Gastil 1971) which can vary significantly between studies (Ellison,Burr, McCall, 2003). A particularly odd definition of Southern in the literature used French vs English ancestry in Louisiana to measure Southern and non-Southern (Bankston, Thompson, Jenkins, Forsyth 1990). Other studies have used voting history (Anderson & Anderson 1996), state population originally from southern areas (Corzine & Huff-Corzine 1989) or some measure of time spent in the south (Cohen, Bowdle, Nisbett, Schwarz 1996). With such disparate measures of the key variable it is unsurprising that the literature is difficult to evaluate.

Furthermore, the research questions that utilize the notably unstandardized definition of 'southern' vary wildly. Some look at the entire country, trying to find an effect using some measure of every city's residents originally from southern regions (Lee, Bankston, Hayes & Thomas 2007; Blau & Reid 1986) while others contrast the South with the rest of the country (Messner 1983a) and still others consider the South and West together and contrast that with the rest of the United States (Copes, Kovandzic, Miller, Williamson 2009). Such a wide range of conceptions and research questions make it difficult to settle the matter convincingly.

Despite an admitted lack of ringing success, this literature cannot be dismissed entirely since it contains some important findings. Studies that account for competing structural explanations of crime have found that structural variables like poverty model in markedly different ways in the South and non-South (Messner 1983b; Parker & Pruitt 2000; Lee, Hayes, & Thomas 2008). The finding that, inside a national culture, a subcultural difference could be associated with such a fundamental change is a strong argument for the importance of culture.

Some less well-known currents in this literature concern the importance of rurality and size of urban areas. Some conceptions of the SSV argue that the Southern culture is being erased in cities and the effect will only be found in rural areas; others simply argue it will be stronger in rural areas. These studies can find a significant effect, but while Southern rural whites have a slightly higher homicide rate than Northern rural whites (Lee, Hayes, & Thomas 2008), an important finding not emphasized, and slightly obscured due to sample selection, is that *both* Northern and Southern rural homicide rates are much smaller than the rates in urban areas (Wells & Weisheit 2004). Other research seems to indicate that not all cities are created equal. Blau & Golden (1986) in their investigations into the SSV found that in the 125 largest US cities, one of the strongest predictors of violent crime was city size: the larger the city, the higher the violence rate found, net of other structural and cultural factors. Further, the importance of "rurality" is sometimes implied by the importance given to the “frontier", a place more removed from law enforcement and thus engendering its own cultural idiosyncrasies (Cohen 1996; D'Antonio-Del Rio, Doucet,Chauvin 2010). These findings are generally peripheral in the SSV literature but have important logical extensions which show that variation in culture across rural and urban spaces is a fruitful area of study.

Summary

The view that objects are used in the context of culture necessarily allows for different cultures to use identical objects in very different ways. This conception of how objects, such as firearms, are used in behavior has explicit ties to Social Learning Theory, one of the strongest macro theories in criminology (Pratt et al 2010) as well as the related theory of Differential Association. Sutherland's conception of Differential Association emphasizes the importance of

subculture, rather than the overarching culture, in learning how to behave. Together this ties to one of the most well- known literatures in criminology: the literature investigating the Southern Subculture of Violence. This literature contains more evidence for differences along the RUC and a case in point for the importance of establishing a hypothesized difference empirically.

Examining the cultural argument together with the Southern Subculture of Violence literature leads to a consideration of the possible cultural differences related to the Rural-Urban Continuum. Is the national culture of the United States so strong that any subcultural variation still produces the same relationship between firearms and their use? Or does cultural, and subcultural, variation along the Rural-Urban Continuum affect the type, frequency, reason and outcomes of firearm use? Cook's Index answers that this variation has no significant effect. The theoretical grounding presented here indicates that this variation may be introducing error to Cook's Index.

Chapter 4: Data Section

In order to test for differences in Cook's Index across the Rural-Urban Continuum, data were sought from various sources. Generally, there are three main concepts that must be measured: Rural-Urban Continuum, Cook's Index, and Firearm Prevalence. Cook's Index and Firearm Prevalence will be used to test how well Cook's Index functions as a proxy variable. That is, when using Cook's Index as a measure for firearm prevalence, how closely does it track with measured firearm prevalence? Then the third concept to be measured, The Rural-Urban Continuum, can be incorporated into further analyses. These analyses will look at the affect of the RUC on the accuracy of Cook's Index. The types of analyses which are run depend upon the type of data procured to measure these three concepts. An overview of the data used to investigate these questions is found in Table 3. The challenges of each concept and the data available will be investigated for each of these three main concepts.

Independent Variable: Rural-Urban Continuum Data

The Rural-Urban Continuum is a complex phenomenon. The two most widespread county-based measures are from the United States Department of Agriculture (USDA), which are themselves two different organizations of data from the Office of Management and Budget (OMB), and the United States Census Bureau. Both of these sources include multiple categorizations so that researchers can have the leeway to construct coarser categories that are most appropriate for the specific research underway. These data use distinct terminology and speak of "Metropolitan" and "non-Metropolitan" counties rather than "Urban" and "Rural".

Table 3

Data Overview

Rural-Urban Continuum Data		
Rural-Urban Continuum Data, 8 point continuum	USDA	2013
Urban Influence Data, 9 point continuum	USDA	2013
Selected County Level Data *	US Census	2010 & 2016
Cook's Index Data		
Population	CDC	1999-2015
Number of Suicides	CDC	1999-2015
Number of Firearm Involved Suicides	CDC	1999-2015
Type of Firearm Used in Suicide	NYVDRS	2015
Data for Firearm Prevalence (Legitimate Handgun Ownership)		
New York County Licenses Issued Yearly	NYPB	2006-2011
Sum of All Licenses Issued	NYPB	1936-2011
New York City Active Licenses	NYPB	2011
Data taken from: US Department of Agriculture, US Census Fact Finder, Centers For Disease Control WONDER system, New York Violent Death Reporting System, New York State Pistol/Revolver Permit Bureau		
*These data were used in Cluster Analyses. See Appendix 2 for full data description and cluster analyses		

Most measurements of the Rural and Urban continuum are based on the OMB's creation of "Metropolitan Statistical Areas". These start with "Urban Areas" from Census data which hinge on population thresholds and density of population (Geographic Areas Reference Manual 1990, chapter 12). The OMB then calculates various measures of economic ties and commuting patterns to create areas heavily influenced and tied to central cities (OMB Bulletin 15-01). These are then called "Metropolitan Statistical Areas" or "MSA's".

A major concern using the MSA definitions is their tendency to subsume suburban areas into metro areas. The OMB Metropolitan Statistical Areas comprise 85% of the American population (OMB Bulletin 15-01, pg 2), despite only about 30% of the population living in central cities (Hobbs & Stoops 2002). This occurs because the OMB data explicitly takes into consideration economic ties. Consider the most pertinent example in New York State: The city of Rochester. Rochester has a large enough Metropolitan Area that its parent county Monroe is classified alongside New York City as "Large Urban" (metro area with over a million population). This seems reasonable enough. However, its neighboring Ontario County is also classified as Large Urban. Yet Ontario County does not seem to be "urban". If you head down Route 444, you will see farmhouses, silos and cornfields — hardly what most people think of as "Urban". Yet that county, due to its population's commuting and economic ties to Rochester, is in the largest "Urban" classification in the continuums. Intuitively, this is probably more properly classified as a commuting area or what we normally think of as "suburban". In this specific case, it is probably a former rural area becoming a suburban area. The people who live in these areas probably differ importantly from the apartment dwellers in central Rochester, yet the MSA classification scheme sees them as substantively the same.

This is perhaps balanced by areas where this classification scheme works very well. Nassau county, between Suffolk County on Long Island and New York City, shares the same classification as New York City. And while New York City residents can point out how much more like the suburbs Suffolk feels to them, it is in fact comparable to many of the cities across the US in terms of size of streets, density of buildings and traffic, and shopping opportunities. Classifying it as a part of a large city seems reasonable to anyone who has spent time in many areas of the country; it only feels suburban compared to the extreme urban status of New York City.

The data used in this analysis are the two main county-based USDA data sources: Rural-Urban Continuum and Urban Influence. Table 4 shows the classification differences between these categorizations. Both of these data share the cut point of 50,000 population to qualify as a Metropolitan Area. These categorizations differ with respect to Metropolitan Counties only in that the Rural-Urban Continuum data have three classes for Metropolitan areas while the Urban Influence data has two. The more complex differences are in the non-Metropolitan categories. The heart of the differences in these two classifications is the use of "Micropolitan" as a classifier in the Urban Influence data. "Micropolitan" is a grouping that categorizes an urban area of 10,000-50,000 as its own central area. The micropolitan classification may offer an important distinction between areas that are effectively small cities and areas that are simply suburban commuter areas for the large cities. Both raw forms of data are kept and are used to recode the data into larger categories for analysis. How much difference in county classification to the final groups is considered at length. Are these differences important? Or, merely distinctions without a difference?

Table 4

Rural-Urban Continuums from the USDA

	Urban Influence Data		Rural-Urban Continuum Data
1	Large Metro (County is in a metro area with at least 1 million residents)	1	Metro - Counties in metro areas of 1 million population or more
2	Small Metro (County is in a metro area with between 50,000 and 1 Million residents)	2	Metro - Counties in metro areas of 250,000 to 1 million population
		3	Metro - Counties in metro areas of between 50,000 and 250,000 population
3	Micropolitan (10,000-50,000) adjacent to a large metro area	4	Nonmetro - Urban population of between 20,000 and 50,000. Adjacent to a metro area.
4	Noncore adjacent to a large metro area	5	Nonmetro - Urban population of between 20,000 and 50,000. Not adjacent to a metro area.
5	Micropolitan (10,000-50,000) adjacent to a small metro area	6	Nonmetro - Urban population of between 2,500 to 20,000. Adjacent to a metro area.
6	Noncore adjacent to a small metro with town of at least 2,500 residents	7	Nonmetro - Urban population of between 2,500 to 20,000. Not adjacent to a metro area.
7	Noncore adjacent to a small metro and does not contain a town of at least 2,500 residents	8	Nonmetro - Completely rural or less than 2,500 urban population, adjacent to a metro area
8	Micropolitan not adjacent to a metro area		
9	Noncore adjacent to micro area and contains a town of 2,500-19,999 residents		

An important limitation of this data is that it does not address the unique challenges New York City presents. Due to its size, New York City is the largest city in the US, with approximately double the population of the next largest city (Los Angeles). It is also the most densely populated area in the US. Of the top ten most densely populated census tracts in the US, only one tract is not a part of the New York City Metropolitan Area. The population size and density creates a unique organization in the city of New York which results in unique living situations for the residents. Additionally, and more importantly for the purposes of this research, the laws concerning firearms in New York City are even more stringent than they are for New York as a state. Thus, the counties that make up New York City were coded with a unique identifier so they can be placed in their own category when considering the RUC.

Another limitation of this data is that the data is at the county level rather than the census tract level. Census tract level data is available but would prevent integration with other county level data, including the firearms prevalence estimates. As the firearm prevalence data is the most important thing to test and is only available at the county level, the coarser county measurements were chosen as base units for these analyses.

A final limitation to consider is the transient nature of the Rural-Urban Classifications. The data are updated following each census and the OMB's additional analysis. Importantly the 2000 census had significant changes to the definition of "Urban" which wound up affecting the coding of Rural-Urban Continuum data from USDA 3 years later. The 2003 date is the watershed at which the Rural-Urban Continuum codings are no longer directly comparable (USDA 2004). Some categorizations, particularly the ones closer to the rural side of the continuum, are still directly comparable and the rest are still usefully comparable if not directly so.

The change in definitions between Metropolitan and non-Metropolitan merits some special consideration by researchers. The bright line used to be that any county part of an urban area with at least 100,000 population qualified as Metropolitan. Post 2003, any county part of an urban area with over 50,000 population is Metropolitan. In other words, the minimum population to qualify as Metropolitan was halved. This change meant that it is possible that some non-Metropolitan areas in 1993 became Metropolitan areas in 2003 despite minimal change in population. Here it is important to understand what population is being counted for definition determination. If you look at data on county population in from New York Vital Statistics, in 1990 there were twenty-four New York counties between 50,000 and 100,000 population. However, in comparing both USDA Rural-Urban Continuum Classifications, only two counties (Tompkins and Ulster) were actually affected by the change in definition. This is because the population living within the "urban areas" as defined by the Census Bureau change the classification, not the overall county population. Without proper understanding of how things are being defined it would have seemed the coding change would affect almost half of New York counties; in reality it affected approximately 4%.

Additionally, during the definitional changes in the 2000 Census definitions, ten New York counties were affected by a data merge that eliminated a distinction between "fringe large Metropolitan" and "large Metropolitan". Realistically, this had no permanent effect because it was merely a combination of two types of "large Metropolitan" areas. A merge can be performed on any data before 2000 so that it is identical to the current classification scheme. For practical purposes the change is of minimal importance. While Queens county changed classification from "Fringe Large Metropolitan" to "Large Metropolitan", its place on the RUC has not changed substantively. And again, the older code can be easily recoded to be in accord with modern

categorization. The remaining nine counties which underwent some change in classification from 1993 to 2003 were minimally related to coding changes and are better understood as part of the ongoing changes in the RUC.

With no substantive differences in definition over time, the county-level data on the Rural-Urban Continuum from 1983, 1993, 2003, and 2013 can be used to look at changes in the RUC over those 30 years. These ongoing changes are considered in depth in appendix 1. Overall, the counties of New York show a large degree of stability over time. The greater the stability, the more data from the CDC can be used, and the fewer cells will be suppressed. This long view of the RUC is possible because, in New York at least, the coding change had minimal impact.

Categorizing The Rural-Urban Continuum

Normally the literature leaves specific paths to follow for defining categories, but for the RUC this simply does not exist (Weisheit, Falcone, & Wells 2006 pg 201). There has not been enough work done on the RUC to establish definitively where the break points should be. Categorizations using both researcher judgment and statistical analysis are presented here. Multiple categorizations of the Rural-Urban Continuum are created and retained for use in the analyses following four main approaches: Three from researcher interaction with the USDA data and a fourth using statistical analysis.

Distinguishing between the data available from the USDA can be confusing. The 9-category Urban Influence Data and the 8-point Rural-Urban Continuum Code Data share many definitional aspects but also contain important differences (refer back to Table 4 for definitions). The non-Metropolitan counties are where the important distinctions between the data sets are found. The non-urban classifications in these two data sets are not comparable in a simple

manner as the raw categories measure very different aspects of Non-Urban counties. A brief consultation with the crosstabs provided in Table 5 shows how differently the non-urban counties are coded. If the data were left raw, with the maximum specialization, the remaining 28 counties would be divided between 5 or 7 categories. With the County as the base unit of analysis this would shrink the n for some categories lower than would be desired; in one instance a cell would be defined by a single county.

Researcher Categorizations

The data from the USDA include population data, whether the county was part of Metropolitan Area, and whether the county was adjacent to a Metropolitan area (Urban area with more than 50,000 residents). This yields two main approaches: Adjacency based and Population Based. In the Adjacency based approach, a "suburb" is defined as any county that is adjacent to a Metropolitan area with remaining counties being classified as "rural". In the Population Based approach "rural" are counties with fewer than 20,000 population and "suburb" contains all the non-Metropolitan counties with populations larger than 20,000. One additional piece of data allows distinction of "Megasuburbs" (Adjacent to a Metropolitan area that contains one million residents) which is considered a subcategorization of the Adjacency approach.

A third approach can be found using the USDA defined category "Micropolitan". Any county is "micropolitan" if there is a center that is between 10,000 and 50,000 residents. These are too small to qualify as "Metropolitan" but are large enough to consider whether they are the primary "center" around which the county is organized. This approach categorizes the remaining non-Metropolitan, non-Micropolitan counties as "suburb". Originally one county (Allegany county) was classified as "rural". Because categories defined by a single member preclude most

Table 5

Number of New York non-Metropolitan Counties in Each Rural-Urban Classification Method

	RUC 4	RUC 5	RUC 6	RUC 7	RUC 8
Urban Influence 3	4		2		
Urban Influence 4	1		1		
Urban Influence 5	5				
Urban Influence 6			5		
Urban Influence 7			1		1
Urban Influence 8		1		2	
Urban Influence 9				1	

Data From USDA Urban Influence and Rural-Urban Continuum

statistical analyses, this one county was then included into the remaining category of "suburb" as they were also adjacent to a Metropolitan area. At the same time, the category of Micropolitan profoundly changes the make-up of the categories and so is considered its own approach rather than a subdivision of the Adjacent approach.

Inside each of these approaches there are multiple categorizations possible depending on the number of categories into which the Metropolitan category is subdivided. Four classifications are possible: One which lumps all Metropolitan counties (central population greater than 50,000) together as the same dubbed "Metropolitan". A second separates metro areas that total more than 1 million population ("Megalopolis") from the remaining Metropolitan counties (labeled "Small Urban"). A third approach adds another distinction by putting New York City in its own category while retaining the previous two categories. Finally, in the fourth categorization, an additional line is added to create four categories out of the "urban" category: cities between 50,000 and 249,999 residents ("Small Cities"), cities with between a quarter of a million residents up to a million ("Cities"), cities with more than one million residents ("Megalopolis"), and finally retaining New York City as its own category. These variations can be applied to all three approaches yielding thirteen categorizations over the three approaches as seen in Table 6.

These approaches are very stable over time, few counties change categories, but the approaches disagree with each other over the proper categorization of each county. Each of the approaches was examined for change over time (see appendix 1). Of the 62 New York Counties, between 9 (14%) and 14 (22%) counties change categorization depending on the organizational approach. This is fairly strong evidence that the Rural-Urban Continuum is largely stable over the time period that CDC data for suicide with firearms exists (1999-2015). At the same time, there is not a single non-Metropolitan county that all the categorizations agree has stayed

unchanged that they also agree on the proper category for that county. The disagreement on such a fundamental level is strong evidence that each of these categorizations should be utilized in the analyses.

The size of each category varies over the approaches, which will affect statistical analyses. In general, the more categories an approach has, the fewer counties in each category. Cell count continues to be a challenge even with some larger categories (such as Adjacency based categorizations) which leave a very small Rural despite only dividing between Suburban and Rural. Performing analyses with each approach can show differences between the categories and will help future researchers choose their own categorizations. Running the analyses with multiple approaches is the best way to see if one of the raw categories is having a disproportionate influence. If whichever category has raw category 5 in it is always significantly different, then it may be that category 5 ought be considered on its own terms.

The logic behind each of these categories is strong, and ultimately all the categorizations stemming from the approaches must be tested on the Dependent Variables. The simple logic of Population size must be pursued if for no other reason than much of the existing literature uses population as a category. Adjacency likewise must be tested as the ability to commute to a nearby city center is foundational to the intuitive (and very rarely defined) "Suburb". Finally, the Micropolitan, which offers an entirely different way of categorizing the non-urban and may be an important transitory stage as counties gain or lose Urban status, is far too interesting to dismiss. The analyses themselves will also tell us about the categorization of the Rural-Urban Continuum.

Table 6
Rural-Urban Researcher Classifications and Number of Counties in Each Classification
USDA Data, Urban Influence and Rural-Urban Continuum

Population	*Categories defined solely by population*					
Base	Rural 13	Suburb 11	Metropolitan 38			
2 Urban	Rural 13	Suburb 11	Small Urban 18		Megalopolis 20	
3 Urban	Rural 13	Suburb 11	Small Urban 18		Megalopolis 15	NYC 5
4 Urban	Rural 13	Suburb 11	Small City 6	City 12	Megalopolis 15	NYC 5
Adjacency	*Counties adjacent to Urban Areas are Suburban*					
Base	Rural 4	Suburb 20	Metropolitan 38			
2 Urban	Rural 4	Suburb 20	Small Urban 18		Megalopolis 20	
3 Urban	Rural 4	Suburb 20	Small Urban 18		Megalopolis 15	NYC 5
4 Urban	Rural 4	Suburb 20	Small City 6	City 12	Megalopolis 15	NYC 5
Mega Suburb	Rural 4	Suburb 12	MegaSuburb 8	Small Urban 18	Megalopolis 15	NYC 5
Micropolitan	*Micropolitan category explored*					
Base	Combined Suburb 10	Micropolitan 14	Metropolitan 38			
2 Urban	Combined Suburb 10	Micropolitan 14	Small Urban 18		Megalopolis 20	
3 Urban	Combined Suburb 10	Micropolitan 14	Small Urban 18		Megalopolis 15	NYC 5
4 Urban	Combined Suburb 10	Micropolitan 14	Small City 6	City 12	Megalopolis 15	NYC 5

Statistically Determined Categories

The following categorizations are statistically created with minimal researcher input. These categorizations serve as an important check to the preceding categorizations which are based on researcher interaction with the data. Two types of Cluster analyses were run to determine RUC categories: K-means and Hierarchical. These analyses relied on county level descriptive data taken from the US Census. Complete data used and explication of the cluster analyses are available in appendix 2.

First, I ran the hierarchical cluster analysis as an exploratory technique. After running this analysis with two methods of linkage, I decided that the eight group solution using complete linkage was the most informative. This solution was then manually condensed into a five group solution which maintained the insights of the eight group solution while minimizing the effect of the outlying counties and ensuring there were no single-county "clusters" in the final product.

Second, I ran a K-means cluster analysis. In accord with Everett and Hothorn (2009), I used analysis of the within groups sum of squares plotted against the number of clusters to make decisions on how many clusters to run in a K-means cluster analysis. The three group K-means cluster solution was retained. I also ran a supplementary K-means cluster analysis without the New York City counties, in this analysis the groups established in the first three group K-means cluster analysis were confirmed, indicating this is a robust solution. Full analyses and figures for both the hierarchical cluster analyses and the K-means Analyses are available in appendix 2.

These two methods offer two distinct mathematical takes on categorization of the RUC into categories. For the Hierarchical clustering, a bottom to top method of sorting counties is used. In this method, counties that are most similar to each other are joined into a cluster at each

step and the algorithm then repeats. Especially when utilizing complete linkage, which makes joins based on the most extreme values in a cluster, extreme scoring counties are preserved. The K-means clustering in contrast is a top down organization where central points are identified that minimize distance of each cluster from all its members. Together these contrasting approaches may offer complementary insights in how the RUC ought be categorized.

Summary

Data on the Rural-Urban Continuum were taken from the USDA. Further data on county attributes were taken from the US Census. I used these county level data to create categorizations of the RUC in New York using four approaches: Population, Adjacency, Micropolitan, and Cluster Analyses. For the first three approaches, multiple categorizations exist depending on how the metropolitan counties are defined inside each approach. For the final approach, two categorizations are used using two different Cluster methodologies. This resulted in a total of fifteen categorizations of the RUC which are available for subsequent analyses.

Dependent Variable: Cook's Index Data

Cook’s Index requires both knowledge of suicides (S) and the firearm suicides (FS), the ratio of these (FS/S) is Cook's Index. Azrael, Cook, and Miller (2004) also refer to this as simply "The percentage of suicides committed with a firearm" (pg 44). Generally, both FS and S are publically available through the Centers for Disease Control and Prevention Wide-ranging Online Data for Epidemiologic Research (CDC WONDER) system. Built into this system are safeguards for the anonymity of individuals represented in the data. For data concerning the deaths from 1999-2015 (or any subset of years), any time fewer than ten individuals are represented in a cell, that cell is suppressed.

These safeguards offer significant restrictions to suicide research at the county level. Even spanning sixteen years of data, a query for all suicides by gender and county, resulted in six suppressed cells, all of which were cells with only female suicide data. An additional seventeen cells were flagged as "unreliable" rates estimates due to small n in calculating the statistic. Attempting to break this down by method of suicide, would result in even more suppressed and more unreliable cells. Fortunately, the data are being aggregated up beyond just the county level, counties will be grouped into RUC categories, which will increase the reliability of some estimates. Regardless, attempting running-averages would result in many more suppressed cell values. In addition to the data being missing, it is missing in a way that is biased against small populations, which means that rural areas are the most likely areas to be suppressed. Attempting to look at suicide by method and gender is simply not possible given the available data. As a result, simple FS/S will be used.

Additional and highly specific 2015 data from New York Violent Death Reporting System is used. This is statewide data that includes the use of handguns in suicide, the ratio of handgun to long gun use in suicide, and some information as to when the owner was the decedent. This last category has very high rate of missing data (41%) which will prevent certain conclusions from being drawn, however, the general question of whether legitimate handgun ownership correlates with handgun suicide will be able to be tested.

Dependent Variable: Firearm Prevalence Data

Firearm Prevalence is the single most important piece of this research. Without data on firearm prevalence, there is no way to test the validity of Cook's Index. If researchers are to believe that Cook's Index is an adequate stand in for firearm prevalence, it must be tested against cases of known firearm prevalence. The situation in the US in general must be briefly explained

so that the peculiar rules in New York State —which make this research possible—can be understood.

In the US as a whole, licensing and registration of firearms is not the norm. Most citizens over the age of 18 can buy a long gun (rifle or shotgun) without a license of any sort or registration of that firearm. Most citizens over 21 can do the same with a handgun. It is often thought that any US citizen can own a firearm; however, this is not true. There is, in fact, a large list of factors which turn citizens into "prohibited possessors": any outstanding warrant, a felony conviction of any type, a domestic violence misdemeanor conviction, being under a restraining order of a domestic nature, having ever been committed to a mental health facility, having ever been adjudicated mentally defective, having been an unlawful user or addict of any controlled substance, or having been dishonorably discharged from the military (ATF 2016). Even indictment of a felony (even though the accused is presumed innocent) suspends firearm rights (ATF 2016). These are all federal disqualifiers, so citizens who fall into those categories are prohibited possessors in all fifty states. While there is theoretically a means by which prohibited possessors could be adjudicated as no longer being a risk and thus entitled to having their firearms rights reinstated, the ATF's appropriations bills have forbidden this process from occurring since 1992 (ATF 2015). For researchers, the result is largely the same as if any citizen could own firearms; there is almost no geographically-tied data for firearm prevalence in the US generally. However, in this research the additional restrictions at the NY state level enable geographically-tied estimations.

New York is one of the states which has applied more stringent controls on firearms, including county based registration of pistol owners. In New York, anyone who wishes to own a handgun must be issued a permit from their county government. This permit may have more than

one handgun, but any handgun possession without a license is criminal (by definition) in NY (New York Penal Law § 400). The County Clerks of New York reached a consensus, after legal consultation, that raw number of permits issued would be permissible for researchers to examine (personal correspondence 2015). Data was sought from the New York Pistol Permit Bureau, since all County issued licenses are copied to their department. These data contained the total permits issued since 1936 by county and the number of licenses issued in individual years from 2006-2011. Because of the unique and even more stringent laws in New York City, the counties in New York City were given their own category. Thus, instead of each county that makes up New York City providing data, the City of New York has the number of licenses issued city wide for the years 2007-2011 and the number of active licenses in NYC as a whole in 2011.

These data allow county-level estimates but have important shortcomings. First, long guns are not included in this data. In the US as a whole, an estimated 36% of gun owners owned solely long guns (Cook 1997 pg 2). How that translates to NY is unknown because the process of licensing for handguns may be affecting ownership patterns. This makes it important to distinguish between suicides perpetrated with a handgun compared to those perpetrated with a long gun. Fortunately for this research, the wound patterns between handguns and long guns are distinct (DiMao 1999) and the NYVDRS data for 2015 include a breakdown by weapon type (long gun vs handgun).

Another shortcoming of these data are that the Pistol Permit data fail to capture county to county movement of New York residents. A license issued in one county may not be updated if the resident moves counties (with some exceptions such as New York City). There is doubtless statistical noise due to the movement between counties inside the state in these data.

An important limitation to using legally held handguns to test Cook's Index, is that by definition illegally held handguns are not included. The words "legitimately held" or "legally held" handguns signal this. While this is a limitation, the data still tell us some important things. The category of "legal" or "legitimate" firearms is relevant to policy debates as new legislation primarily impacts this group of firearms and firearm owners. Even the most militant firearms advocates do not endorse illegally held firearms. Rather, the contention is that legitimate firearm ownership does not pose a threat. Looking at how legitimately held handguns are associated with handgun use in suicide is a relevant piece of data for the discussion. Further, Cook's Index is currently used to estimate combined legal and illegal gun ownership. Given that firearms used in crime are not a random subset of the firearms in the US (compare Cook 1997 with Planty & Truman 2013), there is no evidence that illegally and legally held firearms function in suicide the same way. If legally held firearms fail to support Cook's Index, then Cook's Index is dependent on the characteristics of illegally held firearms balancing out the characteristics of legally held firearms, which is a methodological reach. If legally held firearms do not correlate with their use in suicide, then that is an important piece of data in the evaluation of Cook's Index.

A related concern with this Pistol Permit Data concerns the New York State Police. State Police Pistol Licenses are included separate from the counties. Between 1936 and 2011, a total of 944 Pistol Licenses were issued to the New York State Police. However, in the same data, there is no indication of any licenses being issued to the New York State Police between 2006 and 2011. This raises the issue that in this data firearms used by law enforcement may or may not be included. Additionally, there is no standard information about how often police carry their firearms off duty, keep them at home, or keep a firearm post retirement. It is known that many law enforcement officers carry firearms off duty, indeed current and former law enforcement

officers are specifically allowed to carry firearms where most citizens are restricted (Law Enforcement Officers Safety Act, 18 U.S. Code § 926C). And this law has been updated many times to further clarify that most law enforcement officers enjoy this privilege. This seems to indicate that there is significant political force behind this and desire on the part of former and current law enforcement to continue legitimately holding firearms. Regardless, it is not obvious from the data whether law enforcement get their own permit through the county or if there is some other method. Or, once their tenure expires, if they are expected to get their own Pistol Permit from their county. So law enforcement firearms are ambiguously represented in this data.

A final major limitation of this data concerns handgun owners over time. Over time owners die or divest themselves of handguns but the permit still exists in this data set. Especially for the summed permits from 1936, several of those permitted individuals have died or moved away from the State entirely. When working with a short data series (such as the 2006-2011 data) the error from this should be minimal. However, the existence of this confounder prevents any estimate of pistol permit per capita using the cumulative data that spans from 1936-2011. Any work with that dataset would unavoidably encounter licensees passing away and dealing with multiple generations of firearm owners. Some sort of factor would have to be added to attempt to model this but there are too many confounding factors to have any confidence in such factor. How have law enforcement requirements changed? How has each change affected licensees? The NY SAFE act, by requiring licenses to be renewed every few years, is likely to have an effect on licensees. How many will keep it up? Will it reduce the number of casual handgun owners? Researchers can guess, but based on very little concrete data. Each change in law over those 75 years may likewise have had an effect on ownership. Beyond that, how has the culture of gunowners changed in that time? Much was written about a change in handgun

ownership over the last 40 years the but the vast majority of the observations were anecdotal with very little actual data. Professor Yamene's research (2017), blog, and forthcoming book undertake a study of what he deems a current shift in the hobby of gun ownership and use (dubbed "Gun Culture 2.0"). Have these shifts had an impact on New York handgun owners? Their makeup? Their ability to draw new members? The number of relevant factors is large and a simple factor to model the change is unlikely to be accurate. This limits most of the analyses to the 2006-2011 data.

Pistol Permit Count Data into Rates

The Pistol Permit data in its raw state cannot be used to validate Cook's Index. Cook's Index (FS/S) is linearly transformed to predict the percentage of firearm owning households while the Pistol Permit data is count data. In order to transform the Pistol Permit Data to a relative measure of firearm prevalence data on the population for each year in question must be used.

The CDC WONDER system provides an estimate of population over the time period requested. Personal correspondence with the CDC confirmed this is a simple summation of the population estimate for each year as most public health research looks for rates for a demographic per year. Individualized queries were made in order to get each year's population estimate separately. The CDC has extensive documentation of their population estimation practices, particularly as relates to age specific populations.

Two methods of calculating a rate involving pistol permits were performed: averaging the permit/year ratio for each year and using the sum of permits over the average population: for the first method: average (each year's permits/each year's population *100,000); for the second: Sum

of Pistol Permits/average population * 100,000. As this type of Dependent Variable is not previously established in the literature, the two most methodologically sound means of estimating a permit rate in New York will both be presented. Any difference in outcome between these Dependent Variables will be noted.

In general, these two measures of pistol permits will both be used for subsequent analyses. There exists no coherent methodology to combine the two measures of legitimate pistol ownership. Any differences in the final analyses between these Dependent Variables will be explored at length.

Dependent Variables Combined Into Ratio: Cook's Index to Pistol Permit Rate

In order to actually test Cook's Index and the Pistol Permit Data across levels of the Rural-Urban Continuum, a ratio is employed as the Dependent Variable. Two versions of this Dependent Variable are calculated with each of the calculated pistol permit rates. So while Cook's Index does not change between these Dependent Variables, the method used to calculate the permit rate (denominator) does. The first Dependent Variable is defined as

$$\frac{\text{(Firearm Suicides/Suicides)}}{\text{(Each year's permits/Each year's population *100,000)}}$$

The second is defined as

$$\frac{\text{(Firearm Suicides/Suicides)}}{\text{(Sum of pistol permits/Average population * 100,000)}}$$

In both cases, Cook's Index will be the numerator and the calculated permit rate per capita will be the denominator.

To compare these two ratios, the meaning of a larger value must be made clear. A larger value occurs when a higher percentage of firearm suicides exist for a given rate of permits. Or, a larger value occurs when for a given percentage of firearm suicides, a lower rate of permits exists. Either of those explanations is mathematically true. For the purposes of interpreting this dissertation, the general way to think of it is that groups that have a higher value of this ratio are areas with a higher rate of firearm suicide for a given number of permits.

Summary

In order to explore the issues of Cook's Index and the Rural-Urban Continuum, data was needed for three things: The Rural-Urban Continuum, Cook's Index, and Firearm Prevalence. Data for all three concepts at the county level for state of New York was found and is summarized in table 3. Data for the RUC come from the USDA and the US Census and result in categorical level data. There are four approaches to categorizing the RUC, and within those four approaches there are fifteen categorizations. Data for Cook's Index are exactly the data required by Cook and result in a ratio level data with values between 0 and 1. Finally, Firearm Prevalence is measured through a ratio of handgun licenses and each county's population. This measure was calculated in two slightly different ways and both will be used in the analysis.

Chapter 5: Methodology

The following hypotheses are tested using Cross-sectional data. The Cross-sectional methodology is appropriate for two main reasons. First, Cook's Index only claims cross-sectional validity. Second, the data available do not allow longitudinal analyses due to issues with both suppression and overall sample size.

While Cook and his co-authors note that while they believe that Cook's Index is a valid measure of firearm prevalence in an area, they caution that there has not been enough study of how Cook's Index varies over time and thus how well it can be used for longitudinal analyses (Azrael, Cook and Miller 2004; pg 44). In cases where the percentage of suicide rate involving a firearm changes year to year, Cook's Index does not establish the magnitude of change required to infer a change in firearm owning habits in the population compared to other possible explanations. Therefore, a longitudinal methodology would be a novel application of Cook's Index without any established validity of it as a proxy for firearm availability changes over time.

Second, as elaborated in the data section, the data used to calculate Cook's Index require minimum counts to keep cells with few events from being suppressed. Cell suppression is a particular concern for rural areas, which have smaller populations and fewer events. As this research is specifically concerned with differences between rural and urban areas, methods that result in cell suppression are precluded. Additionally, this research's validation variable restricts the inquiry to the State of New York which only contains 62 counties about half of which are considered Urban or Metropolitan.

Hypotheses

Hypothesis 1: Cook’s Index will moderately correlate with legitimate handgun ownership

Hypothesis 2: The rural counties will have higher firearm prevalence but less firearm use in suicide.

Hypothesis 3: The relationship between Cook's Index and legitimate handgun ownership will be different across categories of the urban and rural.

Hypothesis 4: The majority of firearm suicides will have legitimate access to firearms.

Hypothesis 5: Long guns will be majority choice for suicide.

H1: Cook's Index and Legitimate Handgun Prevalence

This is the foundational hypothesis and is the first validation test of Cook's Index that does not rely on survey data. The Independent Variable here is Cook's Index, calculated as (Firearm Suicide / Suicide or FS/S). This will be linearly transformed using the equation found in Azrael, Cook and Miller (2004; fig 2) to predict individually owned handgun prevalence. The Dependent Variable is the calculated New York State Pistol Permit Rate. Both variants of this pistol permit rate will be used and any differences noted

Additionally, the range of values for predicted number of permits will be examined. Especially close comparison will be made in New York City where there is a known population of legitimate firearms for 2011. The specific data for Cook's Index in 2011 in New York City will be compared with this specific data for active pistol permits in New York City. This, even more than the preceding set of correlations offers a test of the validity of Cook's Index that has not been matched in the existing literature.

H2: Rural Firearm Prevalence and Suicide

This analysis uses counties as the unit of analysis and correlations for four separate variables: population (as a proxy measure for rurality/urbanity), pistol permit count data, pistol permit rate (as a relative prevalence measure), and Cook's Index. A premise of Cook's Index is that this percentage of suicides involving firearms is linearly related to firearm availability, regardless of characteristics of the area. By pulling each measure apart and comparing each correlation separately it is possible to see for lower population counties how firearm prevalence and Cook's Index relate to each other, and if the premise of Cook's Index is supported.

The pistol permit rate is correlated against the population and a negative correlation here would indicate a higher relative rate of legitimate ownership in lower population (rural) areas. As a contrast to this, the raw permits issued will also be correlated against population. A positive correlation would mean that as population increases so do the number of pistol permits. If there is a juxtaposition between these two correlations, that would be an indication that despite a general trend of more licenses wherever there are more people, that rural areas have higher ownership rates. This would be a confirmation of something that has been claimed by many studies in the literature although with limited data. Finally, Cook's Index will be correlated with the population measure. Here, a positive correlation would indicate that urban areas have a greater percentage of firearm suicides than rural areas.

H3: Testing Firearm Prevalence Across RUC

This set of analyses is the central focus of this dissertation. These analyses tie together the two main research questions from the literature review: The validity of Cook's Index as a proxy for firearm availability, and the Rural-Urban Continuum's influence on use of firearms in suicide. The classifications outlined in the data section and appendix 2 attempt to capture the

relevant differences across the RUC into usable categories. The data provided for the RUC are designed to allow researchers to make appropriate categorizations rather than function as a true point estimate on a continuum. Even in the most varied form, the data are essentially an eight or nine category division of the RUC. It is finely graded categorical data but it is inescapably categorical level data. The analyses here test whether Cook's Index functions the same across the categories of the Rural Urban Continuum, as is the current premise of Cook's Index.

The Independent Variable in these analyses is the Rural-Urban Continuum. Each New York county has been put into a RUC category following four main approaches: Population, Adjacency, Micropolitan, and Cluster. These approaches are very different ways of conceiving what distinguishes the non-Metropolitan counties (Rural and Suburban). Inside each of these approaches there are also multiple possible categorizations based on how the Metropolitan (Urban) counties are categorized. All together there are 15 possible categorizations, each of which has from three to six categories, and each of which must be tested looking for differences across the Rural-Urban Continuum with respect to Cook's Index.

The Dependent Variable is the ratio of Cook's Index to the Pistol Permit Rate. This is calculated in two different ways, as described in the data section. If Cook's Index is valid, the ratio will be close to one in both cases. In order to compare a ratio level Dependent Variable across a Categorical level Independent Variable with more than two categories, Analysis of Variance (ANOVA) with follow up analyses is the appropriate statistical test.

The null hypothesis of ANOVA is that there is no statistically significant variation of the Dependent Variable across the categories of the Independent Variable. In this case, because the Dependent Variable is the ratio of Cook's Index (FS/S) to the Pistol Permit Rate, the ANOVA

null hypothesis is that Cook's Index has the same ratio to firearm prevalence across each category of the RUC. Without significant evidence to the contrary Cook's Index is assumed to be valid, and any seeming variation simply statistical noise. If the null is retained, all the groups are assumed to be equivalent.

There are a large number of possible categorizations of the RUC, and a separate ANOVA must be calculated for each set of categorizations. Each of these ANOVAs must be run a second time using the alternatively calculated Pistol Permit Rate. In this case a total of twenty-eight ANOVAs will be run. In the event that the null is rejected, follow up tests are utilized to which groups are significantly different, in what direction. A significant ANOVA test merely indicates that at least one of the cell means differs significantly from at least one of the other categories, it is only through follow up analyses that number and direction of significant differences can be found.

The choice of follow up tests in these analyses is a bit complex. The standard tests assume equal number of cases between cells. Because ANOVA is commonly used in research where subjects are assigned to conditions, the assumption is easily met. In this case, as RUC is a measured attribute the counties cannot be assigned to a Rural or Urban condition and the assumption of equal n is not met. There are two main post hoc tests that do not assume equal n: Tukey-Kramer's Honestly Significant Difference often abbreviated to HSD (Salkind 2007) and Dunnett's Modified Tukey-Kramer HSD (Dunnet 1980). Tukey Kramer's allows unequal n but continues to assume equal variance in the data as a whole. Dunnett's modification calculates separate variance for each category. Thus while Dunnett's modification is the most conservative, it suffers in that each category has its own variance for testing differences between cells. This actually runs into the difficulty that New York City permits have had to be amortized (as was

mentioned in the data section), which means the variance is artificially modified for New York City by itself.

For each significant ANOVA, three separate follow up tests are calculated. The two previously listed tests (Tukey-Kramer's HSD, Dunnett's Modified Tukey-Kramer's HSD) and a third more sensitive test: Fisher's Least Significant Difference (Salkind 2010). While the other two are more in line with the specifics of this data, the reality is this is a very small data set with 62 observations. This means that it is likely that the analyses here are underpowered and may miss effects that are actually there. For a three group ANOVA with 20 cases in each cell, the chance of finding a moderate effect existent in the population is less than 40% (Cohen 1988). Of the 62 total counties, the non-Metropolitan counties are fewer than the Metropolitan counties, so the groups sizes of "Rural" and "Suburban" are often very small. Therefore, as a contrast to these more conservative tests the Fisher's LSD will be calculated and any differences between these three follow-up tests will be explored.

Additionally, post-hoc power analyses will be calculated for each ANOVA run. These effect sizes are presented in the η^2 squared or r^2 form and are derived by the formula:

$$\eta^2 \text{ or } r^2 = F/(F+\text{degrees of Freedom})$$

Regardless of whether this is presented as r squared or eta squared, the underlying math is the same. The calculated statistic is akin to the proportion of the variance explained by the model. More properly this is a measure of the strength of the model which happens to be on the same scale as the more familiar coefficient of determination R^2 values used in OLS regression, or from squaring a correlation coefficient.

H4 & H5: Suicide, Legitimate Access, and Firearm Type

For the preceding analyses Firearm Suicides included all types of firearms. However, it is not well established that all firearms are used equally in suicidal behavior. In general, long guns are more easily accessible than hand guns from a legal standpoint in all fifty states. New York State's special licensing of handguns but not long guns may exaggerate this tendency towards long guns, if it is indeed a tendency. At the same time, long guns are significantly more powerful and destructive than handguns (with some exceptions). So use of long guns may be driven by the decedent's choice of perceived efficacy rather than convenience.

There is not enough information about relative types of firearm used in suicide to compare New York data to the general makeup. This data will be establishing a baseline where one is sorely lacking. Rather than statistical tests exploration of data from the NYVDRS about firearm types will presented in tables. This data allows examination of type of firearm, even distinguishing between types of long gun. And, importantly also has some information about legitimate access to the firearms that were used. It is not exhaustive but it instructive, or at least, a beginning. The missing data ultimately precludes strong confirmation or rejection of hypotheses concerning legitimate access.

Chapter 6: Analyses

H1: Cook's Index and Legitimate Handgun Prevalence

In order to test the utility of Cook's Index, the first analysis I performed was a linear transformation from the measured Firearm Suicide/Suicide into Percent of the Population who own a handgun using the equation found in Azrael, Cook and Miller (2004; fig 2). This led to a predicted handgun ownership percentage for each county of New York. Using their model (0.554 * Cook's Index - 0.18 = % of population owning a handgun) to predict individual handgun ownership based off of FS/S (pg 51) . The most striking aspect of the resulting data is that it predicts impossible values for several counties: Westchester, Rockland, Schenectady, Nassau, Albany and Suffolk in addition to the counties that make up New York City. For each of these counties the equation predicted an ownership percentage below zero, varying from -0.00303 (Suffolk) to -0.12823 (New York County). The 2011 population of these counties totaled approximately 66% of New York State's total population. This indicates that the current prediction equation for Cook's Index is wholly inadequate to predict the handgun ownership status for the majority of New York's Population.

Next, the predicted ownership percentage from Cook's Index was correlated against the Pistol Permit rate. Both methods of calculating this rate were used (average of each year's permits/population * 100,000; sum of permits/average population * 100,000) and both returned substantially similar correlations ($r = 0.70328$ and $r = 0.70349$ respectively) both with a calculated p-value of $p < 0.0001$. This is an indication that the methods of calculating the ratio between Cook's Index and the Pistol Permit Data are effectively equivalent. This strength of

correlation is a confirmation of the hypothesis that Cook's Index moderately correlates with pistol permit rates in New York.

Finally, for this hypothesis, the active pistol permits in New York City are compared with Cook's Index. This is an unrivaled test of validity for Cook's Index to predict nearly all legitimately held firearms in New York City. In attempting to test the validity of Cook's Index some of the best available data involves New York City specifically. Using the data of the total number of *current* legitimately owned pistols and close to complete data about suicide and firearms suicide allows the best test of the predictions of Cook's Index seen in the literature.

New York City offers the only data on active Pistol Permits as well as permits issued between 2007-2011. This is the only empirical ratio of active licenses with the number of issued licenses over a time span. Between 2007-2011 New York City issued 11,360 licenses, an average of 2,272 licenses a year, while in the year 2011 New York City had 20,829 active licenses. New York City has long required renewal of handgun licenses so this is not a list that is comparable to the other counties of New York. Combined with the 2011 population of New York (8,244,910), I find that 0.25% of the population of New York legally holds a handgun.

I attempted to calculate Cook's Index for New York City for the year of 2011 and unfortunately the incomplete data forces a range of values rather than a single value. Staten Island has few enough suicides with firearms that the data is suppressed and the rest of the rates are flagged as "unreliable" by the CDC. Summing the remaining boroughs gives enough that they would no longer be flagged as "unreliable" and yields 56 gun suicides over a population of 7,774,443 which is a ratio of 0.720 gun suicides per 100,000 people. Since the suppressed value could be anything from 0-9, the total gun suicides for New York City could range from 56-65

gun suicides, together with a population of 8,244,910 for all 5 boroughs yields a range of 0.679 gun suicides per 100,000 to 0.788 gun suicides per 100,000.

The following procedure takes the data in the preceding paragraph and applies it to yield the only ratio of Cook's Index to legitimate handgun ownership found in the literature. Though the data is "close to perfect", even in this case it is slightly incomplete, which forces a calculation of range rather than a point. The sum total of all suicides in all of New York City (except Staten Island) in 2011 yields a Firearm Suicide/ Suicide (FS/S) of 56/473 which equals 0.118 and this correlates to 20,829 legitimately held handguns. However, some of those firearms are in Staten Island. Adding the general suicides in State Island and the 0-9 firearm suicides which were suppressed, gives us a range of 0.113 (56/497) to 0.130 (65/497), correlating with the 20,829 legitimately held handguns in New York City. This is still the most precise ratio of Cook's Index to legally held firearms in the literature. Meanwhile the predicted percentage of New York City Residents (calculated with Cook's Index) is between -10% and -11% of New York City residents. This is obviously an impossibility. The authors note that while the model appears to be linear, it must in fact be curvilinear as only between 0 and 100% of a population can own handguns. An inadequately specified model may account for some of this discrepancy but, unfortunately, they did not present the "real" model because the linear model was so satisfactory in their view. This test of validity shows that Cook's Index does not function usefully, let alone adequately, for New York City. There is no explanation for this discrepancy that can withstand scrutiny. While New York City is certainly a unique situation with respect to firearms the residents are included in national samples, and Cook's Index is shown here to be inadequate for these almost nine million US citizens.

Taken together the data testing Hypothesis 1 shows some conflicting findings. First, it does show that, over New York State as a whole, there is a moderate correlation between Cook's Index and Pistol Permit Rates. It also shows that the different methods of calculating the Pistol Permit Rate are substantively the same, they show no difference in the correlation until past the ten-thousandth place. However, the analyses also show that Cook's Index predicts nonsensical values for approximately two-thirds of the State of New York which comprises approximately 13 million individuals.

H2: Rural Firearm Prevalence and Suicide

In order to test the second hypothesis a data set was assembled using the following variables: Cook's Index 1999-2015, Pistol Permit Total 2007-2011, Pistol Permit Total 1936-2011, Pistol Permit Rate Each Year Averaged (Rate 1), Pistol Permit Sum Over Average Population (Rate 2), and Population 2011. A correlation was run on this matrix along with p-values for each correlation using Holm's method of adjustment to compensate for the multiple comparisons, any missing data were dealt with via listwise deletion. The entire matrix can be found on table 7.

Several of these correlations are noteworthy. First, this matrix further establishes the two methods of calculating permit rate as virtually identical ($r = 1$, $p<.01$). Second, the Summed Pistol Permits are highly correlated with each other at the county level across time ($r = 0.91$, $p<.01$) indicating that the top counties for issuing permits in the early 1900s are still the top issuing counties in 2011.

Table 7.

Correlation Matrix For Hypothesis 2

All correlations Significant at $p < .05$

	Pistol Permit Rate 1	Pistol Permit Rate 2	Cook's Index	Pistol Permits 2007-2011	Pistol Permits 1936-2011	Population 2011
Pistol Permit Rate 1	-					
Pistol Permit Rate 2	1	-				
Cook's Index	0.7	0.7	-			
Pistol Permits 2007-2011	-0.32	-0.32	-0.53	-		
Pistol Permits 1936-2011	-0.43	-0.43	-0.68	0.91	-	
Population 2011	-0.54	-0.54	-0.76	0.61	0.93	-

Data from CDC WONDER and NY Pistol/Revolver Permit Bureau

Directly pertinent to the second hypothesis, there is a significant negative correlation between the pistol permit rate and the population ($r = -0.54$, $p<.01$). This indicates that there is moderate strength relationship showing a higher relative rate of legitimate handgun ownership in lower population counties. So, when using population as a rude measure of rurality, this is evidence that rural areas do have a higher rate of handgun ownership. This is then contrasted with a significant positive relationship between population and raw numbers of permits issued: $r = 0.61$, $p<.01$ and $r = .93$, $p<.01$ for recent permits (2007-2011) and long running (1936-2011) permits respectively. This indicates that while there is a general trend with more permits in higher population counties, once rates are included it becomes obvious that it is actually smaller population counties that have higher firearm prevalence. In other words, this is moderately strong evidence that rural areas have higher relative rates of legitimate firearm ownership contrasted to urban areas.

Finally for this hypothesis, Cook's Index is negatively correlated with Population ($r = -0.76$, $p <.01$), indicating that there is a higher proportion of firearm suicides in more rural areas. This is contrary to the prediction of the hypothesis. Further, while Cook's Index is negatively correlated with total numbers of pistol permits it is positively correlated with permit rates.

The findings in testing this hypothesis seem largely in favor of Cook's Index. It seems that the long held view that rural areas have more legitimate firearm ownership than urban areas is supported. It also seems that Cook's Index tracks with the relative rate of pistol license issuance with a moderate strength.

H3: Testing Firearm Prevalence Across RUC

These are the main analyses and main focus of this dissertation. Does Cook's Index correspond with legitimate firearm ownership across categories of the Rural-Urban Continuum? Between the two Dependent Variables (Permit Rate: Cook's Index, see the data section) and the four approaches to categorization, I ran a total of 30 ANOVA models to initially test this hypothesis. Then, in order to ensure that the counties that compose New York City were not having a disproportionate influence, an additional 20 ANOVA models were performed after removing all New York City counties and using the same researcher approaches. There are fewer models in the second set of ANOVA analyses because each approach has one fewer categorization and because the cluster analyses were remarkably consistent with the original categorizations (See appendix 2) which obviated the need to test that method of categorization a second time.

It would be tedious to go through all 50 models in the analyses section. All the models are fully explicated in appendix 3. Here I present a summary of the models along with some figures that are illustrative of the analyses inside each category. Each approach is given a single explicated model that illustrates the strongest finding in that approach. Relevant differences inside each approach are included in the explication of the model representing each approach.

For all of these models, the null hypothesis, the baseline, is that all the categories are equivalent to each other. This is what Cook's Index assumes and here this is likewise assumed to be true unless there is compelling evidence to the contrary. This evidence is manifested as a statistically significant difference across the groups indicated by ANOVA and follow up analyses.

Selected Analyses

Hierarchical Cluster Analysis

A one way between groups ANOVA was run to compare the differences between the five categories of the Rural-Urban Continuum (as defined by the hierarchical cluster analysis) with respect to the ratio of Cook's Index to the permit rate. There was a significant effect at the $p<.05$ level [$F(4,57)=13.75$, $p=6.57E-8$]. The effect size estimate is $\eta^2=0.194346$

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to .05 a pictorial representation of the results can be found in figure 2. Dunnett's modified Tukey-Kramer's HSD (nonpooled variance) found no significant pairwise comparisons. Tukey-Kramer's HSD found a significant difference between group 4 and groups 1, 2, 3, and 5. Meaning that group 4 is unique compared to all the other groups, which are then all indistinguishable from each other. The more sensitive Fisher's LSD likewise found this pattern.

Ultimately group 4, comprised of the New York City Boroughs (Staten Island excepted) is the only significant pairwise comparison using this categorization. This group has a ratio of Cook's Index/Permit Rate that is significantly larger than the remaining groups, meaning a greater ratio of Cook's Index to Pistol Permit rate in group 4 compared to the other categories. This relationship holds (as does the size of the effect estimate) for both DV's.

As a whole the follow up analyses for this ANOVA indicate that New York City is significantly different from the remaining categories. For this categorization, the remaining NY counties are unable to be distinguished from each other.

Figure 2. Hierarchical Cluster Pairwise Comparison

Tukey-Kramer's HSD And Fisher's LSD	
(NYC) Group 4 >	Group 1
	Group 2
	Group 3
	Group 5

K-means Clusters

A one way between groups ANOVA was run to compare the differences between the three categories of the Rural-Urban Continuum (as defined by the K-means cluster analysis) with respect to the ratio of Cook's Index to the permit rate. There was a significant effect at the $p<.05$ level [$F(2,59)=30.34$, $p=8.7E-10$]. The effect size estimate is $\eta^2=0.339602$

The significant ANOVA meant that follow up analyses were performed with each method's alpha level set to .05 see figure 3. Dunnett's modified Tukey-Kramer's HSD (nonpooled variance) found no significant pairwise comparisons. Tukey-Kramer's HSD found a significant difference between groups 1 and group 2 as well as groups 1 and 3. Follow ups using the LSD found significant differences between all three groups. The Tukey-Kramer test had a p value of .06 when comparing groups 2 and 3, which just failed to reach significance. In conjunction with a significant effect using the LSD, and the overall low n, this might be indicative of a power problem.

Overall, this is an ANOVA that is significant and has a strong effect (accounting for approximately a third of the measured variance). For both DV's, the pairwise comparisons indicate that group 1 (again composed of NYC minus Staten Island) is significantly different from the rest of New York State when comparing the ratio of Cook's Index and permit rates. The more sensitive LSD follow ups indicate that all three groups are distinct from each other.

In this categorization, group 3 is composed entirely of Metropolitan counties, while group 2 is composed of the remaining New York State Counties, which is also the majority of counties. Group 3 would be considered (based on the cluster analysis) as living on the more "urban" side of the Rural-Urban Continuum. While the LSD is considered by some to be overly sensitive, the

comparison between groups 2 and 3 was close to significant even using the more conservative Tukey-Kramer, and again, with the low overall n, this is perhaps an indication of a power problem.

Regardless, this is evidence that Cook's Index does not correlate with Pistol Permits in the same manner across New York. Certainly for New York City (Staten Island excepted), and possibly across more groupings.

Figure 3. K-means Cluster Pairwise Comparisons

Tukey-Kramer HSD	
(NYC) Group 1 >	Group 2
	Group 3

Fisher's LSD		
NYC >	Group 3 >	Group 2

Micropolitan Based Categorization

The changes in significance and effect sizes as the urban counties were divided into more categories show an interesting pattern in this approach. The pattern of effect sizes and F-values indicate that splitting the Metropolitan categories into three sub-categories (Small Urban, Megalopolis, and NYC) is the most statistically supported option. The η^2 values triple when I move NYC from Megalopolis to its own category (.049 to .150; .048 to .150). However, going from three categories to four I see a reduction in the effect size estimate. This categorization of the Urban was also associated with an additional significant pairwise comparison in the LSD follow up analyses where the Small Urban > Suburb. Moving the Small Urban into "City" and "Small City" categories meant that a significant LSD pairwise comparison with "Small Urban" turned into two comparisons both of which failed to attain significance by a narrow margin. The three degrees of Urban (Small Urban, Megalopolis, and NYC) seems the most salient comparison.

Again, I found strong evidence that NYC has a unique (and larger) mean value. I also found weaker evidence that there is also a difference between the more rural and the urban, both when NYC is part of a larger urban category and when NYC is in its own category. Importantly for future categorization purposes there was no evidence that the "Micropolitan" category was unique in these analyses.

A one way between groups ANOVA was run to compare the differences between the five categories of the Rural-Urban Continuum in this Micropolitan organization (Suburb, Micropolitan, Small Urban, Megalopolis, NYC). The ratio of Cook's Index to the permit rate was

the DV. There was a significant effect at the p<.05 level [F(4,57)=10.09, p=3.04E-6]. The effect size estimate is η^2 =0.150395

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to alpha = 0.05 see figure 4. Dunnett's modified Tukey-Kramer found no significant pairwise comparisons. Tukey-Kramer's method found significant pairwise comparisons with NYC; specifically, it found that NYC was significantly greater than all other categories. The LSD mirrored this but also found a significant comparison that Small Urban > Suburb.

This distinction between the Suburb category is interesting and worth mentioning another ANOVA that was run in this categorization. The four category ANOVA (Suburb, Micropolitan, Small Urban, and Megalopolis) found a significant effect at the p<.05 level [F(3,58)=2.995, p=0.038] but with a much smaller effect size (η^2 =0.049102). However, for the purposes of pairwise comparisons the Dunnet Tukey-Kramer for that weaker model found two significant differences, between Suburb and Megalopolis and between Suburb and Small Urban. Overall this model is much weaker but it is that same pairwise comparison (Suburb and Small Urban) that the LSD found in the much stronger five category ANOVA explicated first in this section. As Dunnet Tukey and Kramer follow ups do not assume equal variance (and thus calculate it for each group), it is not surprising that shrinking sample size causes loss of significant pairwise comparisons. Further given the extreme values in New York City, the possibility that NYC was "driving the bus" for the inclusive megalopolis category is reasonable. This is why the Small Urban > Suburb comparison is more interesting when it reappears in the stronger model, albeit with a more sensitive follow up procedure.

A final finding to mention is that here is one of the very few differences with respect to the two DVs used appears in the 4 category comparisons. Using the averaged rates, the Dunnet Tukey Kramer finds Small Urban > Suburb and Megalopolis > Suburb. However, using the summed permits divided by the average population, the comparison with the Megalopolis loses significance. The Suburb comparison is the one that remains. Again, after NYC is removed into its own category, those comparisons become significant but NYC cannot be the cause of the Suburb category finding and losing significance. Figure 4 summarizes the findings with the Micropolitan Categorization method.

Figure 4. Micropolitan Based Categorization Pairwise Comparisons

Tukey-Kramer HSD Comparisons	
(NYC) >	Suburb
	Micropolitan
	Small Urban
	Megalopolis

LSD Pairwise Comparisons		
NYC >	Micropolitan	
	Small Urban >	Suburb
	Megalopolis	

Population Based Categorizations

Population (and to a lesser extent population density) are commonly used measures of the Rural-Urban Continuum and so are included in these analyses. Two models in these approaches failed to achieve to significance (the categorizations with only two classes of Metropolitan for each DV). In general the pattern shows that the category which includes New York City counties, is significantly different from the rest of the New York counties. These analyses also concur with the Micropolitan models that dividing the metropolitan counties into three categories maximizes effect size. Both fewer and more categories than three result in smaller effect sizes.

Even in the context of this weaker organization, there is evidence that New York City's relationship between pistol permits and Cook's Index is significantly different from the rest of New York. Based on the effect size changes, I also observed a decrease in effect size when going from 3 degrees of urban to 4 degrees of urban. This seems more evidence that "City" and "Small City" probably belong in the same category of "Small Urban".

A one way between groups ANOVA was run to compare the differences between the 5 categories of the Population approach to categorization (Rural, Suburb, Small Urban, Megalopolis, and NYC). The ratio of Cook's Index to the permit rate was the DV. This model was significant at the $p<.05$ level [$F(4,57)=9.526$, $p=5.72E-6$]. The effect size estimate is $\eta^2 =0.143192$.

The significant ANOVA meant that follow up analyses were performed with each method's alpha level set to 0.05 see figure 5. Dunnett's modified Tukey-Kramer found no significant pairwise comparisons. Tukey-Kramer found that NYC> each of the other groups. The LSD mirrored this result.

Figure 5. Population Based ANOVA results

LSD and Tukey-Kramer HSD Comparisons	
(NYC) >	Suburb
	Micropolitan
	Small Urban
	Megalopolis

Adjacency Based Categorization

In this categorization, non-Metropolitan counties are considered "Suburban" if they are adjacent to a Metropolitan county. As in the other approaches, I find that dividing Metropolitan counties into 3 categories yields the best results and reveals relationships that are obscured in the other categorizations. The weaker categorizations still join together to show very strong evidence that New York City is significantly different from the rest of New York. It is also demonstrated that there is evidence that other points on the Rural-Urban Continuum differ to each other with respect to this as well.

Specific to these analyses, the category of "MegaSuburb" doesn't seem to offer any increased explanatory power. Models with "Megasuburbs" failed to attain significance although they came close. Because of how close they were, the effect size was calculated, and the effect size is $\eta^2 = 0.03$, so even if it was a power problem that kept it from attaining significance the overall power of the model is quite small. Much like "Micropolitan" this category, despite its theoretical interest, fails to be supported in these analyses.

As a categorization scheme, the Adjacency based definition of suburbs seems adequate. There continues to be evidence that New York City's relationship between pistol permits and Cook's Index is significantly different from the rest of New York. Based on the effect size changes three categories of urban are ideal, there is a decrease in effect size when going from three categories of urban to either two or four degrees of urban. While four degrees of Urban is superior in terms of effect size to the two category solution, the three classes (Small Urban, Megalopolis, and NYC) seem to be the ideal categorization of the Urban counties. This also the category where the Dunner Tukey-Kramer and Tukey-Kramer together mirror the LSD analyses

and there is evidence not just of the importance of NYC but also between the Small Urban and the Suburban.

A one way between groups ANOVA was run to compare the differences between the 5 categories of the Adjacency based approach to categorization (Rural, Suburb, Small Urban, Megalopolis, and NYC). The ratio of Cook's Index to the permit rate was the DV. This model was significant at the $p<.05$ level [$F(4,57)=10.09$, $p=3.02E-6$]. The effect size estimate is $\eta^2 =0.150395$

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05 see figure 6. Dunnett's modified Tukey-Kramer found that Small Urban > Suburban. Tukey-Kramer found that NYC was larger than each of the other categorizations. And LSD found both that NYC was larger than all the other categories (mirroring the Tukey-Kramer follow ups) and that Small Urban > Suburban (mirroring the Dunnet modified Tukey-Kramer).

Figure 6. Adjacency Based Categorizations Pairwise Comparisons

Tukey Kramer	
NYC >	rural
	Suburban
	Small Urban
	Megalopolis

Dunnet Tukey Kramer	
Small Urban >	Suburban

Fisher's LSD		
NYC >	Rural	
	Suburban	
	Small Urban >	Suburban
	Megalopolis	

Models Without New York City

Referring to figures 2-6 it is obvious that New York City, or in the case of figure 1, New York City except Staten Island, is always statistically distinct from the rest of New York. To ensure that this extreme case (with respect to both level of urbanization and gun control legislation) was not unduly biasing the analyses as a whole, 20 ANOVAs were performed using a data set stripped of New York City counties. The population based approach (6 ANOVAs) were unanimously non-significant. The Adjacency and Micropolitan based categorizations retained significance until "Small Urban" was broken into "Small City" and "City", a point in categorization where previous models had begun exhibiting a smaller effect size.

Even with the extreme values of New York City removed Adjacency and Micropolitan based categorizations of the Rural-Urban continuum were found to be significantly different with respect to Cook's Index and Legitimate Handgun ownership. The direction of effect is the same as the previous models with "Small Urban" showing as significantly greater than "Suburb" across follow up analyses and models. The general finding of Urban areas having a worse ratio of Cook's Index to Legitimate Handgun ownership is confirmed.

The effect size is remarkably diminished for the models that exclude New York City counties. Dropping from an average of approximately 15% of variance explained to 6% of the variance explained. This is a significant drop and obviously the extreme counties of New York City were directly related to the much larger effect estimates. Dropping the New York City counties is an over-reaction to their strong influence, indeed their importance lies in their extreme place along the Rural-Urban Continuum. With or without the New York City counties

the non-Population based categorizations of the RUC show significant differences in how well Cook's Index corresponds with legitimate firearm ownership. This is a robust finding.

Summary

Of the original 30 ANOVAs, only four failed to meet the minimum criteria for statistical significance. These four models were actually two categorizations with the two different Dependent Variables, meaning that of the original approach only two specific categorizations failed to find compelling evidence that Cook's Index differs across categories of the Rural-Urban Continuum. Of the 20 subsequent ANOVAs (performed on New York State counties without New York City counties) 12 failed to meet criteria for statistical significance. The pattern of the nonsignificant models lost significance is interesting. Recall that there are three approaches used, of those three: Population Size, Adjacency to Metropolitan Area, and Micropolitan only Population Size was entirely nonsignificant. Population size had also been the weakest approach in the original ANOVAs. In the other approaches, the models lost significance after the "Small Urban" was broken into "City" and "Small City", the same point where the original ANOVAs suffered a loss of power. In other words, the same general pattern was found without the possibility of the extreme New York City being the cause of a spurious relationship.

There are a couple things to note then in the pattern of significance. First, that over the entire state of New York, a difference was found across levels of the RUC in the vast majority of analyses. Even with the advantage given to Cook's Index both in what is assumed to be true and with the low statistical power of these tests, Cook's Index does not come out unscathed. Second, the population size approach was the weakest method of categorization in all the analyses. This approach included half the nonsignificant findings in the in the original 30 ANOVAs, had the

lowest effect size estimates, and lost significance entirely in the ANOVAs performed after removing New York City Counties. This is important as it is an indication that Population based categorizations are missing relationships that are found in other methods of classifying the Rural-Urban Continuum. Finally, there was all but unanimity when considering the Dependent Variables. The DVs mirrored each other almost perfectly throughout the analyses with respect to the pattern of significance and the measured differences in effect sizes between the DVs did not manifest until past the thousandth place.

While the effect size varied with the different models, approximately 15% of the variation was explained on average by the categorizations of the Rural-Urban Continuum. The changes in effect size, as different categorizations of the RUC were tested, indicated that a division with New York City, Megalopolis (urban areas with 1 million + residents), and Small Urban (urban areas between 50,000 and 1 million) for the Metropolitan counties was associated with the greatest effect size. The clear winner concerning effect sizes found is the k-means cluster analysis. The k-means categorization was associated with the largest effect size (33%) which is approximately double the average effect size. This is a clear indication that statistical investigation of where the categorical difference lie is a promising avenue for future research.

Generally, there was support for the hypothesis that the ratio of Cook's Index to Permit Rate would vary across the Rural-Urban Continuum. This was true regardless of which of the two ways of calculating the DV was used. Not only does this warrant a greater degree of care in the use of this proxy variable and evaluating research based on it, it also is an indication that the way in which firearms are used varies along the Rural-Urban Continuum.

The variation found was unanimous in agreement that the Urban side of the Rural-Urban Continuum has a greater ratio of (Firearm Suicides/Suicides)/(Permit Rate). This is especially true for the New York City counties according the pairwise comparisons. Given an identical permit rate, the urban areas have a higher proportion of suicides committed with firearms. This seems at odds with respect to the literature as it is commonly understood. Nevertheless, this is clearly what is demonstrated in these analyses. All the significant differences found followed the general pattern that Urban areas have a higher percentage of suicides involving firearms for a given level of legitimate handgun ownership.

Hypotheses 4 and 5: Exploring the 2015 NYVDRS Data

While these hypotheses are relevant and were originally thought to be answerable, data restraints will keep them from being answered definitively. Nonetheless there are some interesting findings that can be shown. This data is presented more as descriptive than testing hypotheses due to these unforeseen data limitations.

Unrelated to the specific hypotheses but relevant to the dissertation, it emerged from the data that, across age ranges, women utilized firearms at about the same rate. Other methods showed change over the life span, but across all age ranges females used firearms for 10-20% of suicides. Men on the other hand show much greater variation with older males (65+) using firearms in 66% of cases. Other male age groups vary between a low of 28% and a high of 42%, all of these are much higher than the percentage of female suicides using a firearm.

Hypothesis 4: The majority of people who die by suicide will have legitimate access to firearms.

It was originally thought this would be answerable as the object used to complete suicide is normally at the scene when the decedent is discovered. With New York's Pistol Licensing

requirement, it was reasonable to believe that whether the firearm was legitimately owned would be easily verifiable and a matter of course for the investigation. However there is a large percentage of this data that is missing: In 64% of the observed firearm suicides in New York (New York City excepted) the weapon information is either "Unknown" (23%) or "Missing" (41%). Even the question of whether the firearm used was stolen was only answerable definitively as "No" in 30% of the cases; the remaining 70% were either "Unknown" or "Missing". For these data a victim of suicide accessing a household firearm was not coded as "stolen".

There is a large amount of missing data here that prevents any real answer to whether the victims of suicide have legitimate access. In this data, the largest category of known firearm owner, was the shooter him or herself (29%). Parents and Family were the owners in 4% of the known cases and friend/acquaintance in 1%. With such large categories of "missing" and "unknown" even to the basic question of whether the firearm was stolen, "legitimate access" is unknowable. With so many possibly stolen firearms (up to 70% of the data) it seems that in New York at least, Cook's Index relies heavily on legitimately and illegitimately firearms functioning in the same manner.

H5: Long Guns Will Be The Majority Choice For Suicide.

There is some light confirmation for this hypothesis, a slight majority (57%) of suicides with firearms utilizing a long gun (shotgun or rifle). Inside the long gun category, 60% of the long guns utilized were shotguns. For complete totals (New York City excepted), 36% used a handgun, 34% used a shotgun, and the remaining 30% used a rifle or some unknown or unrecorded type of firearm.

New York City did not provide its specific data, but some can be inferred from the CDC WONDER system. A total of 90 firearm suicides occurred in New York City for the year 2015, this represents an increase of 27% of the total firearm suicides in New York. If all 90 of these suicides were handguns, then handguns would become the dominant method of firearm suicides (comprising 49% and long guns would comprise 45% with remaining cased unknown or missing). This turns a confirmed hypothesis into a lightly confirmed hypothesis. The missing specific data prevents full confirmation. What this data does is contribute to the general breakdown of firearm type used in suicide. The data indicate that long guns are used for suicide between 45-57% of firearms used in suicide.

Summary

Overall there are mixed results for the hypotheses. Hypothesis 1 shows that Cook's Index does correlate moderately with permit rates though at a lower value than predicted by Cook. Hypothesis 2 found that rural areas do seem to have a higher firearm permit rate, and thus more legitimate handgun ownership for a given population. Hypothesis 3 found that there is very strong evidence that Cook's Index correlates differently with Pistol Permits across categories of the RUC. Not only for the extreme case of New York City but also between Small Urban areas (50,000-1 million population) and Suburban Areas (non-Metropolitan areas adjacent to Metropolitan areas). Hypothesis 4 and 5 were plagued with incomplete data that prevents definitive statements about legitimate access to firearms used in suicide along with whether handguns or long guns are more represented.

Chapter 7: Discussion and Implications of Findings

The research question with which I began was: Is Cook's Index an adequately valid proxy variable for measuring firearm prevalence? After identifying the strength of the Rural-Urban Continuum with respect to firearms and suicide, the question was extended: Is Cook's Index equally valid across the Rural-Urban Continuum? The main implications from this investigation are that Cook's Index is weaker than previously thought and that the Rural-Urban Continuum is significantly related to variation in Cook's Index and Legitimate Firearm Ownership.

A separate implication of this research is that the way in which researchers distinguish the rural and the urban must be updated. While there is little agreement on how to categorize the Rural, the Suburban, and the Urban the most common way is with simple metrics of population and population density. This research found that this method of categorization was the weakest method. The strongest method, by contrast, was K-means Cluster analysis which ultimately identified a subgroup of Metropolitan counties as being distinct. This is a good indication that even for agreed upon "urban" areas, they are not all created equally. Lingering concerns about sample size of non-urban areas are an indication that more research needs to be done on the non-urban with adequate power. At the same time the theoretical categories of "Micropolitan" and "Megasuburb" failed to be supported in these analyses. In order to understand the very real differences across the Rural-Urban Continuum, more empirical research, especially cluster analysis, is indicated.

Cook's Index has a weaker relationship to legitimate ownership than previous research indicates

The correlation between the permit issuance rate and Cook's Index resulted in a correlation strength of approximately 0.7. This contrasts to the most extensive and recent validation study which found 0.8 and 0.9 as the correlation strength compared to the GSS. While a decline from 0.8 to 0.6 may not seem earth shattering, the loss in predictive power is actually very high. Social Scientists in this field tend to be more conversant with R square values, and if you consider the R square values instead of the R values, the amount of variance explained by Cook's Index drops from a respectable 81- 64% down to 49% of the variance in handgun ownership being explained by Cook's Index. Unfortunately, there is not enough data provided by Azrael, Cook, and Miller (2004) to calculate a statistic demonstrating this is significantly less. It is reasonable to say that a new lower bound estimate of Cook's Index's validity is shown here.

This finding could have several explanations indicating that Cook's Index must be treated as being less predictive than previously believed. It is possible that the permit issuance rate is very different from the pistol ownership rate. However, the pistol issuance numbers are very stable over time (correlations are 0.9). Certainly, this pistol permit data is at least as good a validation measure as the phone surveys and GSS, and thus ought to be considered alongside them – which would lead to a reevaluation of Cook's Index as being weaker. Alternatively, this could be seen as an issue of legitimately held firearms being an undercount of the total number of firearms (illegally and legally held firearms). However, this requires a belief that illegal firearm owners answer the surveys honestly and that the surveys are to be preferred to licensing data. This research demonstrates that legitimately held firearms are not well predicted by Cook's Index.

Cook's Index Does Not Work for New York City

Regardless of categorization approach, New York City was found to be different. Prediction of firearms from Cook's Index (using known perfect data about legally held firearms) returned a nonsensical number. The suicide numbers used as predictors had very specific missing data that allowed a strict range to be calculated, and using either the high or low estimate did not matter. The prediction was nonsensical for both numbers.

While illegally held firearms can be appealed to in order to explain the weak correlations in the previous section, they cannot be appealed to here. If illegal firearms are associated with the same suicidal behavior as legally held firearms, then there should be MORE suicides with firearms for the given number of legally held firearms. These illegally held firearms should be artificially inflating the suicides associated with the legal firearms, which would artificially increase the prediction from Cook's Index. Yet the overall prediction is still that there are fewer than zero firearms in New York City.

The other option to explain this discrepancy is that illegally held firearms are used in suicide differently than legally held firearms. If this is so, and there are no estimates of illegally held firearms in the US, then the adequacy of Cook's Index to estimate prevalence becomes worse. It is inadequate to estimate legitimately held firearms and illegally held firearms. One can appeal to later analysis to attempt to say that the illegal firearms maybe be making the finding that urban areas have worse firearm suicide for the same number of firearms, but that does not help the fact that the linear prediction of Cook's Index is nonsensical.

In other words, the more illegal firearms you add to this equation, the worse Cook's Index fares. The more illegal firearms there are; the more striking their lack of use in suicide is. Because illegally held firearms, of some number, are known to be in New York City this is

evidence that cuts against the idea that legally and illegally held firearms are used in suicide identically, which in turn cuts against Cook's Index and buttresses the first finding that Cook's Index is weaker than previously believed.

The ANOVAs likewise demonstrated that New York City's ratio of firearm suicides to suicides is significantly different from the rest of the state. The pairwise comparisons strongly show this in almost all the models; NYC is found to be distinct. The ANOVAs indicate there is a significantly higher ratio of firearm suicide to suicide for their amount of legitimately owned firearms. This may well be a result of having such strict gun control that the denominator (Permit Rate) was so small that even the incredibly small numerator forms a larger fraction than other counties. Conversely, it may be evidence of a law of diminishing returns with respect to gun control and suicide. If the ratio of FS/S: Permit Rate that is true for New York City were also true for the rest of the state there should be many more firearm suicides outside the city than are actually observed.

There are a handful of implications for this finding. The strong gun control in NYC may be changing the way Cook's Index functions. The strong urban nature of NYC may be changing the way Cook's Index functions. Or it might be the combination of those two things. In any of those three situations, Cook's Index must be used more carefully as these situations exist elsewhere in the United States (and internationally). Finding which of these three possibilities is true is the only hope of adequately correcting this measure. Should we expect this different situation in Atlanta (high urbanization), Connecticut (high gun control), Chicago (high gun control high urbanization)? Getting to the root of this difference is vital for future research.

Cook's Index Returns Nonsensical Estimates for 11 Counties

In addition to the perfect information test of New York City where the number of active licenses was known, predictions with less perfect information were made for the rest of New York Counties. Ultimately eleven counties returned nonsensical values based on the FS/S. These eleven counties compose 17% of the counties and, in 2011, these counties represented 65.9% of the population of the entire state. In general these are contiguous with New York City or Albany, arguably the most important cities in New York.

There are a couple of implications to this finding. First, the shortcomings of Cook's Index seem to be related to the level of Urbanization rather than the simple strictness of the gun control present. The six other counties that are not NYC are more analogous to the rest of the state with respect to the regulation of firearms but also return nonsensical predictions from Cook's Index. The second implication is that Cook's Index does not apply to approximately 2/3 of the population of New York State.

Cook's Index varies comparing Suburb and Small Metro

The pairwise comparisons from the ANOVAs are not as unanimous here as they are with NYC as being different, however in multiple ANVOAs and follow ups of different types, there was evidence that Small Urban (50,000-1 million residents) were distinctly different in ratio of Cook's Index to Permit Rate compared to the Suburban (counties adjacent to metropolitan areas). This was not demonstrated in all the models but was true often enough for the stronger models to be an indication that the variation in FS/S: Permit Rate is not limited to the extreme case that is NYC. It was also a comparison that came close to attaining significance in several other models. Given that I am working with an N of 62, this might well be a power problem where these

models are on the edge of having enough power to find the effect. Regardless it is a shot in the arm to the thinking that counties adjacent to metropolitan centers may be in a unique situation that makes them different. And the direction of this difference is in the same direction as the other finding: where the more urban area has a worse ratio of firearm suicides to suicides for its level of legitimate pistol issuance.

K-means Cluster Analysis Best Method of Categorizing the RUC

The K-means analysis, by far had the strongest effect size with an Eta square (or r square) of .3398 almost double the average strength of the researcher defined categories. The categorizations with the K-means analysis are not strictly in line with the Metropolitan/non-Metropolitan divisions as was discussed earlier. However, they do divide into what might be characterized as "New York City" (four Counties), "Special Cases of Urban" (sixteen Counties), and "The Rest of the State" (forty-two counties). What is it about these sixteen Counties that makes them different? How can we generalize off the K-means cluster analysis, since it does seem to capture large amounts of variance? These questions are particularly salient as two theoretically important groups "Megasuburbs" (Suburban counties specifically next to larger metro areas) and "Micropolitan" (Central areas that are non-metro) both failed to be important in these analyses.

Further research should be pursued using cluster analyses to define categories. This instance also seems to indicate that differences among the types of Urban counties may be more important for firearms research than the distinctions between Suburb and Rural pursued here. Pew's research into firearms has already started using a more complex division that defines any non-central part of a metropolitan statistical area as a "suburb" (Pew 2017, pg 78). The difficulty here is that most sociologically relevant data are not found at this specific gradation instead

being found at the Census Tract or more often county level data. Cluster analysis seems to provide a more relevant means of sorting this coarse data meaningfully. What it is measuring and how well it applies to other states is an important avenue for future research.

Limitations of the Research

This research has an overall low number of counts, just 62 counties in total, and 57 when New York City is removed. As was mentioned in the methodology, this means that there is low power particularly for multiple ANOVAs. Further, New York is just one State in the US and the specific manifestation of the RUC may vary slightly across states. Replication with larger data sets is needed. The Pistol Permit Data that allowed a validity test of Cook's Index restricted this research to New York State.

This research also is limited in its validation to just legitimate pistol ownership through pistol permit rates. With the exception of the analysis in New York City, the number of active licenses was not available. Likewise, it is unclear in the data how Law Enforcement firearms are licensed. The data seem to indicate that some licenses are granted to the New York State Police, but there seem to be too few of them to account for all 75 years of issuance (994 licenses total), and it does not address other forms of law enforcement entitled or obligated to keep a firearm.

While these limitations are unavoidable, the question is not whether this is the perfect validation variable, but if it is at least as good as the GSS? In light of the difficulties with the GSS as shown in the literature review, I think it is difficult to say that the GSS is a stronger validation measure. At least this deserves to be included among the validation tests, and to temper the full throated endorsement of Cook's Index as a way to measure firearm prevalence.

Chapter 8: Conclusion

The question of how firearms are measured in America is fundamental to any research into how firearms function in America. This question of measurement underlies every study on how firearms are used in America. While the question of how firearms are used is the more attention grabbing question, the answers given by criminologists, sociologists and public health officials to this question often serve as ammunition (for both sides) in the political fight over firearms regulation in the United States. This is an issue of constitutional gravity in the United States and it is of utmost importance that the research performed be high quality and as free from bias as possible. To that end it is imperative that the research not be overstated. Weakness, caveats, and limitations of the research must be understood and communicated. Expedience cannot be a replacement for accuracy and honest ignorance must be preferred to the illusion of knowledge.

Cook's Index has many qualities and the research that relies on it was in line with the academic understanding of the proxy variable. It is only through painstakingly pulling apart the undergirding logic and searching for disconfirming evidence that the weaknesses of this variable begin to be seen. A casual reader or researcher would rightly be more concerned with models and findings of the papers that rely on an established proxy variable than with the proxy variable itself. However, this dissertation has demonstrated this proxy variable has severe issues and must become a new focus of research before it can be used as a piece in the more interesting and important question of how firearms are used in society.

This dissertation used the unique laws and data of New York State to run validation tests on Cook's Index using permits rather than phone surveys. As was shown in the literature review,

there are very good reasons to be cautious of using surveys as a validation measure. This indicated that more validation tests were appropriate. Validation of Cook's Index using legitimate handgun ownership was weaker than validation using survey data. More strikingly, in a test with as close to perfect data as possible Cook's Index failed to predict meaningfully New York City's legitimate handgun ownership at all. Still further, the nature of this failure was such that adding illegally held firearms (in any number) could not account for the discrepancy. The model returned nonsensical estimates. With slightly weaker data, Cook's Index returned nonsensical values for counties that comprised approximately two thirds of the population of the state of New York.

Especially the negative numbers predicted by Cook's Index should give researchers pause. Linearly transformed data perform identically to the nontransformed original data in a correlation matrix and this is why FS/S or Cook's Index is often used without transformation. This research shows that instances of using FS/S may be feeding impossible values into more complex models and through that indicating stronger findings than can be demonstrated to exist.

Moving beyond simple validation to the incorporation of a variable that was implied in the literature to matter to firearm use, the simple version of Cook's Index encountered still more issues. The ratio of Cook's Index to Pistol Permits ought to have been a simple relationship with minimal statistical noise across categories. Indeed, the validity of Cook's Index was the null hypothesis in these tests. Instead the Rural-Urban Continuum was found to be an important factor with differences between New York City and the rest of the State, but also between Small Urban counties and Suburban counties. The ANOVAs overwhelming agreed that the differences in ratio were not random. Explicit incorporation of this finding must be pursued to understand the bias in this measure and how it is affecting the current research. Without an adequate

understanding of this proxy variable, the research being used in the political fight may wind up as damaging to academic researchers as "Arming America" was to Bellesiles.

The importance of understanding how firearms are being used in America, and how to better protect citizens from their misuse, is a matter of universal agreement. Both sides of the debate wish to curb misuse and to keep all citizens safe. Academic research is the best tool to accomplish this goal, but only if that research that is properly cognizant of its limitations. Cook's Index is more limited than was previously thought and it, and the research based on it, must be re-examined.

This research is an indication that something along the Rural-Urban Continuum is associated with different firearm use. The theoretical grounding in this research argues that it is in fact cultural (or subcultural) differences along the Rural-Urban Continuum that lead to different groups of people using identical items differently. It has already been established that firearms are differently used in crime along the Rural-Urban Continuum. Urban areas having higher firearm misuse both as a rate and in raw numbers despite there being indications that they have fewer firearms. The current research is evidence that how firearms are used in suicide likewise varies along the Rural-Urban Continuum. It is not the firearms that change, nor are what changes in prevalence that have been established by researchers adequate to explain these differences. Rather it is people in the context of culture who use firearms in very different manners. Manners that are a result of their culture and social network. It is my contention that the insular nature of locations along the RUC has resulted in cultural changes and one of the effects of these changes, is that firearms are used differently both in suicide and homicide.

Appendix 1. Researcher Categorizations and Stability

This appendix shows the major approaches I adopted and the categorizations that resulted. The choice between the two forms of Adjacency to a Metropolitan area are explained and the approaches are examined for temporal stability. The paradoxical finding that while there is great stability within each approach over time, the approaches themselves fundamentally disagree on how to categorize the RUC is shown. From there the decision to retain multiple approaches in the dissertation is explained.

Approaches to Categorization

I examined the data and found four main approaches that could be taken towards categorization. These approaches mainly impact the non-urban classifications but within each of those four approaches there are multiple categorizations depending on how Urban classifications are pursued. Depending on how many levels urban classification are desired, a total of fifteen classification schemes present themselves within these four approaches. The classification schemes are numbered consecutively for future reference and summarized in Appendix Table 1. This table not only indicates which classifications fall within which approach but also the number of counties in each category and how larger classification are broken down into subcategories.

Two of these approaches (Adjacency) would seem to be identical, however this is not the case because the first approach uses the Rural-Urban Continuum Data and the third approach uses the Urban Influence Data. One county in particular is not in agreement along the Rural/Suburban border. The county in question (Hamilton County) is part of the Rural-Urban Contiuum code "Nonmetropolitan - Completely rural or less than 2,500 urban population,.

Appendix Table 1 . Rural Urban Classifications From Office of Money and Budget MSA data

Rural Urban Continuum Data Used													
Adjacency		*Counties adjacent to Urban counties are Suburban. Else, Rural. Urban distinctions based on population*											
Categorization 1		Rural	Suburban					Urban					
		5	19					38					
Categorization 2		Rural	Suburban					Small Urban		Megalopolis			
		5	19					18		20			
Categorization 3		Rural	Suburban					Small Urban		Megalopolis		NYC	
		5	19					18		15		5	
Categorization 4		Rural	Suburban					SmallCity	City	Megalopolis		NYC	
		5	19					6	12	15		5	
Population		*Categories are defined solely by population.*											
Categorization 5		Rural	Suburban					Urban					
		13	11					38					
Categorization 6		Rural	Suburban					Small Urban		Megalopolis			
		13	11					18		20			
Categorization 7		Rural	Suburban					Small Urban		Megalopolis		NYC	
		13	11					18		15		5	
Categorization 8		Rural	Suburban					SmallCity	City	Megalopolis		NYC	
		13	11					6	12	15		5	
Urban Influence Data													
Adjacency		*Counties adjacent to Urban Areas are Suburban.*											
Categorization 9		Rural	Suburban					Small Urban		Megalopolis			
		4	20					18		20			
Categorization 10		Rural	Suburban					Small Urban		Megalopolis		NYC	
		4	20					18		15		5	
Categorization 11		Rural	Suburb		MegaSuburb			Small Urban		Megalopolis			
		4	12		8			18		20			
Categorization 12		Rural	Suburb		MegaSuburb			Small Urban		Megalopolis		NYC	
		4	12		8			18		15		5	
Micropolitan		*Micropolitan category explored*											
Categorization 13		Rural	Suburb	MegaSuburb	Micropolitan			Small Urban		Megalopolis			
		1	7	2	14			18		20			
Categorization 14		Rural	Suburb	MegaSuburb	Micropolitan			Small Urban		Megalopolis		NYC	
		1	7	2	14			18		15		5	
Categorization 15		Suburb Combined			Micropolitan			Small Urban		Megalopolis		NYC	
		10			14			18		15		5	

adjacent to a metropolitan area". This explicit application of the "rural" label led to Hamilton's being ruled "rural" in the Rural-Urban Coding data. However, in the Urban Influence it is "Noncore adjacent to a small metropolitan and does not contain a town of at least 2,500 residents". The Urban Influence coding lacks the explicit descriptor of "rural" so the fact that it is adjacent to a small metropolitan meant that it is in the "suburban" category. After understanding how each approach organizes the counties of New York, I will compare the first and third approaches to determine if the difference is worth keeping for subsequent analyses.

Approach 1: Adjacency using the Rural-Urban Continuum Data

In this classification the Non-Metropolitan counties are divided into Rural and Suburban areas based on whether the county in question is adjacent to a Metropolitan county. Suburban counties are adjacent to Metropolitan Areas while Rural areas are counties that are neither Metropolitan nor adjacent to a Metropolitan county. The implication here is that commuting to the economically larger county is an option for people adjacent to Metropolitan Counties and that this is definition for the suburbs.

Four classifications result from this approach. Categorization 1 lumps all Metropolitan counties together as the same ("Urban"). Categorization 2 separates metropolitan areas that total more than one million population ("Megalopolis") as separate from other Metropolitan counties (labeled "Small Urban"). Categorization 3 adds another distinction by putting New York City in its own category while retaining the previous two categories. This allows the effects of the unique living situation and gun control laws that affect citizens who live in New York City to be separated from New York. Finally, in Categorization 4 an additional line is added to create three categories out of the "urban" category: cities between 50,000 and 249,999 residents ("Small

Cities"), cities with between a quarter of a million residents up to a million ("Cities"), and the "Megalopolis" is unchanged from the previous categorizations .

Approach 2: Population using the Rural-Urban Continuum Data

This approach uses simple metric of population to define rural and suburban. Categorization 5 is the basal categorization and defines Rural areas as counties with fewer than 20,000 residents. Suburbs are all counties with populations larger than 20,000 but fewer than 50,000, which is where the definition for City begins. Categorization 6 extends this by separating the Megalopolis (cities with a population greater than one million) from the remaining Metropolitan counties ("Small Urban") . Categorization 7 separates New York City counties into their own category from the Megalopolis category. And Categorization 8 divides the "Small Urban" category into the categories "Small City" (50,000-249,999) and "City" (250,000-one million).

Approach 3: Adjacency using the Urban Influence Data

As was mentioned previously this is very similar to Approach 1, however the Urban Influence Data's differences and the further exploratory categorizations of the Suburban category justify consideration of this approach on its own terms. Categorization 9 is the base categorization and places any county adjacent to a Metropolitan area as "Suburban" including any "micropolitan" areas. Any county that is neither Metropolitan nor adjacent to a Metropolitan county is "rural". The Metropolitan counties are categorized as either "Megalopolis" (one million plus) or "Small Urban". Categorization 10 separates the New York City counties ("NYC") from "Megalopolis" category.

The remaining two categorizations in this approach are designed to test whether suburbs are simply suburbs or if suburbanites adjacent to a "Megalopolis" are distinct from suburbanites adjacent to "Small Urban". Certainly price points in housing and the affluence of inhabitants are going to be different, but as we have seen the effect of money on crime is importantly moderated by Rural-Urban Continuum. For Categorization 11, the "Rural", "Small Urban", and "Megalopolis" categories are unchanged. The category "Suburban" has been split into "MegaSuburb" and "Suburb". "MegaSuburb" are counties adjacent to "Megalopolis" counties and "Suburb" are adjacent to "Small Urban". Categorization 12 is the same, except "Megalopolis" has New York City counties removed into "NYC".

Approach 4: Micropolitan Centered Urban Influence Data

The main difference in this classification scheme used by the Urban Influence Data is the use of "Micropolitan" as a classifier. Any county is "micropolitan" if there is a center that is between 10,000 and 50,000. These are too small to qualify as "Metropolitan" but are large enough to consider whether they are the primary "center" around which the county is organized. Counties with smaller centers (lower than 10,000 population) are classified differently.

Categorization 13 builds off of Categorization 11, preserving the distinction between "MegaSuburb" and "Suburb" as being adjacent to a "Megalopolis" or "Small Urban" respectively. However, in this categorization all counties that classify as "Micropolitan" are given their own category. This a major change in the classification scheme as it leaves only 9 counties in "Megasuburb" and "Suburb". Most of the counties categorized as "Suburban" are classified as "Micropolitan" here. Categorization 14 simply removes "NYC" from "Megalopolis".

Because these classifications are precursors to ANOVAs (which require multiple counties in each cell) Categorization 15 bows to mathematical requirements and combines rural, suburb and megasuburb together in Suburb Combined. This is necessary to have an adequate cell count for analyses, as an n of 1 is simply not allowable within an ANOVA.

Categorizations Contrasted: Across Time

In this section I examine the categories created by these four approaches for stability over time as well as the differences between the categories. Data for both Urban Influence and Rural-Urban Continuum are available for years 1993, 2003, and 2013. Both sources use at least eight classifications which are combined into larger categories as described in the preceding section. Effectively, this means that some changes in classification will cause a county to jump a category and some will not. Because the four approaches differ in which categories are combined to form the larger categories, it is possible for some counties to change from "Rural" to "Suburban" in one approach, but not in another (or vice versa). A knowledge of which counties change categorization and which counties are counted differently help determine the best categorizations for subsequent analyses.

Each approach will be examined for change over time. In the case of approach 3, two categorizations will be explicated, as they importantly impact the classification of the non-urban counties. After each approach's base category has been examined for stability over time, the approaches will be contrasted against each other to decide which classification scheme(s) ought be used in the final analyses.

Rural-Urban Continuum Data: Approach 1

For the first approach, Categorization 1, a total of 11 counties change their classification over the 20 years. Four counties (Genesee, Montgomery, Cayuga, and Chautauqua) lose their urban status and became Suburban. Of the Suburban counties which changed categories, two (Uslter and Yates) became Urban and one (Ostego) became Rural. Of the Rural counties which changed, two (Tompkins and Jefferson) became Urban and two (St Lawrence and Schuyler) became rural. Thus at the beginning there were 8 Rural, 16 Suburban, and 38 Urban. At the end there are 5 Rural, 19 Suburban, and 38 Urban counties.

This first approach is based on adjacency to urban counties. Counties that are not adjacent to an Urban county are Rural and counties that are adjacent are Suburban. One of the effects of this method of definition is that any change to urban status has a ripple effect. A single county which loses Urban status affects the counties adjacent to it. Of course this also occurs for counties that gain urban status. As county borders tend to be idiosyncratic, the effects are not easily predicted. Even though this method of definition is a volatile method over time, there is still remarkable stability. Overall, a majority (50 out of 62) of counties remain stable in their categorization of the Rural-Urban.

Rural-Urban Continuum Data: Approach 2

For the second approach, Categorization 5, we see a total of nine counties change their classification over the time span. Four Urban counties (Genesee, Montgomery, Cayuga, and Chautauqua) become Suburban. Three suburban counties (Ulster, Tompkins and Jefferson) become Urban. One Rural county becomes Urban (Yates) while one Rural county becomes Suburban (Sullivan). Additionally there was an oddity in one Rural county (Franklin) which was considered Suburban in 2003 but had reverted to Rural in 2013. At the beginning of the time

period there are 15 Rural, 9 Suburban, and 38 Urban. At the end of the time period there are 13 Rural, 11 Suburban, and 38 Urban.

This second approach is based on population size, which makes each change more individually meaningful. The influence caused by other counties' changes may still be there — a newly urban county may attract more people to an adjacent county for instance — but it is only the county's own change that is measured in this method. This method results in a larger and more stable Rural population. So while four counties changed from Rural to Suburban in Categorization 1, only two counties changed from Rural in this second approach. Further, the counties that became Urban all changed from Suburban counties. Again, in general there is stability with 53 of 62 counties staying unchanged.

Urban Influence Data: Approach 3

For the third approach, Categorization 9, I again use adjacency as the method of distinguishing between the Urban, Suburban, and Rural but with a different data set than approach 1 (Urban Influence rather than the Rural-Urban Continuum). Counties that are adjacent to an Urban county are designated as Suburban and the remaining counties are designated as Rural. In this approach eleven Counties change categories over the three data points.

Unsurprisingly (as the definition for Urban remains unchanged across all four approaches) Genesee, Montgomery, Cayuga, and Chautauqua lose their Urban status in the urban influence data just as they did in the rural urban continuum data. In approach 3, these counties all become "Suburban". Equally unsurprising, Yates, Ulster, Tompkins, and Jefferson become Urban. In this approach the counties in question were originally "Suburban". St Lawrence county is an oddity with a change in category in 2003 (Rural) before reverting to its

1993(Suburban) category. The remaining 3 counties that change are Schuyler, Otsego, and Clinton which change from Suburban to Rural. Overall, 51 out of 62 counties remain stable.

An additional complication for categorization of the Rural-Urban Continuum in approach 3 must also be explained: Categorization 11. In Categorization 11 Adjacency still determines whether a county is Suburban, however I then extended this logic and distinguished between "MegaSuburbs" and "Suburbs" depending on whether the county in question is adjacent to a "Megalopolis" (More than one million residents in the city that the Urban county is a part of) or a "Small Urban" (all counties part of Urban areas with less than one million residents). The logic here is a simple extension of the logic of distinguishing these urban classes: if very large cities might be different from the rest of the urban category, and suburbs are satellites of the cities, then these differences might also be reflected in the suburbs in question. This brings new possible changes in categorization.

For categorization 11 we see fourteen counties change category. This is three more than in categorization 9. As the difference between Categorizations 9 and 11 is the use of "Suburb" and "Megasuburb" instead of an inclusive "Suburban", the difference in number of changes means that there are only three instances of a shift between "suburb" and "megasuburb". Importantly however the existence of these two classes of suburbs lets us say more about the changes mentioned above.

For the counties that gain Urban Status not much new information presents itself. Yates goes from being a "MegaSuburb" to a "Megalopolis". While Ulster, Tompkins, and Jefferson go from being "Suburb" to "Small Urban". This is a simple indication that the urban area to which they were adjacent expanded to incorporate the suburb. Similarly unenlightening are the changes

in Ostego and Clinton from "Suburb" to "Rural", where a decrease in the influence of an urban area meant these counties were no longer adjacent to an Urban area.

The new categories though cast a different light on counties that lost Urban status. Genesee goes from "Megalopolis" to "MegaSuburb" in a simple contraction of the city. Cayuga and Montgomery likewise have a change from "Small Urban" to "Suburb". Chautauqua on the other hand goes from "Small Urban" to "MegaSuburb" which indicates a rather more complicated situation than a county being affected by its closest city's expansion or contraction. It was its own city but other urban changes meant that it became a "suburban" area to an even larger city. Also indicative of a more complicated picture are the changes between "Suburb" and "Mega Suburb". Steuben, Sullivan, and Columbia go from being "Suburb" to "MegaSuburb". In any of the cases it could be either the Urban county they border increasing from "Small Urban" to "Megalopolis" or a "Megalopolis" growing to incorporate another County that borders the County in question. In short, a "Megalopolis" can steal a suburb from a "Small Urban" due to the way the data are coded. Adjacency to a "Megalopolis" and adjacency to "Small Urban" are mutually exclusive categories, which is accomplished by "Megalopolis" adjacency being given priority in the raw data.

In general we find that 47 of the 62 counties in NY do not change over the time period in question. At the beginning of the period in question "Urban" has 38 counties, "MegaSuburb" has 4 counties, "Suburb" has 18 counties and "Rural" has 2. At the end of the period in question "Urban" has 38 counties, "MegaSuburb" has 8 counties, "Suburb" has 12 counties and"Rural" has 4. So we see growth in Rural and MegaSuburb, decrease in Suburb, and seeming stasis in urban. This is still a remarkable degree of constancy in this categorization even though it does show the most change over time.

Urban Influence Data: Approach 4

Approach 4 centers around a new category: Micropolitan. This is a concept that tries to separate counties that are based around commuting to an urban county (what is intuitively a "Suburb") from counties that organized around a smaller urban area albeit one that doesn't qualify as "Metropolitan". "Micropolitan" is a grouping that categorizes an urban area of 10,000-50,000 (below the cutoff for "Urban" classification from the USDA which is based on the "Metropolitan" category from the OMB) as its own central area. After Micropolitan counties are placed in their own category, the remaining counties are classified as "Suburb" if adjacent to a "Small Urban" county and as "Megasuburb" if adjacent to a "Megalopolis". Especially given the legal distinctions that are emphasized for some areas outside of MSAs (Rury & Saatcioglu 2011), the Micropolitan classification may offer an important distinction between areas that are small cities and areas that are satellites of a Metropolitan area. This distinction may prove to be a particularly pertinent category while studying the RUC and firearms.

For categorization 13 a total of twelve counties change classification. As in all previous categorizations four counties (Genesee, Montgomery, Cayuga, and Chautauqua) lose their Urban status. In this categorization the counties all become "Micropolitan". Again, as in previous categorizations, Yates, Ulster, Tompkins, and Jefferson counties become Urban. In this categorization Yates changes from "Megasuburb" to "Megaloplis" while Tompkins changes from "Suburb" to "Small Urban". A more interesting picture is painted by Jefferson and Ulster, both of which change from "Micropolitan" to "Small Urban". In the case of Jefferson the transition moves from "Suburb" to "Micropolitan" to "Small Urban". Three counties (Columbia, St Lawrence, and Clinton) moved from "Suburb" to "Micropolitan". Sullivan County made a jump from "Suburb" to "Megasuburb", and Allegany County went from "Micropolitan" to "Rural".

The change shown in Category 13 where Urban counties that lose their Urban status become Micropolitan and most of the counties that become Urban change from Micropolitan is strong evidence in favor of the Micropolitan category. An Urban area losing its "urban" status due to population loss is unlikely to immediately reorganize its civic life around the nearest "Urban" county or become what we think of as "rural". Rather it will continue in its organization at a lesser intensity. Likewise implementing the type of infrastructure and civic life associated with an Urban county is likely a slow change rather than a quick reorganization from a small area supporting commuters to its own Urban area attracting commuters. The "Micropolitan" category effectively communicates that. The micropolitan category also allows the researcher to distinguish between cases where the city subsumes its suburb (Tompkins and Yates) from the growth of a county on its own.

In general we find that 48 of the 62 counties in New York undergo no change over the time period. At the beginning of the time period there are 38 Urban, 9 Micropolitan, 2 Megasuburb, 13 Suburban, and 0 Rural counties. At the end the counties are organized into 38 Urban, 14 Micropolitan, 2 Megasuburb, 7 Suburban, and 1 Rural. There is growth in Micropolitan and Rural, seeming stasis in Urban and Megasuburb, and decreases in Suburban.

Summary of Changes in time

Overall, there is much stability over time in all of the approaches. Of the 62 New York Counties, between 9 (14%) and 14 (22%) counties change categorization depending on which organizational approach I take. This is fairly strong evidence that the Rural-Urban Continuum is largely stable over the time period that CDC data for suicide with firearms exists (1999-2015). It also opens the possibility of performing analyses with the counties that do not change category at

all over the time period in question. This would shrink sample size but would also exclude any effects of changing Rural-Urban Continuum from affecting the results.

Categorization Schemes Compared

Adjacency Decision: Choosing Between Approaches 1 and 3

As these approaches are identical in philosophy; disagree on only one county in the final measurements; and show minimal disagreement in changes over time, maintaining both sets of categories would add to the burden of the reader without increasing clarity. As I mentioned earlier, the one county of disagreement (Hamilton) differs because the word "rural" is used as a descriptor in one data set despite it being adjacent to an urban county. The attachment of "rural" to its description led me to classify it as "rural" in that dataset despite it being adjacent to an Urban county. To make the decision between these similar classifications I will focus on the five oddities that present themselves when looking at the history of the counties across all three time points.

Remember that both of these approaches use Adjacency to an Urban county as the defining characteristic of the Suburban. Only Clinton, Jefferson, Schuyler, St Lawrence, and Tompkins counties do not completely mirror each other in the sister approaches. For each of these five counties they began in the same category for 1993: "Rural" in approach 1 and "Suburban" in approach 3. For 2003 and 2013 both approaches are in agreement about whether they are Rural, Suburban, or Urban. Indeed it is only in 1993 that there is any disagreement. Yet that disagreement determines whether the number of rural counties has doubled or of the number has decreased by 37.5%. This all stems from one year's disagreement as all the other data points mirror each other perfectly.

I chose approach 3 over approach 1 for the dissertation because Approach 3 is slightly more stable in classification than Approach 1; it is my contention that the Rural-Urban Continuum is a fairly stable social reality. Specifically, Schuyler and St. Lawrence begin and end as Surburban in Approach 3 while they both change from rural in Approach 1. Similarly, Jefferson goes from Rural to Urban over the time period in Approach 1 and only changes from Suburban to Urban in Approach 3. By choosing Approach 3 over Approach 1, the distinction over Hamilton county as Rural due its original classification is lost and its adjacency simply classifies it as Suburban.

Approach 3 is also preferable because the data allow further exploration of adjacent counties based on whether they are adjacent to larger or smaller Urban counties. This type of comparison is not possible with Approach 1, the raw data simply do not lend themselves to such a comparison. Thus, while Approach 1 could be used, I have chosen to drop the approach in favor of the substantially similar Approach 3.

After painstakingly examining the counties' places on the Rural-Urban Continuum using four philosophical approaches with two datasets over two decades of time, I am left with 4 base categorizations: Population definition using Rural-Urban Continuum Data (Classification 5), Adjacency using Urban Influence Data (Classification 9), Adjacency with City Size (Classification 11), and Micropolitan (Classification 13). Appendix Figures 1 and 2 show these categorizations across the timepoints available.

Appendix Figure 1. Urban Categorization Changes Over Time

Population				Adjacency				Adjacency and City Size				Micropolitan			
Approach 2 Classification 5				Approach 3 Categorization Classification 9				Approach 3 Classification 11				Approach 4 Classification 13			
County name	1993 Rural-urban Continuum Code	2003 Rural-urban Continuum Code	2013 Rural-urban Continuum Code	County name	1993 Urban Influence Code	2003 Urban Influence Code	2013 Urban Influence Code	County name	1993 Urban Influence Code	2003 Urban Influence Code	2013 Urban Influence Code	County name	1993 Urban Influence Code	2003 Urban Influence Code	2013 Urban Influence Code
Bronx County	0	1	1	Bronx County	1	1	1	Bronx County	1	1	1	Bronx County	1	1	1
Erie County	0	1	1	Erie County	1	1	1	Erie County	1	1	1	Erie County	1	1	1
Kings County	0	1	1	Genesee County	1	3	3	Genesee County	1	3	3	Genesee County	1	3	3
Monroe County	0	1	1	Kings County	1	1	1	Kings County	1	1	1	Kings County	1	1	1
Nassau County	0	1	1	Livingston County	1	1	1	Livingston County	1	1	1	Livingston County	1	1	1
New York County	0	1	1	Monroe County	1	1	1	Monroe County	1	1	1	Monroe County	1	1	1
Niagara County	0	1	1	Nassau County	1	1	1	Nassau County	1	1	1	Nassau County	1	1	1
Queens County	0	1	1	New York County	1	1	1	New York County	1	1	1	New York County	1	1	1
Richmond County	0	1	1	Niagara County	1	1	1	Niagara County	1	1	1	Niagara County	1	1	1
Rockland County	0	1	1	Ontario County	1	1	1	Ontario County	1	1	1	Ontario County	1	1	1
Suffolk County	0	1	1	Orleans County	1	1	1	Orleans County	1	1	1	Orleans County	1	1	1
Westchester County	0	1	1	Putnam County	1	1	1	Putnam County	1	1	1	Putnam County	1	1	1
Genesee County	1	4	4	Queens County	1	1	1	Queens County	1	1	1	Queens County	1	1	1
Livingston County	1	1	1	Richmond County	1	1	1	Richmond County	1	1	1	Richmond County	1	1	1
Ontario County	1	1	1	Rockland County	1	1	1	Rockland County	1	1	1	Rockland County	1	1	1
Orleans County	1	1	1	Suffolk County	1	1	1	Suffolk County	1	1	1	Suffolk County	1	1	1
Putnam County	1	1	1	Wayne County	1	1	1	Wayne County	1	1	1	Wayne County	1	1	1
Wayne County	1	1	1	Westchester County	1	1	1	Westchester County	1	1	1	Westchester County	1	1	1
Albany County	2	2	2	Albany County	2	2	2	Albany County	2	2	2	Albany County	2	2	2
Broome County	2	2	2	Broome County	2	2	2	Broome County	2	2	2	Broome County	2	2	2
Cayuga County	2	4	4	Cayuga County	2	5	5	Cayuga County	2	5	5	Cayuga County	2	5	5
Dutchess County	2	2	1	Chautauqua County	2	3	3	Chautauqua County	2	3	3	Chautauqua County	2	3	3
Herkimer County	2	2	2	Chemung County	2	2	2	Chemung County	2	2	2	Chemung County	2	2	2
Madison County	2	2	2	Dutchess County	2	2	1	Dutchess County	2	2	1	Dutchess County	2	2	1
Montgomery County	2	4	4	Herkimer County	2	2	2	Herkimer County	2	2	2	Herkimer County	2	2	2
Oneida County	2	2	2	Madison County	2	2	2	Madison County	2	2	2	Madison County	2	2	2
Onondaga County	2	2	2	Montgomery County	2	5	5	Montgomery County	2	5	5	Montgomery County	2	5	5
Orange County	2	2	1	Oneida County	2	2	2	Oneida County	2	2	2	Oneida County	2	2	2
Oswego County	2	2	2	Onondaga County	2	2	2	Onondaga County	2	2	2	Onondaga County	2	2	2
Rensselaer County	2	2	2	Orange County	2	2	1	Orange County	2	2	1	Orange County	2	2	1
Saratoga County	2	2	2	Oswego County	2	2	2	Oswego County	2	2	2	Oswego County	2	2	2
Schenectady County	2	2	2	Rensselaer County	2	2	2	Rensselaer County	2	2	2	Rensselaer County	2	2	2
Schoharie County	2	2	2	Saratoga County	2	2	2	Saratoga County	2	2	2	Saratoga County	2	2	2
Tioga County	2	2	2	Schenectady County	2	2	2	Schenectady County	2	2	2	Schenectady County	2	2	2
Chautauqua County	3	4	4	Schoharie County	2	2	2	Schoharie County	2	2	2	Schoharie County	2	2	2
Chemung County	3	3	3	Tioga County	2	2	2	Tioga County	2	2	2	Tioga County	2	2	2
Warren County	3	3	3	Warren County	2	2	2	Warren County	2	2	2	Warren County	2	2	2
Washington County	3	3	3	Washington County	2	2	2	Washington County	2	2	2	Washington County	2	2	2

Metropolitan	Suburb	Small Urban	Megalopolis	Small Suburb	Mega Suburb	Micropolitan

Appendix Figure 2. Non-Urban Categorization Changes Over Time

Population				Adjacency				Adjacency and City Size				Micropolitan			
Approach 2 Classification 5				Approach 3 Categorization Classification 9				Approach 3 Classification 11				Approach 4 Classification 13			
County name	1993 Rural-urban Continuum Code	2003 Rural-urban Continuum Code	2013 Rural-urban Continuum Code	County name	1993 Urban Influence Code	2003 Urban Influence Code	2013 Urban Influence Code	County name	1993 Urban Influence Code	2003 Urban Influence Code	2013 Urban Influence Code	County name	1993 Urban Influence Code	2003 Urban Influence Code	2013 Urban Influence Code
Cattaraugus County	4	4	4	Cattaraugus County	3	3	3	Cattaraugus County	3	3	3	Cattaraugus County	3	3	3
Cortland County	4	4	4	Seneca County	3	3	3	Seneca County	3	3	3	Seneca County	3	3	3
Fulton County	4	4	4	Wyoming County	4	4	4	Wyoming County	4	4	4	Wyoming County	4	4	4
Steuben County	4	4	4	Yates County	4	4	1	Yates County	4	4	1	Yates County	4	4	1
Ulster County	4	3	3	Cortland County	5	5	5	Cortland County	5	5	5	Cortland County	5	5	5
Clinton County	5	5	5	Fulton County	5	5	5	Fulton County	5	5	5	Fulton County	5	5	5
Jefferson County	5	4	3	Otsego County	5	5	8	Otsego County	5	5	8	Otsego County	5	5	8
St. Lawrence County	5	5	4	Steuben County	5	5	3	Steuben County	5	5	3	Steuben County	5	5	3
Tompkins County	5	3	3	Ulster County	5	2	2	Ulster County	5	2	2	Ulster County	5	2	2
Chenango County	6	6	6	Chenango County	6	6	6	Chenango County	6	6	6	Chenango County	6	6	6
Columbia County	6	6	6	Columbia County	6	5	3	Columbia County	6	5	3	Columbia County	6	5	3
Delaware County	6	6	6	Delaware County	6	6	6	Delaware County	6	6	6	Delaware County	6	6	6
Essex County	6	6	6	Essex County	6	6	6	Essex County	6	6	6	Essex County	6	6	6
Greene County	6	6	6	Greene County	6	6	6	Greene County	6	6	6	Greene County	6	6	6
Lewis County	6	6	6	Hamilton County	6	7	7	Hamilton County	6	7	7	Hamilton County	6	7	7
Otsego County	6	6	7	Lewis County	6	6	6	Lewis County	6	6	6	Lewis County	6	6	6
Seneca County	6	6	6	Schuyler County	6	7	7	Schuyler County	6	7	7	Schuyler County	6	7	7
Sullivan County	6	4	4	Sullivan County	6	6	4	Sullivan County	6	6	4	Sullivan County	6	6	4
Wyoming County	6	6	6	Clinton County	7	8	8	Clinton County	7	8	8	Clinton County	7	8	8
Yates County	6	6	1	Jefferson County	7	5	2	Jefferson County	7	5	2	Jefferson County	7	5	2
Allegany County	7	7	7	St. Lawrence County	7	8	5	St. Lawrence County	7	8	5	St. Lawrence County	7	8	5
Franklin County	7	5	7	Tompkins County	7	2	2	Tompkins County	7	2	2	Tompkins County	7	2	2
Hamilton County	8	8	8	Allegany County	8	9	9	Allegany County	8	9	9	Allegany County	8	9	9
Schuyler County	8	6	6	Franklin County	8	8	8	Franklin County	8	8	8	Franklin County	8	8	8
Rural				Small Suburb				Micropolitan				Small Urban			
Suburb				MegaSuburb								Megalopolis			

Comparing Approaches by Separating the Urban

This leaves three approaches: Population, Adjacency, and Micropolitan. To this an additional distinction between size of the Metropolitan area allows an "Adjacency and City Size" categorization, the previously mentioned "Megasuburbs". So inside these 3 approaches, I have 4 basic categorizations.

To examine the non-Metropolitan areas more closely the "Micropolitan" and "Megasuburbs" must be entertained and these are each a base categorization as the Metropolitan counties still need to be categorized for each. These approaches affect the Non-Urban rather than the Urban as there is complete agreement about where the dividing line between "Urban" and "Non-urban" is across all the approaches. How the Urban should be categorized can be considered separately from the "Non-Urban" categories as any of the categorizations could be applied to any of the approaches.

38 counties are classed as "Urban" which can be broken down into four categories or fewer. The approach based on population breaks the urban into three classes: "Megalopolis" (metropolitan areas with more than 1 million residents), "City" (metropolitan areas with more than 250,000 residents), and "Small City" (cities in between 50,000 and 250,000). The remaining approaches use a simpler two category division between "Megalopolis" and all the remaining Urban areas which are classified as "Small Urban". Because there is complete agreement on the definition of Urban, I can apply either the 2,3, or 4 (New York City counties separated) categorization of the urban counties with equal ease to any of the approaches. I examined the ANOVAs in hypothesis 3 to determine which of the Urban divisions is most useful in explaining variance. If the results are comparable I prefer parsimony; however, if the more numerous

categorizations lead to more clarity, they will be retained. To examine firearms licenses I retained the ability to put New York City in its own category even if no significant difference is found with suicide rate.

Comparing the Base Categorizations

Appendix Figure 3 shows the 2013 divisions between the final 4 basic categorizations in non-Meropolitan counties. Note that the 24 "non-Metropolitan" counties are divided fairly differently among these four classifications. Using the 2013 data points (the temporal endpoint) I find that Population divides the counties so that 11 are "Suburban" and 13 are "rural". Adjacency based definitions turn many of those "Rural" counties into Suburban. The Adjacency approach creates a much larger "Suburban" category of 20 counties that leaves a mere 4 counties in the Rural Category. Using the joint approach where adjacency and population size of the urban center in question are both used, the rural counties are unchanged from the Adjacency category but there is now a "Megasuburb" (8 counties) and "Suburb" (12 counties). The final approach removes the "Micropolitan" category (14 counties) which leaves 9 Suburban counties (2 Megasuburb and 7 Suburban counties) and only one Rural county. As was mentioned previously, this forces the use of categorization 15 for the actual analyses concerning the Micropolitan as the cell count is too low in categorization 13.

The size of each category varies over the approaches, which affect statistical analyses. In general, the more categories an approach has the fewer counties in each category. Cell count continues to be a challenge even with some larger categories (such as Adjacency based categorizations), which leave a very small Rural despite only dividing between Suburban and Rural. The size differences in the categories created by each of the approaches may themselves

cause different result patterns as ANOVA (effectively) weights all the calculated means as if the cells are equal which can obscure important differences. At the same time we are dealing with philosophical differences in the methodology which, contrary to the colloquial use of the term, cannot be dismissed as irrelevant or unimportant. It would be folly to prefer a categorization that fits the model better than it does the reality of the Rural-Urban Continuum. Only by performing analyses with each approach can differences between the categories be seen. Running the analysis with multiple approaches is also the best way to see if one of the raw categories is having a disproportionate influence. If whichever category has raw category 5 in it is always significantly different, then it may be that category 5 ought be considered on its own terms. Only by comparing the ANOVAs over these categories can the truth of the matter be found.

Appendix Figure 3. Non-Urban Categorization Comparison

Population		Adjacency		Adjacency and City Size		Micropolitan	
Approach 2 Classification 5		Approach 3 Categorization Classification 9		Approach 3 Classification 11		Approach 4 Classification 13	
County name	2013 Rural-urban Continuum Code	County name	2013 Urban Influence Code	County name	2013 Urban Influence Code	County name	2013 Urban Influence Code
Cattaraugus County	4	Cattaraugus County	3	Cattaraugus County	3	Sullivan County	4
Cayuga County	4	Chautauqua County	3	Chautauqua County	3	Wyoming County	4
Chautauqua County	4	Columbia County	3	Columbia County	3	Chenango County	6
Cortland County	4	Genesee County	3	Genesee County	3	Delaware County	6
Fulton County	4	Seneca County	3	Seneca County	3	Essex County	6
Genesee County	4	Steuben County	3	Steuben County	3	Greene County	6
Montgomery County	4	Sullivan County	4	Sullivan County	4	Hamilton County	7
St. Lawrence County	4	Wyoming County	4	Wyoming County	4	Lewis County	6
Steuben County	4	Cayuga County	5	Cayuga County	5	Schuyler County	7
Sullivan County	4	Cortland County	5	Cortland County	5	Cattaraugus County	3
Clinton County	5	Fulton County	5	Fulton County	5	Cayuga County	5
Chenango County	6	Montgomery County	5	Montgomery County	5	Chautauqua County	3
Columbia County	6	St. Lawrence County	5	St. Lawrence County	5	Clinton County	8
Delaware County	6	Chenango County	6	Chenango County	6	Columbia County	3
Essex County	6	Delaware County	6	Delaware County	6	Cortland County	5
Greene County	6	Essex County	6	Essex County	6	Franklin County	8
Lewis County	6	Greene County	6	Greene County	6	Fulton County	5
Schuyler County	6	Lewis County	6	Lewis County	6	Genesee County	3
Seneca County	6	Hamilton County	7	Hamilton County	7	Montgomery County	5
Wyoming County	6	Schuyler County	7	Schuyler County	7	Otsego County	8
Allegany County	7	Clinton County	8	Clinton County	8	Seneca County	3
Franklin County	7	Franklin County	8	Franklin County	8	St. Lawrence County	5
Otsego County	7	Otsego County	8	Otsego County	8	Steuben County	3
Hamilton County	8	Allegany County	9	Allegany County	9	Allegany County	9
Rural				Small Suburb		Micropolitan	
Suburb				MegaSuburb			

Stable Counties and the Base Categorizations

Another way to compare these four base categorizations is by looking only at the stable counties. Stable counties are counties that do not change category inside each approach over the three data points. I am not considering the stable Metropolitan counties in this section which would give us the normal total of sixty-two counties, but rather the non-Metropolitan counties, which shrinks the counties in question to twenty-four.Using Population as a metric leaves with eighteen stable counties. Of these, six are suburban and twelve are rural. This categorization has the most stable counties associated with it. An Adjacency based categorization has seventeen stable counties, with fifteen Suburban and two Rural counties. The combined approach using both Adjacency and Size, by virtue of having more categories, has only fourteen stable counties (three MegaSuburbs, nine Suburbs, and two Rural counties). The Micropolitan approach has 15 stable counties (seven Micropolitan, seven Suburb, and one MegaSuburb).

Contrasted against each other there are only eleven counties which are agreed, across organization schemes, to stay the same (see Appendix Figure 4). However, none of these counties are put in the same class across all four categorizations. There is not a single non-urban county that all the categorizations agree has stayed unchanged that they further agree on the proper category for that county. Much of the reason for this hinges on whether Megasuburbs are distinct from suburbs, and whether micropolitan is its own category or should be subsumed into the intuitive Rural or Suburban categories. Ultimately the disagreement on such a fundamental level is strong evidence that each of these categorizations should be utilized in the analyses.

Appendix Figure 4. Stable Non-Urban Counties In Each Base Categorization

	Approach 2 Classification 5	Approach 3 Classification 9	Approach 3 Classification 11	Approach 4 Classification 13
Allegany County	7	8	8	
Cattaraugus County	4	3	3	
Chenango County *	6	6	6	6
Clinton County	5			
Columbia County	6	6		
Cortland County*	4	5	5	5
Delaware County*	6	6	6	6
Essex County*	6	6	6	6
Franklin County		8	8	8
Fulton County*	4	5	5	5
Greene County*	6	6	6	6
Hamilton County*	8	6	6	6
Lewis County*	6	6	6	6
Otsego County	6			5
Schuyler County*	8	6	6	6
Seneca County*	6	3	3	3
St. Lawrence County	5			
Steuben County	4	5		5
Sullivan County		6		
Wyoming County*	6	4	4	4

* a county stable across time points in all classification schemes

Rural | Suburb | Small Suburb | MegaSuburb | Micropolitan

Appendix 2: Cluster Analyses For Categorizing The Rural-Urban Continuum

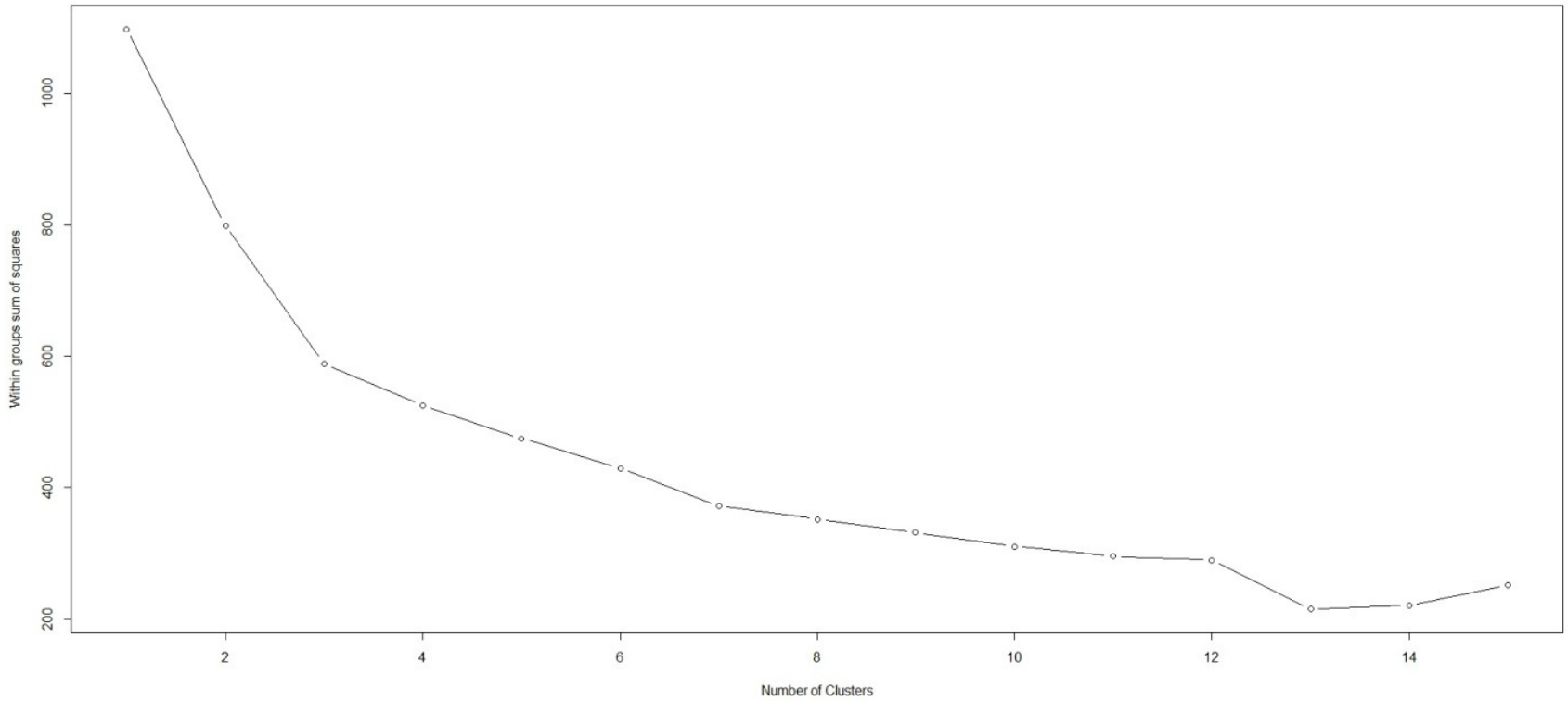
Cluster Analyses for Categorization

While my own interaction with the data and its definitions have yielded several worthwhile categorizations these are inescapably tied to my own biases and philosophy. As an important contrast to that, I also ran two types of cluster analyses. These mathematical categorizations, based on empirically measured attributes of the counties, offer an important counterpoint to the philosophical divisions. From the multiple analyses explicated here, two separate cluster solutions will be added as categorizations to be tested with ANOVAs: One is the result of a hierarchical clustering technique and one the result of a K-means technique.

First, I ran a hierarchical cluster analysis as an exploratory technique. After running this analysis with two methods of linkage I decided that the eight group solution using complete linkage was the most informative. This solution that was then manually winsorized into a five group solution which maintained the insights of the eight group solution while minimizing the effect of the outlying counties and ensuring there were no single-county "clusters" in the final product.

Second, in accord with Everett and Hothorn (2009) I plotted within groups sum of squares by number of clusters to make decisions on how many clusters to run in a k group analysis (Appendix figure 5). Pronounced bends indicate good candidates for numbers of clusters. Appendix Figure 5 indicates that three and seven clusters may be good candidates. Thus K-means cluster analysis was run with three and seven cluster solutions. Additionally a five cluster solution was run, in part to compare with the Hierarchical solution but also because the seven cluster solution is not enlightening. Due to restrictions requiring at least two counties in

Appendix Figure 5. Within Groups Sum of Squares by Number of Clusters



each cell (and preferably more) The three group K-means cluster solution was retained for ANOVA analyses.

Caveats for Cluster Analyses

While these models have less direct researcher involvement they each suffer from their own peculiar biases. First, these models weigh all the variables equally. The models therefore give population density as of equal importance to vacant housing units for rent and all other data. Effectively this means that all data is assumed, rather than shown, to be unique and germane. While some see this as removing the researcher, in reality this merely changes the way in which the researcher's philosophy influences the results as it is the researcher who selects from the data that is available that he believes to be germane.

Cluster analyses also adds pitfalls for the researcher in the form of understanding what "normal" data look like. While most data need to be standardized so that differences in scale do not obfuscate the actual differences, researchers must be aware of other factors. For example, "mean hours of sunlight in January" is one of the variables for each county determining (in part) an "amenability" score. If the researcher were to use the USDA's standardized amenability score, the data from southern states would be included in the data to compute this value. However, if I am looking only at New York State, this variable should be dropped or re-standardized on the NY counties. Either of those options of course has a philosophical impact. As this research is attempting to create categories that will inform the national RUC using the national level data would be desirable. As this uses only NY state counties standardizing on them alone would be more informative about differences in NY. There is no "right" answer, merely tradeoffs in philosophy which will affect the ultimate outcome.

Data Used For Cluster Analyses

The data used were county level data taken from the US Census Fact Finder Website. As much readily available data as possible was downloaded and then appraised for variables that were relevant for distinguishing between the rural and the urban. I chose eighteen variables that I believed had relevance to the Rural-Urban difference based on my reading of the literature. Some of these variables are readily understandable, variables like "% of vacant housing units available for rent" and "Population Density". Other variables like "Males per 100 females- 18 years and over", "% Asian" may not be as intuitive but the former is actually a mathematical measure of population movement versus stagnation and "% Asian" beyond a baseline may be an indication of a "Little China" which may serve as an indicator of a certain urban threshold. Appendix Table 2 has all the variables used in this analysis.

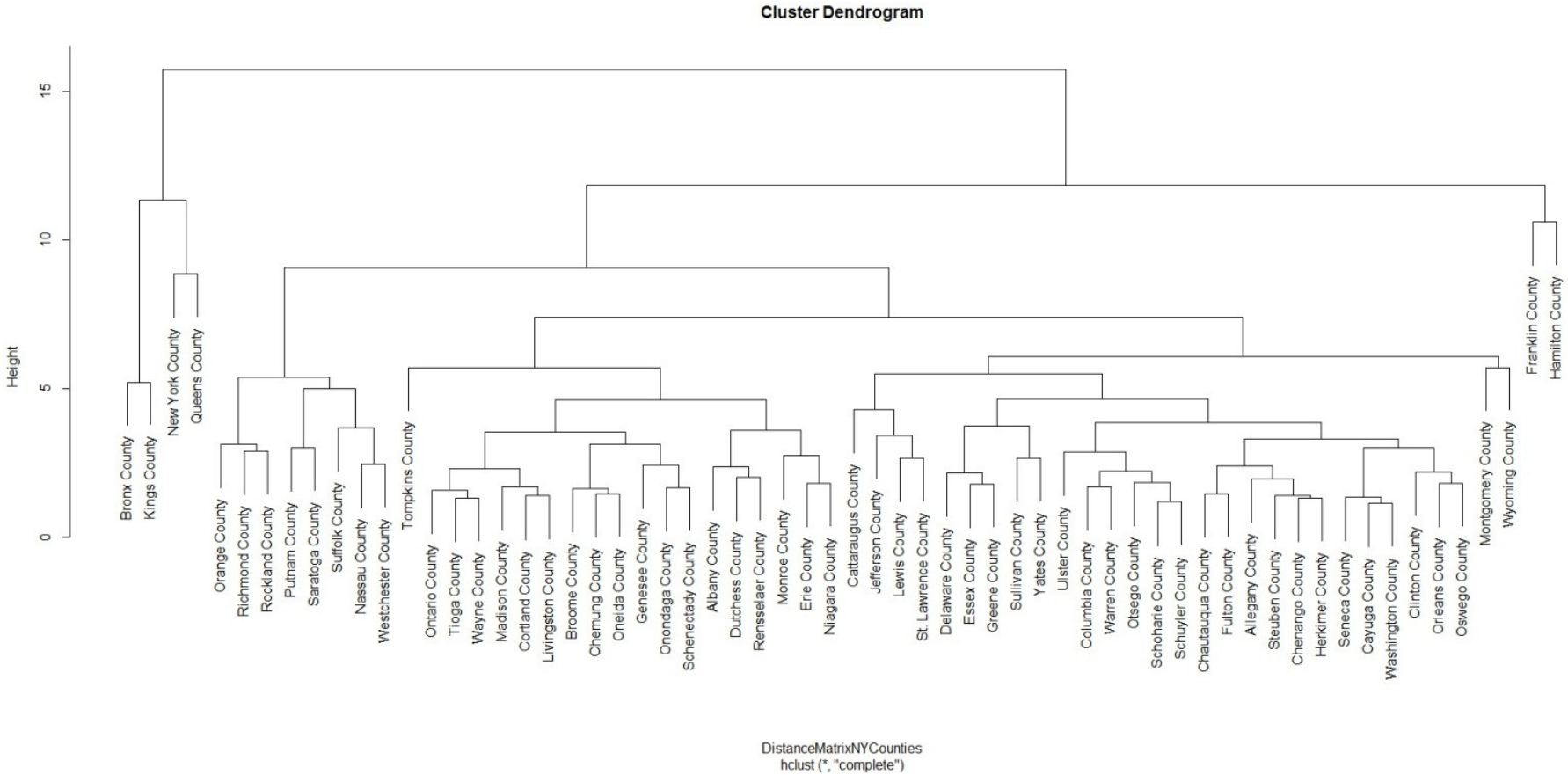
Appendix Table 2. Variables Selected For Cluster Analyses
Population 2010
USDA Natural Amenities Scale
% Black
% Native American
% Asian
%Housing Units Vacant
% Vacant Housing Units Available for Rent
%Vacant Housing Units for seasonal, recreational, or occasional use
Median household income (averaged 2010 and 2016)
Median Family Income (averaged 210 and 2016)
Males per 100 females - 18 years and over
% below poverty Line within last 12 months (2016)
% of adults who are military veterans
Population Density (per square mile of land)
Housing Unit Density (per square mile of land)
% of population highschool graduates
% of population under 18 years
% of population 65 years and older
Data taken from US Census Fact Finder

Hierarchical Cluster Analyses

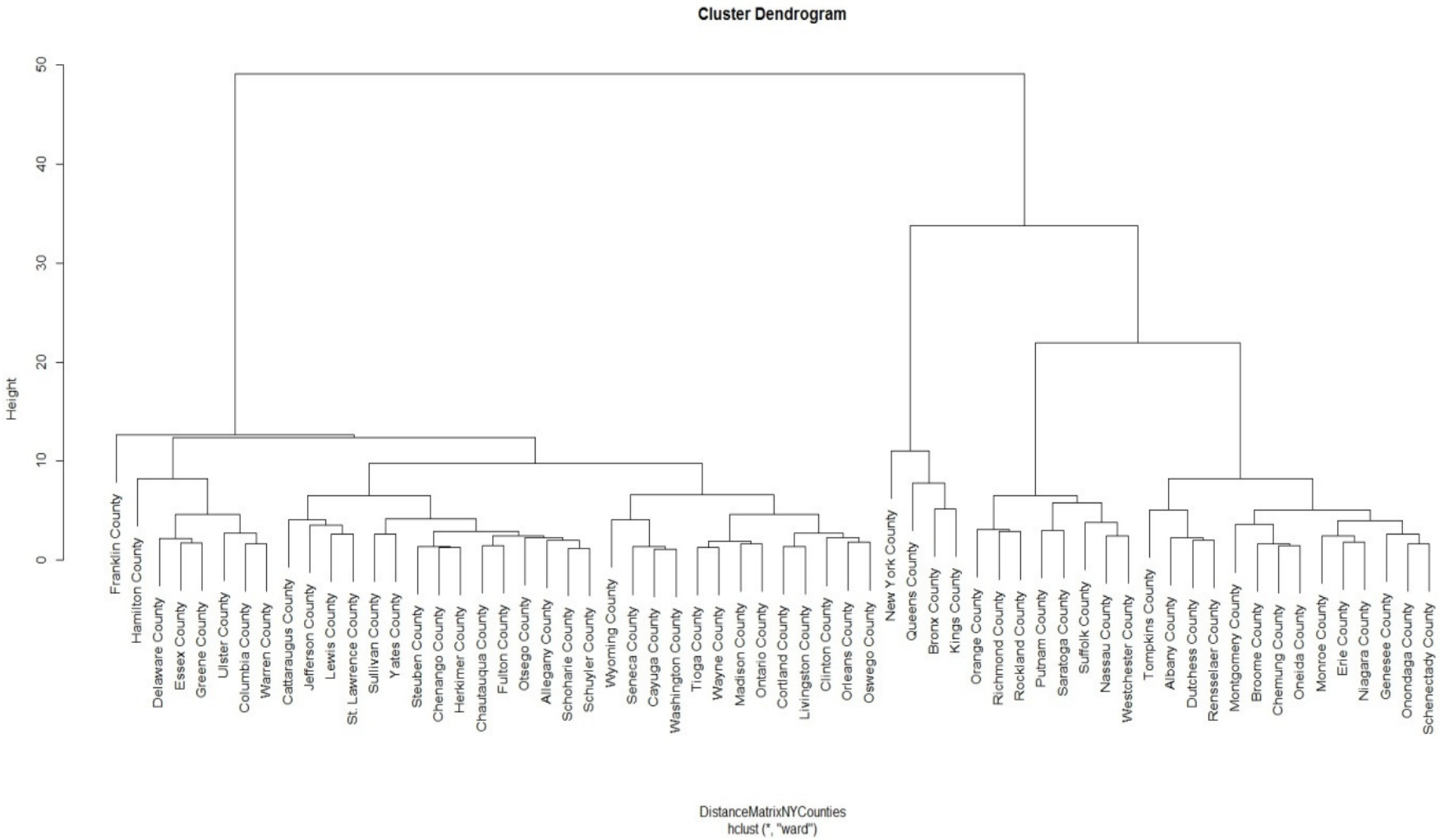
The hierarchical cluster analysis was performed in R using Euclidian distance on the data set after it had been standardized into z scores. With Hierarchical Clustering all the data points (counties) are originally seen as constituting their own cluster. Then the program joins the two closest clusters into one new cluster, then the program repeats until all the data points are a single cluster. As there is no standardized method of linkage in a hierarchical cluster analysis I ran two cluster analyses using two of the most common methods of linkage: Complete linkage and Ward's Method. Complete linkage joins clusters based on the most extreme value in any pairwise comparison, thus preserving extreme outliers as definitional to the clusters. Ward's method on the other hand, calculates a central point of each cluster after each step and uses it for future joins. The philosophical difference between using only real data points (Complete Linkage) vs the theoretical center of a cluster (Ward's Method) is irresolvable and there is no metric other than researcher judgment in choosing the method

The normal method of comparing the result of a hierarchical cluster analysis is through dendrogram (Appendix Figures 5 and 6). It is important to note here that the interpretation of cluster analysis relies upon researcher decision rather than agreed-upon cut off values. The principal guiding the decisions is the fact that in a hierarchical cluster analysis the higher on the dendrogram the more unlike the groups being clumped together are. Thus at the top of the dendrogram are always the most unlike groups being forced together.

Appendix Figure 5. Cluster Dendrogram Complete Linkage



Appendix Figure 6. Cluster Dendrogram Ward's Method



After comparing the two outcomes of the hierarchical cluster analysis I decided that I prefer the Complete Linkage method. The main reason for this preference is its preservation of the extremes in the Rural-Urban Continuum. For the complete linkage method the bulk of the counties get lumped together before the extremes (Bronx, Kings, New York, and Queens counties on the left and Franklin and Hamilton counties on the right in Figure 5) get grouped together. In other words these six counties have individual values which are so extreme that all the other counties get joined before those six counties. The extreme Urban (New York City excluding Staten Island) is the final cluster to join to the rest of the counties of New York. The extreme rural cluster (Hamilton and Franklin counties) is the next to last group to join together with the rest of the New York Counties. This seems a good indication on how distinct the extreme urban and rural are. Ward's method, on the other hand, mediates the extreme values in Hamilton and Franklin results and the extreme rural is not in evidence in this method.

The challenge in using the complete linkage method is the correct number of clusters to use. A simple three cluster solution would simply put the extreme urban, extreme rural, and the rest of the state. Any difference in the bulk of the state would be masked in order to join the most extreme urban to each other and the most rural to each other. On the other hand, a solution that retains the three groups that seem to present themselves in the bulk of the counties would require an eight group solutions where New York, Queens, Franklin and Hamilton counties each constitute their own cluster. This is both a violation of the assumptions of ANOVA analyses and unenlightening philosophically.

Putting aside the grouping of the extreme rural and urban, the remaining counties present three main groupings. I contrasted these clusters with the agreed upon "Metropolitan" "non-Metropolitan" data categorizations (data which was not used in the cluster analysis). The logic

here is to see how well this hardline definition from the US census is reflected in the raw data associated with the counties. The smallest group of eight counties is made up entirely of "Metropolitan" counties. The next group has a total of eighteen counties and is likewise "Metropolitan" with two exceptions (Cortland and Geneesee counties) one of which used to be metropolitan but lost that status in the 2000 census. The final group of 29 counties contains all the rest of the counties, which includes 9 counties that are (or were) metropolitan at some point over the last 30 years. This seems to indicate that the cluster analysis finds less diversity among the non-Metropolitan counties than it does between types of Metropolitan. This classification is then useful in contrasting a procedurally distinguished Rural-Urban Continuum with the researcher distinguished.

Ultimately I chose to use the extreme rural/urban groupings along with the 3 groupings of the majority of NY counties in a nontraditional fashion. It is my judgment that the ways in which the majority of the counties are joined in the hierarchical cluster analysis is instructive for future analyses as are the extreme rural and urban groups. This is a philosophical judgment somewhat akin to the idea of "Winsorizing" where outlying data is retained but the extreme values are moderated so the outliers do not obscure the relationships in the overall data. By putting Hamilton and Franklin as the "extreme rural" and Kings, Queens, New York, and Bronx counties as "extreme urban" and retaining the other three groupings, the resulting five cluster solution is retained.

K-means Clustering

The K-means clustering analysis works by placing a certain number of central points in the eighteen dimensional dataspace and then find positions of those centroids that minimize

distance to all datapoints. This means that different results occur depending on the number of clusters specified. The largest number of clusters (k=7) resulted in two clusters defined by a single case. These outliers (Franklin and Manhattan) again illustrate the strength of the extremes on the Rural-Urban continuum as they can be seen as exemplars of the extreme Rural and Urban. However, clusters defined by a single point are not appropriate for ANOVA and therefore this solution is not tenable. Nor is the five cluster solution which likewise has a cluster defined by a single point.

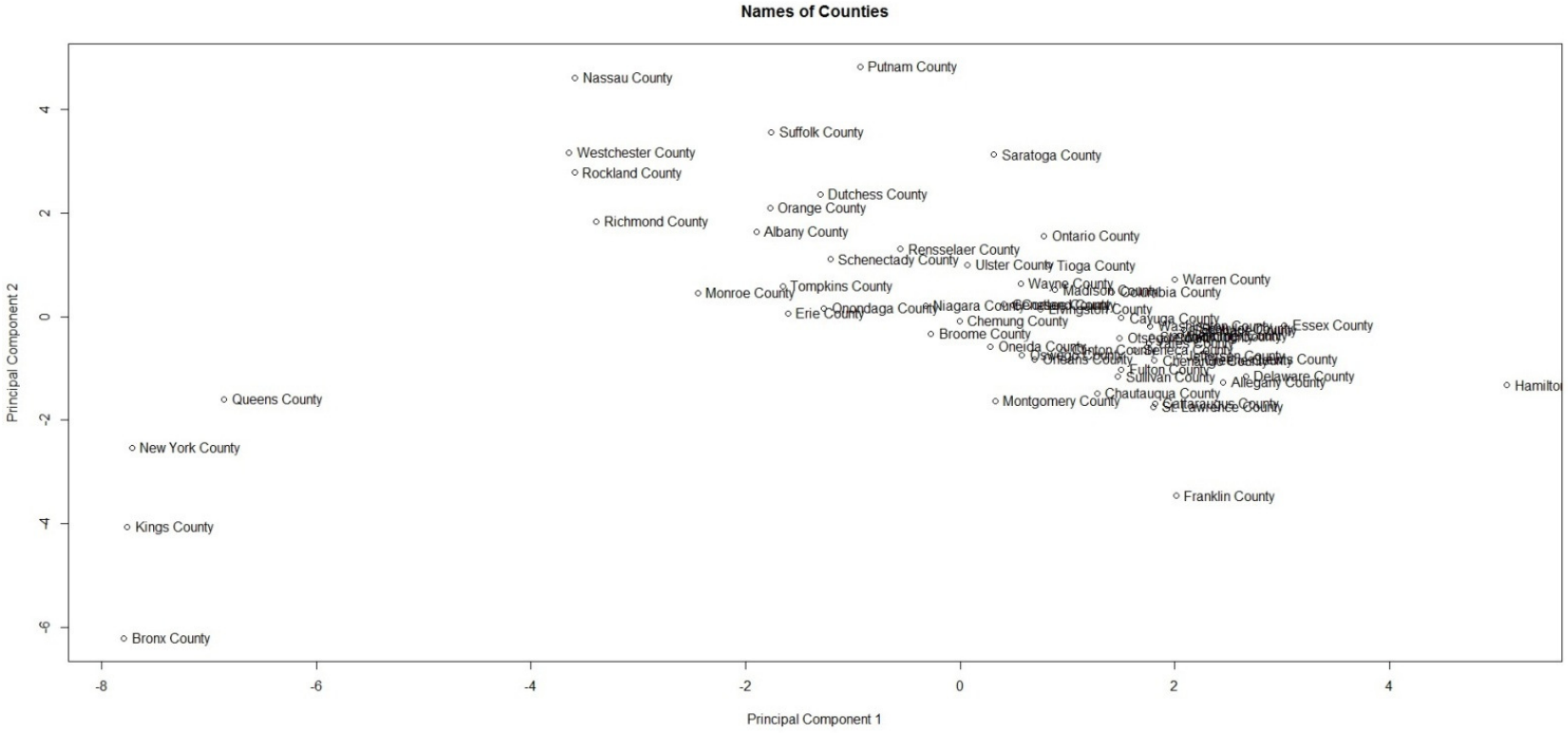
The smallest cluster solution (k=3) is the one that is ultimately retained. This clustering solution distinguishes between two categories of Metropolitan Counties and leaves the majority of counties (Metropolitan and non-Metropolitan) in its own cluster. This again seems to indicate that the data demonstrate a bigger difference inside the Metropolitan category than they do in the non-Metropolitan counties.

Visualizing the Clusters and Categories

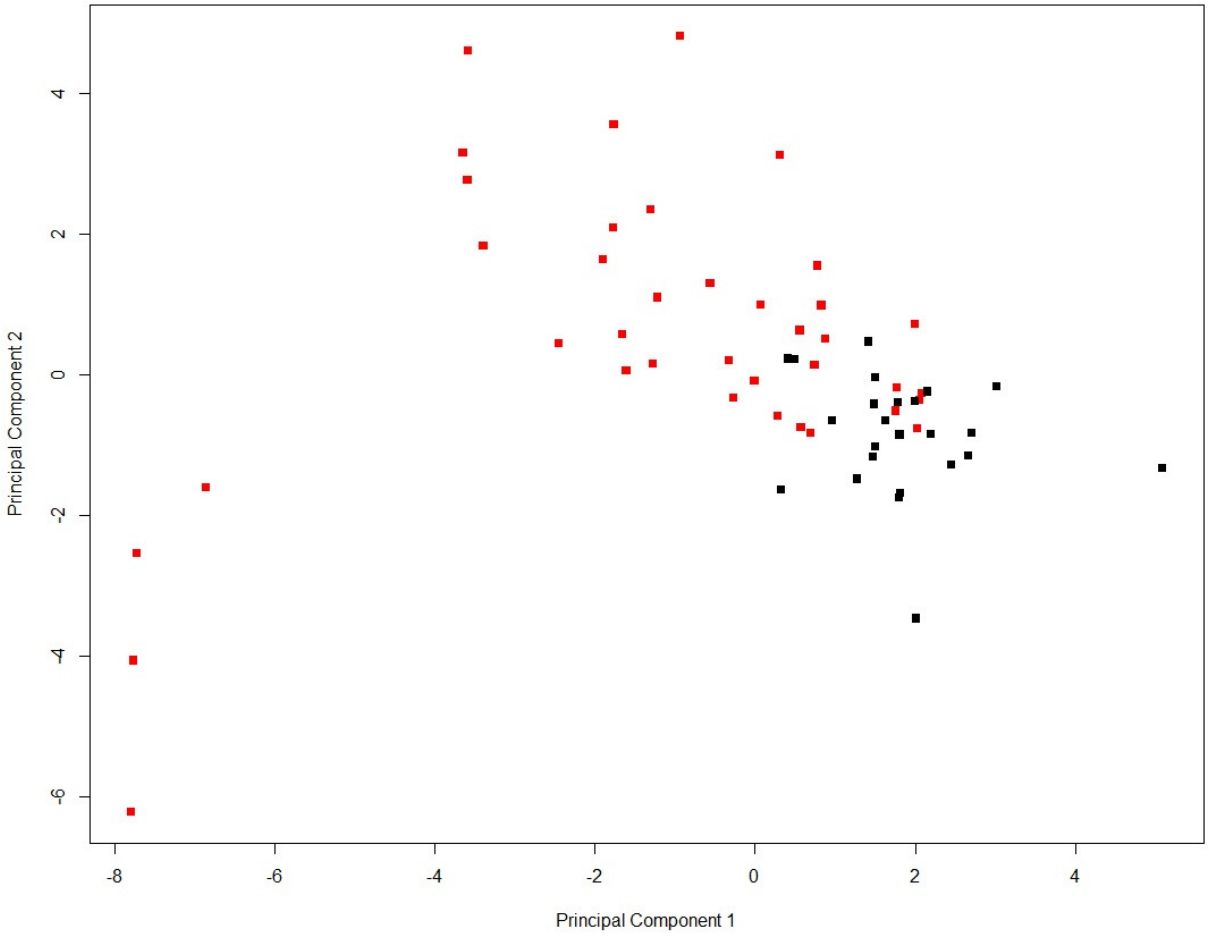
In order to visualize the cluster and categorizations they are presented here as scatterplots using the Principal Component Analyses (PCA) as the XY axes. Principal Component Analysis uses vectors to capture as much of the variance in the Data Space as possible. The First Principal Component will necessarily be the axis that captures the majority of the variance and the Second Principal Component the next most variation in the data. While this technique is often used to try to identify underlying concepts in measurement, in this case the technique is used to show something about the structure of the data which was used to calculate the clusters. By displaying the clusters along these axes we can see the two most important aspects of the data and where each county and cluster falls. Here I show the county names as points (Appendix Figure 7), the metropolitan-non-Metropolitan dichotomy (Appendix Figure 8), metropolitan only with the

subgroups as clusters (Appendix Figure 9), the Winsorized Hierarchical cluster solution (Appendix Figure 10) , the kmeans cluster solution (Appendix Figure 11), and finally in the remaining figures (Appendix Figures 12,13,14, and 15) I show the base categories with only 2 distinctions between the Metropolitan counties (Megalopolis vs Small Urban) . The figures are not exhaustively labeled and are presented here mainly to give an idea of how the same counties are differently categorized depending on the approach.

Appendix Figure 7. Counties Along Principal Components



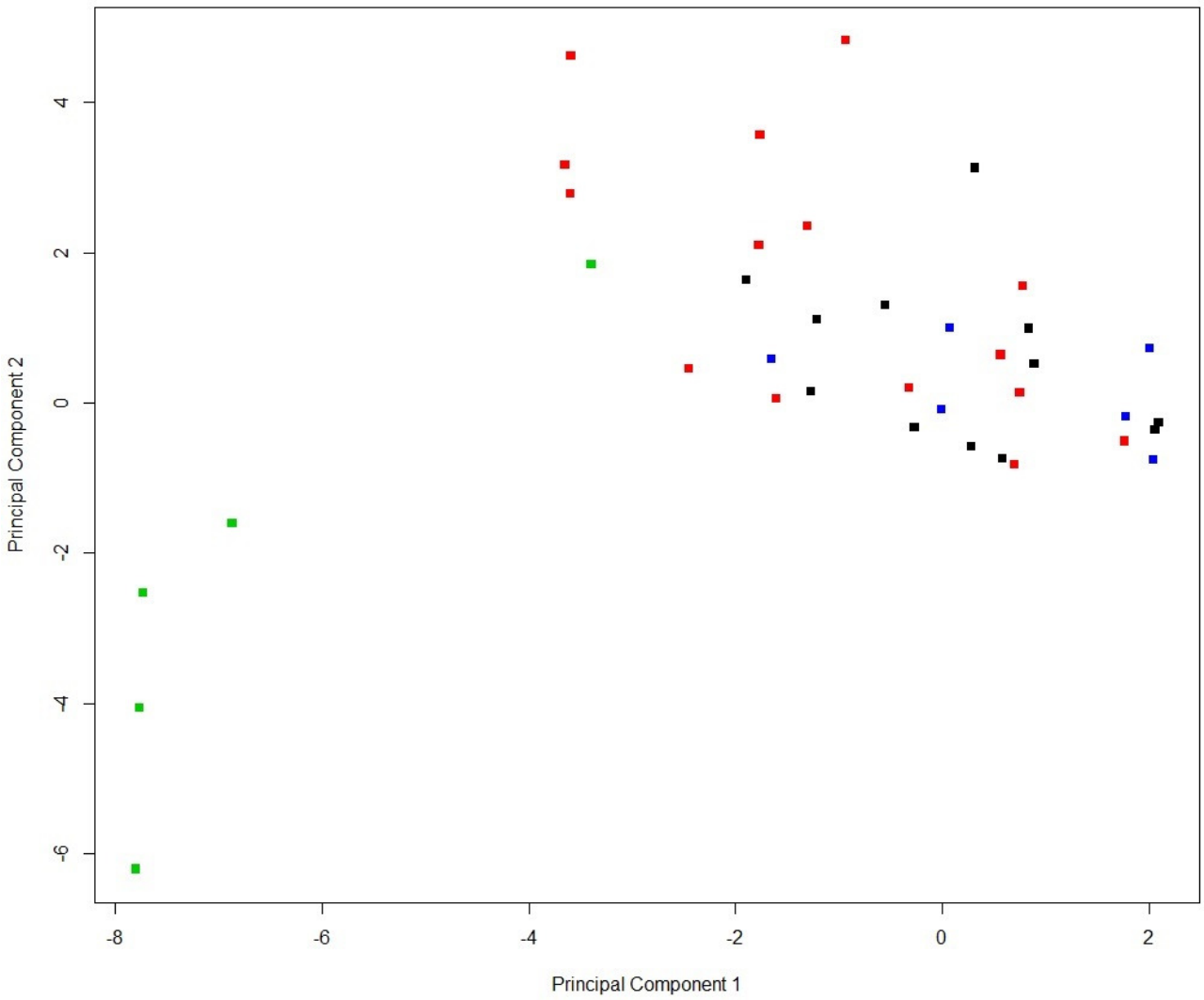
Appendix Figure 8. Metropolitan vs Non-Metropolitan counties On Principal Components



Red= Metro

Black= Non-Metro

Appendix Figure 9. Metropolitan County Categories On Principal Components.



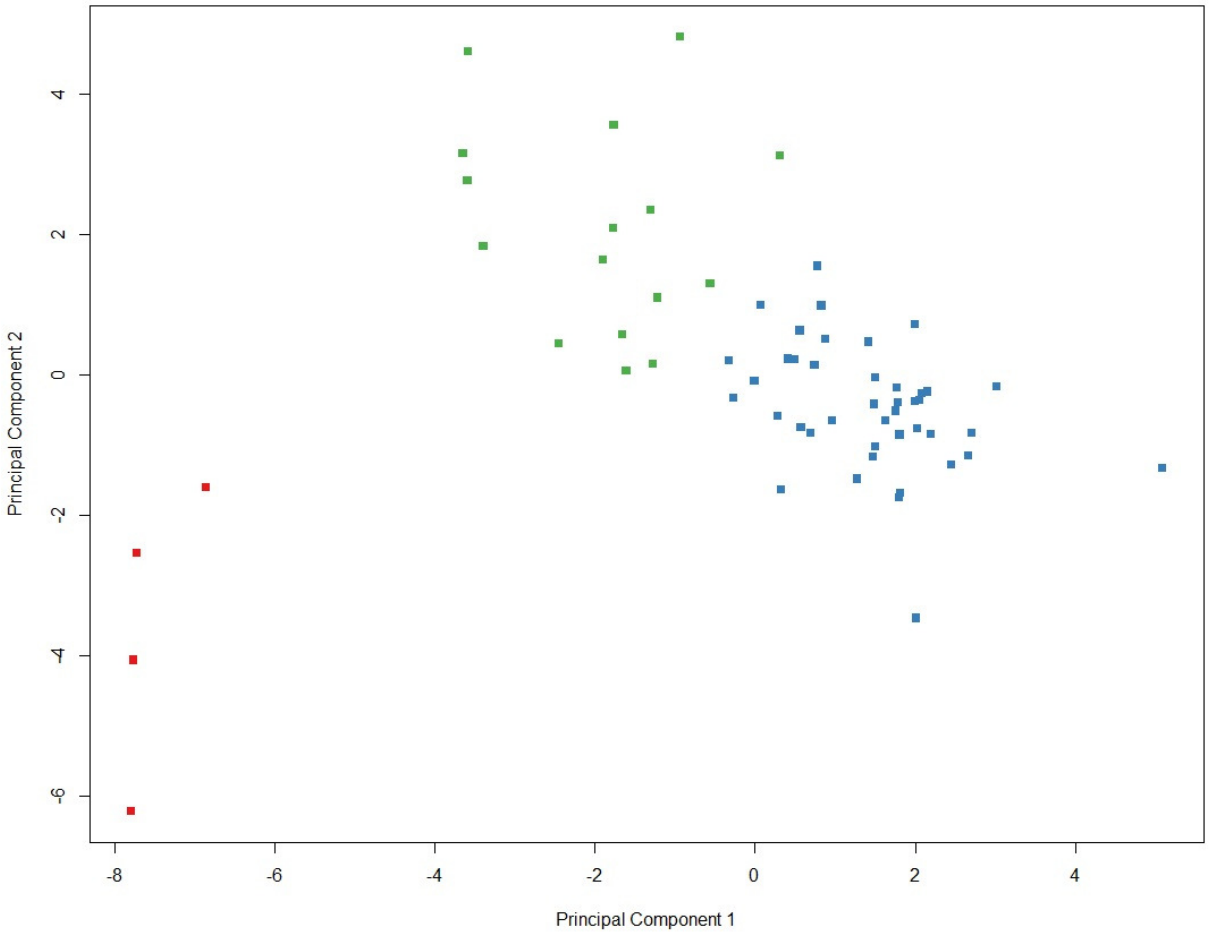
Green: NYC

Blue: Small City

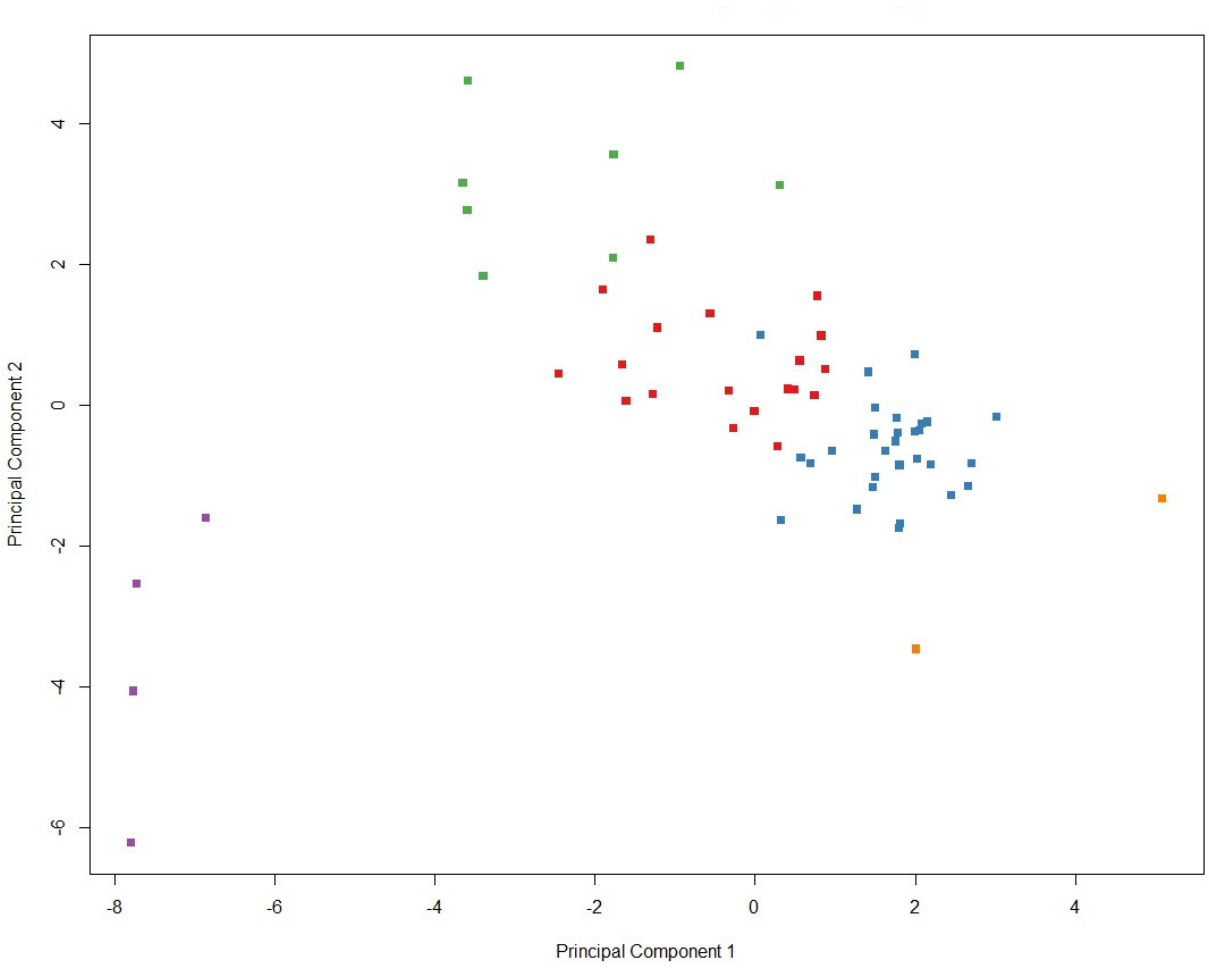
Black: City

Red: Megalopolis

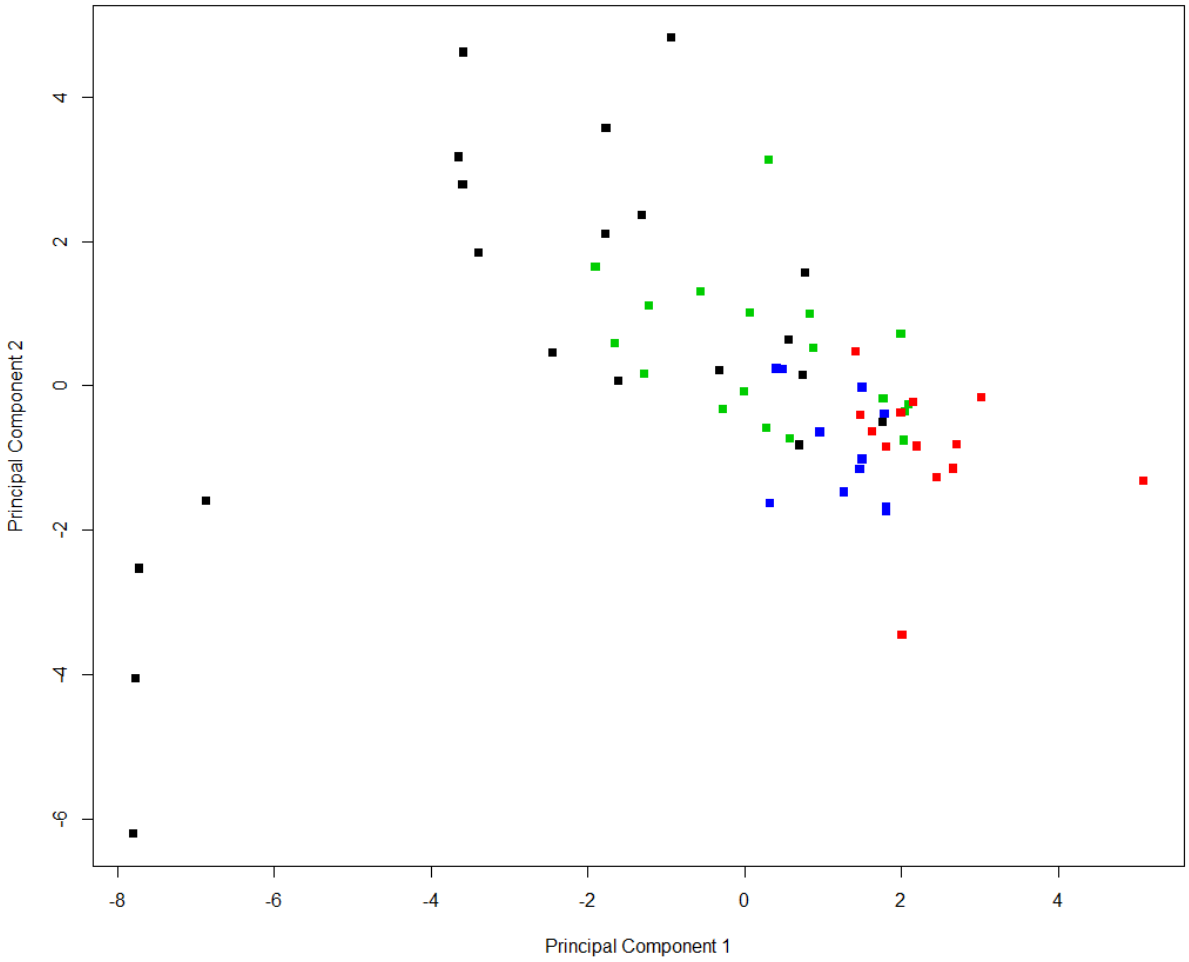
Appendix Figure 10. K-means 3 Cluster Solution on Principal Components



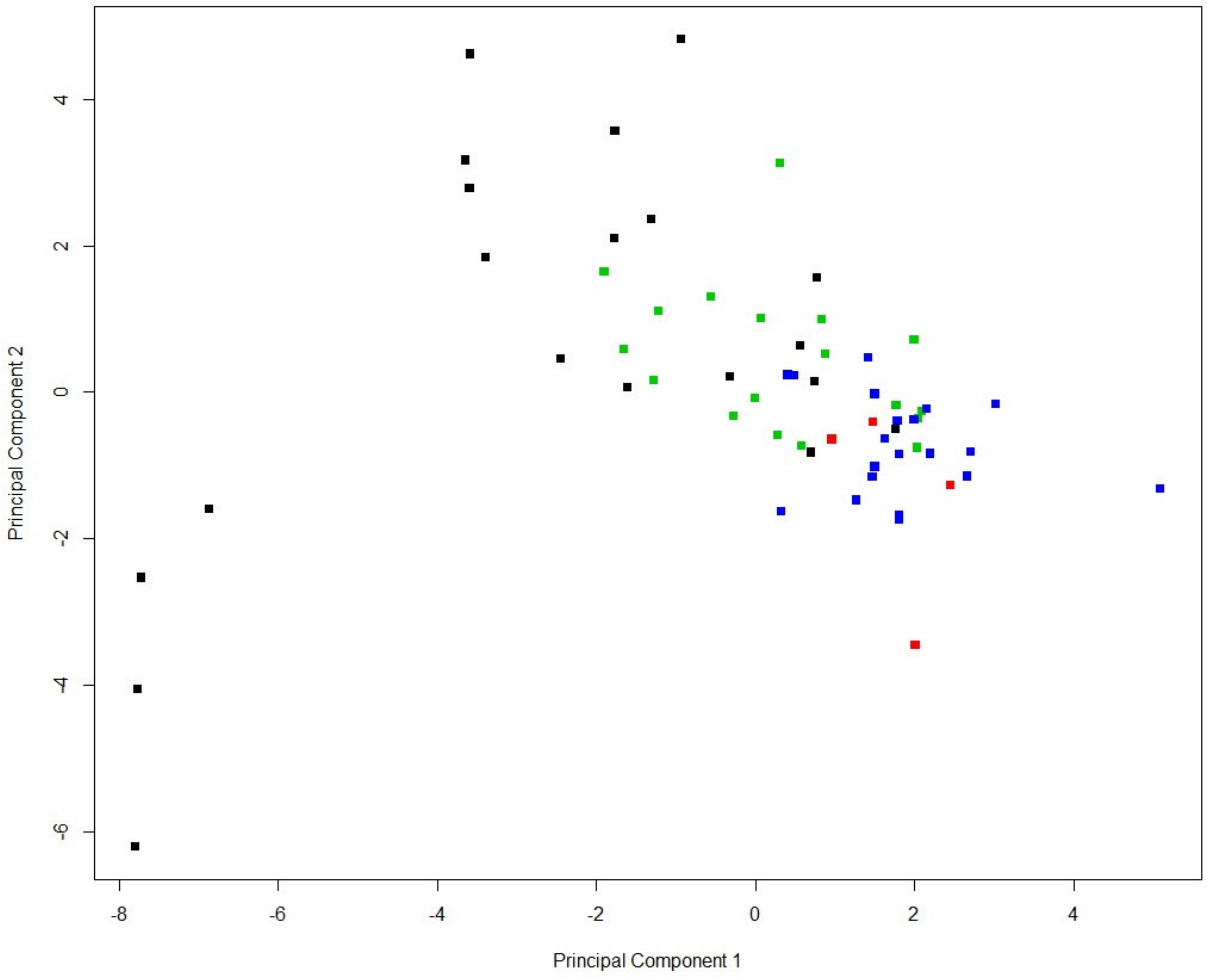
Appendix Figure 11. Winsorized Hierarchical, 5 Cluster Solution



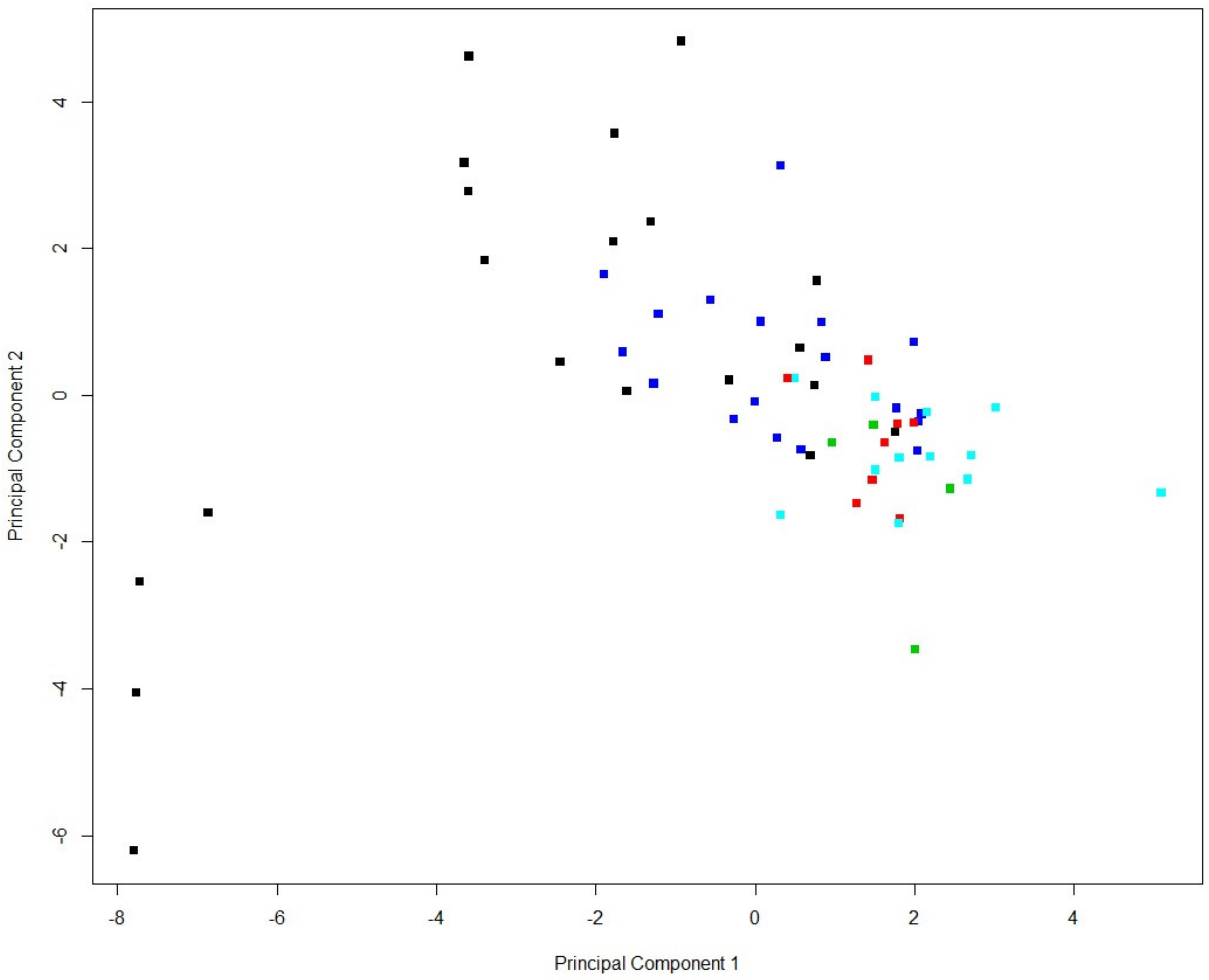
Appendix Figure 12. Population Defined Categories On Principal Components



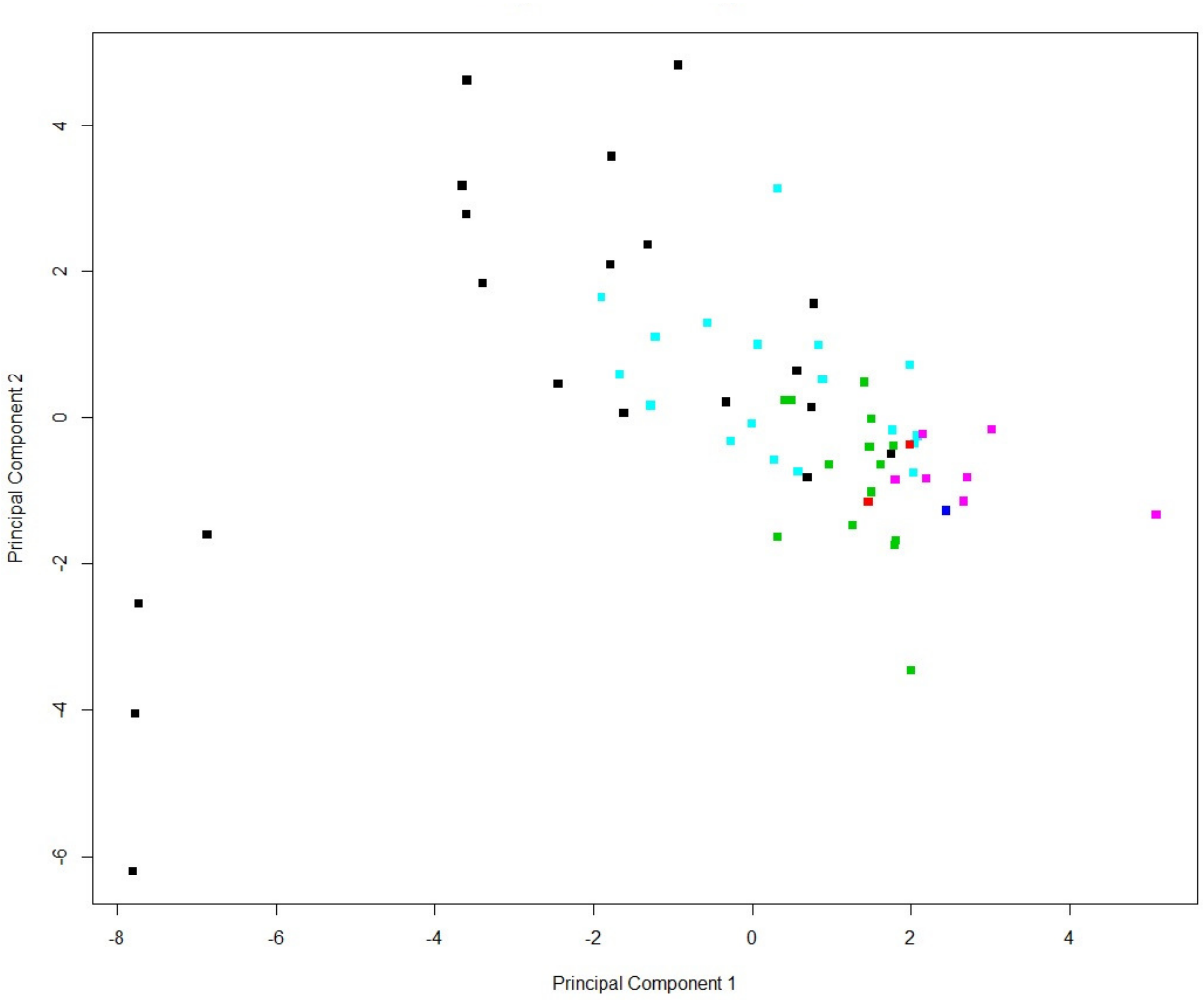
Appendix Figure 13. Adjacency Defined Categories On Principal Components



Appendix Figure 14. Adjacency And City Size Defined Categories On Principal Components



Appendix Figure 15. Micropolitan Based Categorizations On Principal Components



Appendix 3: Complete ANOVA Writeup

Summary:

Altogether 28 ANOVA models were run, 14 models with the two DV's measuring: The Ratio of Cook's Index and the Pistol Permit Rate. Of the 28 models, only 4 failed to meet the minimum criteria for significance. These nonsignificant models were mirrored results, meaning that only 2 ways of dividing the Rural-Urban Continuum resulted in the null hypothesis being retained. All the other methods of dividing the counties found significant differences in the ratio of Cook's Index to the Pistol Permit Rate across categories of the Rural-Urban Continuum.

Independent Variable: The Rural-Urban Categories

ANOVA models were run with the 4 main approaches to categorization of New York Counties into the Rural-Urban Continuum: Population Based, Adjacency to Metro Area, Micropolitan, and Cluster Analysis. Inside each of these approaches (except Cluster Anaylsis) multiple ANOVA models were run with varying degrees of Metropolitan Counties. As was mentioned earlier, while each approach differs on how it divides the Non-Metropolitan counties, they are all in agreement about where the line between Metropolitan and Non-Metropolitan counties is. As Metropolitan counties comprise a majority of New York counties (38 out of 62 total counties), how these should be divided is an open question. The approaches chosen are detailed in the Data section, especially in Table 6, alongside the cluster analyses summarized in the Data section and detailed in Appendix 2.

Dependent Variable - Ratio of Cook's Index to Pistol Permit Rates

The dependent variable here is a fairly complex ratio composed of two other ratios which are then compared to each other. The logic is simple even if the math and interpretation appears convoluted: Cook's Index attempts to measure firearm prevalence (including handgun specific prevalence). The Pistol Permit rates are actual measures of legitimate handgun ownership. The ratio between these two measures ought show nothing but statistical noise. If however there is variation in the ratio across categories of the RUC, then that is evidence that Cook's Index as it stands is being confounded by the RUC and a more complex proxy is needed. While the methods of calculating Cook's Index are clear, the correct way to measure Pistol Permit Rate has not been established so two methods are presented. This results in two dependent variables:

(Cook's Index 1999-2015)/(Sum of Permits 2007-2011/Average Population 2007-2011)

(Cook's Index 1999-2015)/ (Average of the calculated Permit Rates 2007-2011)

Cook's Index

The form of Cook's Index most recently and strongly endorsed by Cook is the simple ratio of (Firearm Suicides/Suicides) abbreviated as (FS/S). This he argues is the most valid available proxy. In order to estimate prevalence this is linearly transformed to estimate the percent of the population that owns a firearm, without reference to population. In a correlation matrix, any linear transformation of Cook's Index and Cook's Index itself yield identical correlations. So rather than using the formula to transform the FS/S into % handgun ownership the base FS/S was used. And as no population measure was used to calculate the FS/S in the paper, I did not use one either.

The one point of contention open here is the use of the FS/S for the years 1999-2015. This was retained for several reasons. First, one of the premises of the current study is that the Rural-Urban Continuum is a fairly stable construct. I have offered extensive analysis showing that in the case of New York at least this does seem to be true. The categories are fairly stable over time. Second, The idea is to compare the best, most complete, versions of both measures. Restricting the FS/S to the same years as there is pistol permit data resulted in a majority of suppressed cells. In the interests of using the best possible data to describe the NY counties, I followed Cook's example of using multiple years to calculate the FS/S, though admittedly I used a significantly longer stretch of years.

Pistol Permit Rates

To calculate the pistol permit rates several pieces of data had to be tied together. First the data from NYPD Pistol Permit Bureau was analyzed. This data is a measure, for a stretch of years, of how many new pistol permits were issued each year. There is an important caveat here. These are license issuance data and do not reveal how many total permits are in the county. Thus I am creating an assumption that the issuance permit rate corresponds in a meaningful manner with the total population of permit holders. As the permit holder population must be issued their licenses, there is at least some direct link between these constructs.

In the Pistol Permit Data, New York City Pistol Permit data was lumped together rather than reported by each borough/county. To obtain complete county estimates the NYC data was amortized among its boroughs for each of the 5 years(2007-2011). This means that this group of counties does not have its true variation measured and the counties are artificially identical.

Separately, the CDC WONDER database was queried for yearly population estimates for the years 2007-2011 and these data were merged into a single database. These count data were transformed to create two different Pistol Permit Rates for use in the final DV.

For the First calculated Pistol Permit Rate, I summed the 5 years of pistol permit issuances and divided by the average population over the 5 years. Finally, I multiplied this by 100,000 to get a Pistol Permit Rate per Capita for each county. By doing this I created an assumption that these newly issued permits continued to be held in the county in question and the owners were still alive at the end of the period.

For the second calculated permit rate, a permit rate per capita was calculated for each year and those rates were then averaged for the period. The number of permits from each county divided by that year's population estimate was then multiplied by 100,000. The 5 averages were then themselves averaged, yielding an average permit rate for each county.

Ratios: (FS/S)/ Pistol Permit Rate

The two permits rates formed the denominators for the two DV's with FS/S serving as the numerator. Thus, I have the ratio of Cook's Index to the Summed Permit/Average Population for the first DV and the ratio of Cook's Index to the Averaged Permit Rates for the second DV.

Analyses

For analyzing the relationship between a categorical Independent Variable with more than 2 states and a quantitative Dependent Variable Analysis of Variance (ANOVA) is the relevant statistical test. ANOVA avoids the alpha inflation that would result from multiple T-

tests among the categories. Given an analysis where the p-value is less than .05, follow up analyses are employed.

Due to unequal N and an overall fairly small N (62 counties), follow up analyses were calculated 3 ways: Tukey-Kramer's HSD, a variation of the Honestly Significant Difference that allows unequal N but continues to assume equal variance. Dunnett's modified Tukey-Kramer which no longer assumes equal variance. To contrast these more conservative tests, Fisher's LSD (one of the most sensitive follow ups) was also calculated. Additionally effect size estimates are included, these are presented in the η^2 squared or r^2 form and are derived by the formula:

η^2 or r^2 = F/(F+degrees of Freedom)

Due to the large number of ANOVAs, I will go through the ANOVAs by the 4 approaches to categorization. For each approach I will report the ANOVAs with both DVs and each model's relevant follow up analyses and effect size estimate.

Cluster Analysis Categorizations

As was previously shown, cluster analyses of the NY counties using census data were pursued. The 5 group winsorized hierarchical cluster and the 3 group kmeans cluster solutions were saved and then ANOVAs calculated with each method of categorizing the NY counties. As I will show the Kmeans approach finds more significant relationships and has a stronger effect size estimate. There is strong evidence that NYC (minus Staten Island) is significantly different from the rest of NYC with regards to the DVs, and some weaker evidence that other differences also exist along the Rural-Urban Continuum.

Hierarchical Clusters

- summed permits/avg population ratio

A one way between groups ANOVA was run to compare the differences between the 5 categories of the Rural-Urban Continuum (as defined by the hierarchical cluster analysis) with respect to the ratio of Cook's Index to the permit rate. There was a significant effect at the $p<.05$ level [F(4,57)=13.75, p=6.57E-8]. The effect size estimate is η^2 =0.194346

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to .05. Dunnett's modified Tukey-Kramer's HSD (nonpooled variance) found no significant pairwise comparisons. Tukey-Kramer's HSD found a significant difference between group4 and groups 1,2,3, and 5. This is the same pattern of pairwise results as Fisher's LSD.

- averaged permit rates

A one way between groups ANOVA was run to compare the differences between the 5 categories of the Rural-Urban Continuum (as defined by the hierarchical cluster analysis) with respect to the ratio of Cook's Index to the permit rate. There was a significant effect at the $p<.05$ level [F(4,57)=13.72, p=6.72E-8)]. The effect size estimate is η^2 =0.194005

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to .05. Dunnett's modified Tukey-Kramer's HSD (nonpooled variance) no significant pairwise comparisons. Tukey-Kramer's HSD found a significant difference between group4 and groups 1,2,3, and 5. This is the same pattern of pairwise results as Fisher's LSD.

- Taken Together

For both DVs significant results were obtained with identical pairwise comparisons. Ultimately group 4, comprised of the New York City Boroughs (Staten Island excepted) is the

only significant pairwise comparison using this categorization. This group has a ratio of Cook's Index/Permit Rate that is significantly larger than the remaining groups. This relationship holds (as does the size of the effect estimate) for both DV's. As a whole the follow up analyses for this ANOVA indicate that New York City is significantly different from the remaining categories. For this categorization, the remaining NY counties are unable to be distinguished from each other.

	Group 1
(NYC)	Group 2
Group 4 >	Group 3
	Group 5

Kmeans Clusters

- summed permits/avg population ratio

A one way between groups ANOVA was run to compare the differences between the 3 categories of the Rural-Urban Continuum (as defined by the kmeans cluster analysis) with respect to the ratio of Cook's Index to the permit rate. There was a significant effect at the $p<.05$ level [$F(2,59)=30.37$, $p=8.54E-10$]. The effect size estimate is $\eta^2=0.3398223$

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to .05. Dunnett's modified Tukey-Kramer's HSD (nonpooled variance) found no significant pairwise comparisons. Tukey-Kramer's HSD found a significant difference between

group 1 and group 2 as well as group 1 and 3. Indicating that group 1 is significantly different from the other two groups. Follow ups using the LSD found significant differences between all three groups. It is worth noting that the Tukey-Kramer almost found a distinction between groups 2 and 3 (p=.069) While this failed to reach significance, in conjunction with a significant effect using the LSD, and the overall low N, this might be indicative of a power problem.

- averaged permit rates

A one way between groups ANOVA was run to compare the differences between the 3 categories of the Rural-Urban Continuum (as defined by the kmeans cluster analysis) with respect to the ratio of Cook's Index to the permit rate. There was a significant effect at the $p<.05$ level [$F(2,59)=30.34$, $p=8.7E-10$]. The effect size estimate is $\eta^2=0.339602$

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to .05. Dunnett's modified Tukey-Kramer's HSD (nonpooled variance) found no significant pairwise comparisons. Tukey-Kramer's HSD found a significant difference between groups 1 and group 2 as well as group 1 and 3. Follow ups using the LSD found significant differences between all three groups. It is worth noting that the Tukey-Kramer almost found a distinction between groups 2 and 3 (p=.06). While this failed to reach significance, in conjunction with a significant effect using the LSD, and the overall low N, this might be indicative of a power problem.

- Taken Together

Overall this is an ANOVA that is significant and has a strong effect (accounting for approximately a third of the measured variance). For both DV's, the pairwise comparisons

indicate that group 1 (again composed of NYC minus Staten Island) is significantly different from the rest of New York State when comparing the ratio of Cook's Index and permit rates.

NYC >	Group 2
	Group 3

The more sensitive LSD follow ups indicate that all three groups are distinct from each other.

NYC >	Group 3 >	Group 2

In this categorization group 3 is composed entirely of Metropolitan counties, while group 2 is composed of the remaining New York State Counties, which is also the majority of counties. Group 3 would be considered (based on the cluster analysis) as living on the more "urban" side of the Rural-Urban Continuum. While the LSD is considered by some to be overly sensitive, the comparison between groups 2 and 3 was close to significance even using the more conservative Tukey-Kramer, and again with the low overall N, this is perhaps an indication of a power problem.

Regardless, this is evidence that Cook's Index does not correlate with Pistol Permits in the same manner across New York. Certainly for New York City (Staten Island excepted), and possibly across more groupings.

Micropolitan Approach to Categorization

No Rural category: a single county can't be used for ANOVA. Was incorporated to the "suburb" category.

The changes in significance and effect sizes as the urban counties were divided into more categories show an interesting pattern. The Micropolitan approach with the urban counties divided into Small Urban, Megalopolis, and NYC seems to maximize the effect size and the number of significant pairwise comparisons. Moving the Small Urban into "City" and "Small City" categories turned a significant pairwise comparison into 2 comparisons both of which failed to attain significance by a narrow margin. The 3 degrees of Urban (Small Urban, Megalopolis, and NYC) seems the most salient comparison.

Again I found strong evidence that NYC has a unique (and larger) mean value. And again I found weaker evidence that there is also a difference between the more rural and the urban, both when NYC is part of a larger urban category and when NYC is in its own category. Importantly for future categorization purposes there was no evidence that the "Micropolitan" category was unique in these analyses.

- summed permits/avg population ratio

Micropolitan, 2 Degrees Urban

A one way between groups ANOVA was run to compare the differences between the 4 categories of the Rural-Urban Continuum in the base Micropolitan organization (Suburb, Micropolitan, Small Urban, and Megalopolis). The ratio of Cook's Index to the permit rate was the DV. There was a significant effect at the $p<.05$ level [$F(3,58)=2.985$, $p=0.0385$]. The effect size estimate is $\eta^2=0.048946$

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found only one significant difference (Small Urban>Suburb). Tukey-Kramer likewise found only one difference but with a separate comparison (Megalopolis > Suburb). The LSD comparison mirrored the Tukey-Kramer finding (Megalopolis > Suburb).

Micropolitan, 3 degrees urban

A one way between groups ANOVA was run to compare the differences between the 5 categories of the Rural-Urban Continuum in this Micropolitan organization (Suburb, Micropolitan, Small Urban, Megalopolis, NYC). The ratio of Cook's Index to the permit rate was the DV. There was a significant effect at the p<.05 level [F(4,57)=10.09, p=3.04E-6]. The effect size estimate is η^2 =0.150395

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found no significant pairwise comparisons. Tukey-Kramer's method found significant pairwise comparisons with NYC. This method found that NYC was significantly greater than all other categories. The LSD mirrored this but also found a significant comparison that Small Urban > Suburb.

Micropolitan, 4 degrees urban

A one way between groups ANOVA was run to compare the differences between the 6 categories of the Rural-Urban Continuum in this Micropolitan organization (Suburb, Micropolitan, Small City, City, Megalopolis and NYC). The ratio of Cook's Index to the permit rate was the DV. There was a significant effect at the p<.05 level [F(5,56)=7.937, p=1.04E-5]. The effect size estimate is η^2 =0.124138

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found no significant pairwise comparisons. Tukey-Kramer's method found significant pairwise comparisons with NYC. This method found that NYC was significantly greater than all other categories. The LSD follow up analyses mirrored this exactly.

- averaged permit rates

Micropolitan, 2 Degrees Urban

A one way between groups ANOVA was run to compare the differences between the 4 categories of the Rural-Urban Continuum in this Micropolitan organization (Suburb, Micropolitan, Small Urban, and Megalopolis). The ratio of Cook's Index to the permit rate was the DV. There was a significant effect at the $p<.05$ level [$F(3,58)=2.995$, $p=0.038$]. The effect size estimate is $\eta^2 =0.049102$

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found two pairs of significant differences: (Suburb<Megalopolis; Suburb<Small Urban). Tukey-Kramer's method found only one significant pairwise comparison: (Suburb<Megalopolis). The LSD mirrored the Tukey-Kramer with (Suburb<Megalopolis).

Micropolitan, 3 degrees urban

A one way between groups ANOVA was run to compare the differences between the 5 categories of the Rural-Urban Continuum in this Micropolitan organization (Suburb,

Micropolitan, Small Urban, Megalopolis, and NYC). The ratio of Cook's Index to the permit rate was the DV. There was a significant effect at the p<.05 level [F(4,57)=10.08, p=3.06E-6]. The effect size estimate is η^2 =0.150268

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found no significant pairwise comparisons. Tukey-Kramer found that NYC > than all the other mean values. LSD likewise found that NYC was greater than all the other comparisons. Using the LSD also showed that Small Urban > Suburb.

Micropolitan, 4 degrees urban

A one way between groups ANOVA was run to compare the differences between the 6 categories of the Rural-Urban Continuum in this Micropolitan organization (Suburb, Micropolitan, Small City, City, Megalopolis, and NYC). The ratio of Cook's Index to the permit rate was the DV. There was a significant effect at the p<.05 level [F(5,56)=7.933, p=1.05E-5]. The effect size estimate is η^2 =0.124083

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found no significant pairwise comparisons. Tukey-Kramer found that NYC > than all the other mean values. LSD likewise found this same difference. Interestingly, in this categorization "Small Urban" was broken into "Small City" and "City", in the previous categorization "Small Urban" was significantly different from "Suburb". In this new categorization, "Small City" and "City" both almost pass the significance test when compared with "Suburb".

- Taken Together

The pattern of effect sizes and F-values indicate that splitting the Metropolitan categories into 3 sub-categories (Small Urban, Megalopolis, and NYC) is the most statistically supported option. The η^2 values triple when we remove NYC from Megalopolis to its own category (.049 to .150; .048 to .150). However going from 3 categories to 4 we see a reduction in the effect size estimate.

The 3 degrees of urban categorization also has an additional significant pairwise comparison where the Small Urban > Suburb. This is a relationship that appears one other place: The base category using the averaged permit rates and the Dunnet Tukey Kramer comparisons. That this difference is found a couple of places but is easily lost is another indication that there might be a power problem in finding the differences in the rural end of the RUC. It is logical that the Dunnet Tukey Kramer, as it is calculating variance separately for each group would lose significance as the sample sizes decrease.

This is also the first evidence that the 2 DVs may be slightly different in effect. The Summed permits/Avg Pop only shows 1 significant pairwise using the Dunnet Tukey Kramer, while the averaged permit rates, shows us 2. This is a small overall effect, but it is a measured difference.

Population Based Categorization

Population (and to a lesser extent population density) are commonly used measures of the Rural-Urban Continuum and so are included in these analyses. As these patterns show, other approaches are superior at finding the actual underlying differences along the RUC.

Using population cutoffs to determine categories resulted in generally less informative analyses. Two models in these approaches failed to achieve to significance (The 2 degrees of urban categorizations with each DV). In general the pattern shows that whatever category has

NYC counties, is significantly different from the rest of the New York counties. These analyses also concur with the Micropolitan models that 3 degrees of urbanization seem to maximize effect size. Both fewer and more categories result in less informative models.

- summed permits/avg population ratio

Population Base Categorization

A one way between groups ANOVA was run to compare the differences between the 3 categories of the base Population approach to categorization (Rural, Suburb, and Urban). The ratio of Cook's Index to the permit rate was the DV. There was a significant effect at the $p<.05$ level [$F(2,59)=3.314$, $p=0.0433$]. The effect size estimate is $\eta^2=0.053182$

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found one significant pairwise comparison (Urban>Suburban). Tukey-Kramer found no significant pairwise comparisons. LSD found that (Urban>Rural). Especially as the cell means between Rural and Suburban are identical, which of these is found to be different from "urban" is based on the cell count and variation alone.

Population 2 Degrees Urban

A one way between groups ANOVA was run to compare the differences between the 4 categories of the Population approach to categorization (Rural, Suburb, Small Urban, and Megalopolis). The ratio of Cook's Index to the permit rate was the DV. This model failed to reach significance at the $p<.05$ level [$F(3,58)=2.635$, $p=0.058$]. The effect size estimate is η^2

=0.043457. The Null was retained, and the mean values of each group are seen to be equivalent statistically.

Population 3 Degrees Urban

A one way between groups ANOVA was run to compare the differences between the 5 categories of the Population approach to categorization (Rural, Suburb, Small Urban, Megalopolis, and NYC). The ratio of Cook's Index to the permit rate was the DV. This model was significant at the p<.05 level [F(4,57)=9.526, p=5.72E-6]. The effect size estimate is η^2 =0.143192.

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found no significant pairwise comparisons. Tukey-Kramer found that NYC> each of the other groups. The LSD mirrored this result.

Population 4 Degrees Urban

A one way between groups ANOVA was run to compare the differences between the 6 categories of the Population approach to categorization (Rural, Suburb, Small City, City, Megalopolis, and NYC). The ratio of Cook's Index to the permit rate was the DV. This model was significant at the p<.05 level [F(5,56)=7.496, p=1.92E-5]. The effect size estimate is η^2 =0.118055

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found no significant pairwise

comparisons. Tukey-Kramer found that NYC> each of the other groups. The LSD mirrored this result.

- averaged permit rates

Population Base Categorization

A one way between groups ANOVA was run to compare the differences between the 3 categories of the base Population approach to categorization (Rural, Suburb, and Urban). The ratio of Cook's Index to the permit rate was the DV. There was a significant effect at the $p<.05$ level [$F(2,59)=3.33$, $p=0.0426$]. The effect size estimate is $\eta^2=0.053425$

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found one significant pairwise comparison (Urban>Suburban). Tukey-Kramer found no significant pairwise comparisons. LSD found that (Urban>Rural).

Population 2 Degrees Urban

A one way between groups ANOVA was run to compare the differences between the 4 categories of the Population approach to categorization (Rural, Suburb, Small Urban, and Megalopolis). The ratio of Cook's Index to the permit rate was the DV. This model failed to reach significance at the $p<.05$ level [$F(3,58)=2.642$, $p=0.0578$]. The effect size estimate is $\eta^2=0.043457$. The Null was retained, and the mean values of each group are seen to be equivalent statistically.

Population 3 Degrees Urban

A one way between groups ANOVA was run to compare the differences between the 5 categories of the Population approach to categorization (Rural, Suburb, Small Urban, Megalopolis, and NYC). The ratio of Cook's Index to the permit rate was the DV. This model was significant at the p<.05 level [F(4,57)=9.517, p=5.79E-6]. The effect size estimate is η^2 =0.143192.

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found no significant pairwise comparisons. Tukey-Kramer found that NYC> each of the other groups. The LSD mirrored this result.

Population 4 Degrees Urban

A one way between groups ANOVA was run to compare the differences between the 6 categories of the Population approach to categorization (Rural, Suburb, Small City, City, Megalopolis, and NYC). The ratio of Cook's Index to the permit rate was the DV. This model was significant at the p<.05 level [F(5,56)=7.489, p=1.93E-5]. The effect size estimate is η^2 =0.117957

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found no significant pairwise comparisons. Tukey-Kramer found that NYC> each of the other groups. The LSD mirrored this result.

- Taken Together

This is an overall weaker categorization. However, even in the context of this weaker organization, there is still evidence that New York City's relationship between pistol permits and Cook's Index is significantly different from the rest of New York. Based on the effect size changes, I also observed a decrease in effect size when going from 3 degrees of urban to 4 degrees of urban. This seems more evidence that "City" and "Small City" probably belong in the same category.

Adjacency Based Categorization

In this categorization non-metro counties are considered "Suburban" if they are adjacent to a Metropolitan county. As before I find that 3 degrees of urban yields the best results and reveals relationships that are obscured in the other categorizations. The weaker categorizations still join together to show very strong evidence that NYC is significantly different from the rest of New York. Again there is also evidence that other points on the Rural-Urban Continuum differ to each other with respect to this as well.

Specific to these analyses, the category of "MegaSuburb" doesn't seem to offer any increased explanatory power. Much like "Micropolitan" this category despite its theoretical interest fails to be supported in these analyses. These analyses in particular show almost no distinction between the DV's, the F values (and thus also the effect size estimates) change slightly but it is a very miniscule difference that is not associated with any changes in significance, significant pairwise comparisons, or meaningful effect size estimates.

- summed permits/avg population ratio

Adjacency Base Categorization

A one way between groups ANOVA was run to compare the differences between the 3 categories of the Adjacency based approach to categorization (Rural, Suburb and Urban). In the Adjacency approach to categorization non-metro counties are considered "Suburban" if they are adjacent to a Metropolitan county. The ratio of Cook's Index to the permit rate was the DV. This model was significant at the $p<.05$ level [$F(2,59)=3.832$, $p=.0272$]. The effect size estimate is $\eta^2 =0.060988$

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found no significant pairwise comparisons. Tukey-Kramer found that Urban>Suburban a result which was mirrored in the LSD follow-ups.

Adjacency 2 Degrees of Urban

A one way between groups ANOVA was run to compare the differences between the 4 categories of the Adjacency based approach to categorization (Rural, Suburb, Small Urban, and Megalopolis). The ratio of Cook's Index to the permit rate was the DV. This model was significant at the $p<.05$ level [$F(3,58)=2.989$, $p=.0383$]. The effect size estimate is $\eta^2 =0.049009$

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found that Small Urban > Suburban. Tukey-Kramer found that Megalopolis>Suburban, a result which was mirrored in the LSD follow-ups.

Adjacency 3 Degrees of Urban

A one way between groups ANOVA was run to compare the differences between the 5 categories of the Adjacency based approach to categorization (Rural, Suburb, Small Urban, Megalopolis, and NYC). The ratio of Cook's Index to the permit rate was the DV. This model was significant at the p<.05 level [F(4,57)=10.09, p=3.02E-6]. The effect size estimate is η^2 =0.150395

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found that Small Urban > Suburban. Tukey-Kramer found that NYC was larger than each of the other categorizations. And LSD found both that NYC was larger than all the other categories (mirroring the Tukey-Kramer follow ups) and that Small Urban > Suburban (mirroring the Dunnet modified Tukey-Kramer).

Adjacency 4 Degrees of Urban

A one way between groups ANOVA was run to compare the differences between the 6 categories of the Adjacency based approach to categorization (Rural, Suburb, Small City, City, Megalopolis, and NYC). The ratio of Cook's Index to the permit rate was the DV. This model was significant at the p<.05 level [F(5,56)=7.943, p=1.04E-5]. The effect size estimate is η^2 =0.12422

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found no significant pairwise comparisons. Tukey-Kramer found that NYC was larger than each of the other categorizations. And LSD found that NYC was larger than all the other categories (mirroring the Tukey-Kramer follow ups).

Adjacency 2 Degrees of Urban and Megasuburbs

A one way between groups ANOVA was run to compare the differences between the 5 categories of the Adjacency based approach to categorization (Rural, Suburb, Megasuburb, Small Urban, and Megalopolis). The ratio of Cook's Index to the permit rate was the DV. This model was not significant at the $p<.05$ level [$F(4,57)=2.307$, $p=0.0691$]. The effect size estimate is $\eta^2=0.038899$

- averaged permit rates

Adjacency Base Categorization

A one way between groups ANOVA was run to compare the differences between the 3 categories of the Adjacency based approach to categorization (Rural, Suburb and Urban). In the Adjacency approach to categorization non-metro counties are considered "Suburban" if they are adjacent to a Metropolitan county. The ratio of Cook's Index to the permit rate was the DV. This model was significant at the $p<.05$ level [$F(2,59)=3.849$, $p=.0269$]. The effect size estimate is $\eta^2=0.061242$

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found no significant pairwise comparisons. Tukey-Kramer found that Urban>Suburban a result which was mirrored in the LSD follow-ups.

Adjacency 2 Degrees of Urban

A one way between groups ANOVA was run to compare the differences between the 4 categories of the Adjacency based approach to categorization (Rural, Suburb, Small Urban, and

Megalopolis). The ratio of Cook's Index to the permit rate was the DV. This model was significant at the p<.05 level [F(3,58)=2.997, p=.0379]. The effect size estimate is η^2 =0.049134

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found that Small Urban > Suburban. Tukey-Kramer found that Megalopolis>Suburban, a result which was mirrored in the LSD follow-ups.

Adjacency 3 Degrees of Urban

A one way between groups ANOVA was run to compare the differences between the 5 categories of the Adjacency based approach to categorization (Rural, Suburb, Small Urban, Megalopolis, and NYC). The ratio of Cook's Index to the permit rate was the DV. This model was significant at the p<.05 level [F(4,57)=10.08, p=3.05E-6]. The effect size estimate is η^2 =0.150268

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found that Small Urban > Suburban. Tukey-Kramer found that NYC was larger than each of the other categorizations. And LSD found both that NYC was larger than all the other categories (mirroring the Tukey-Kramer follow ups) and that Small Urban > Suburban (mirroring the Dunnet modified Tukey-Kramer).

Adjacency 4 Degrees of Urban

A one way between groups ANOVA was run to compare the differences between the 6 categories of the Adjacency based approach to categorization (Rural, Suburb, Small City, City, Megalopolis, and NYC). The ratio of Cook's Index to the permit rate was the DV. This model

was significant at the p<.05 level [F(5,56)=7.935, p=1.05E-5]. The effect size estimate is η^2 =0.12411

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found no significant pairwise comparisons. Tukey-Kramer found that NYC was larger than each of the other categorizations. The LSD comparisons likewise found that NYC was larger than all the other categories (mirroring the Tukey-Kramer follow ups).

Adjacency 2 Degrees of Urban and Megasuburbs

A one way between groups ANOVA was run to compare the differences between the 5 categories of the Adjacency based approach to categorization (Rural, Suburb, Megasuburb, Small Urban, and Megalopolis). The ratio of Cook's Index to the permit rate was the DV. This model was not significant at the p<.05 level [F(4,57)=2.312, p=0.0686]. The effect size estimate is η^2 =0.03898

- Taken Together

As a categorization scheme this approach seems adequate. There continues to be evidence that New York City's relationship between pistol permits and Cook's Index is significantly different from the rest of New York. Based on the effect size changes, I also observed a decrease in effect size when going from 3 categories of urban to either 2 or 4 degrees of urban. While 4 degrees of Urban is superior in terms of effect size to the 2 category solution, the 3 classes (Small Urban, Megalopolis, and NYC) seem to be the ideal categorization of the Urban counties.

This also the category where the Dunner Tukey-Kramer and Tukey-Kramer together mirror the LSD analyses and there is evidence not just of the importance of NYC but also between the Small Urban and the Suburban.

Summary

As a whole the vast majority of the ANOVA's (regardless of philosophy of categorization) come out significant. And while the effect size was not identical approximately 15% of the variation tended to be explained by the categorizations. The ratio of Cook's Index to Permit Rate, regardless of how you calculate that ratio, varies across the Rural-Urban Continuum. Not only does this warrant a greater degree of care in the use of this proxy variable and research based on it, it also is an indication that the way in which firearms are used varies along the Rural-Urban Continuum.

The variation is such that the Urban side of the Rural-Urban Continuum has a greater ratio of (Firearm Suicides/Suicides)/(Permit Rate). This means that given an identical permit rate, the urban areas would have a higher proportion of suicides committed with firearms. This seems at odds with respect to the literature as it is commonly understood. Nevertheless, this is clearly what is demonstrated in this analysis.

New York City especially winds up as being significantly different from the rest of New York State. The pairwise comparisons in general strongly show this in almost all the models. This is particularly interesting given the correlation analyses pursued earlier, where Cook's Index transformed to predict handgun prevalence returned an invalid number. There were so few suicides with firearms in New York City that the linear model predicted that a negative percentage of residents owned firearms. This may well be a result of having such strict gun

control that the denominator (Permit Rate) was so small that even the incredibly small numerator forms a larger fraction than other counties. It is also evidence of a law of diminishing returns with respect to gun control and suicide. Because the flip side is also true. If the ratio of FS/S:Gun Permit that is true for New York City was also true for the rest of the state there should be many more firearm suicides than are actually observed.

Additionally there came evidence that other pairwise comparisons, specifically the Small Urban compared to the Suburban, is also a significant difference. This was not true in all the models but was true often enough for the stronger models to be an indication that the variation in FS/S:Gun Permit Rate is not limited to the extreme case that is NYC. It was also a comparison that came close to attaining significance in several other models. Given that I am working with an N of 62, this might well be a power problem where these models are on the edge of having enough power to find the effect. Regardless it is a shot in the arm to the thinking that counties adjacent to metropolitan centers may be an a unique situation that makes them different.

The Kmeans analysis, by far had the strongest effect size with an Eta square (or r square) of .3398 . The categorizations with the Kmeans analysis are not strictly in line with the Metro-Nonmetro divisions as was discussed earlier. However they do divide into what might be characterized as "New York City" (4 Counties), "Special Cases of Urban" (16 Counties), and "The Rest of the State" (42 counties). What about these 16 Counties that make them different? How can generalize off the kmeans cluster analysis, since it does seem to capture large amounts of variance? These questions are particularly salient as 2 theoretically important groups "Megasuburbs" (Suburban counties specifically next to larger metro areas) and "Micropolitan" (Central areas that are non-metro) both failed to be important in these analyses.

ANOVAs on the New York State (New York City dropped)

It was important to address the possibility that the extreme values in New York City were having an outlier affect on the data. The five counties that comprise New York City were removed from the data set, along with any defunct categorizations that relied on New York City. This procedure left 10 categorizations of the Rural-Urban Continuum in New York, each of which was then tested with both Dependent Variable Ratios, resulting in 20 ANOVAs to be explicated here.

Population Based Categorizations

All categorizations using Population to determine categories were found to be non-significant at the $p < .05$ level. This was invariant with both Dependent Variables. The non-significant results obviates the explication of these six ANOVAs.

The non-significant results here mirror the finding in the full data set that population based categorization is the weakest method of categorization. In the full data set it was associated with the weakest effects size estimates and half of the non-significant models. Without the impact of the extreme New York City counties, population based categorizations of the Rural-Urban Continuum do not show any significant difference.

Adjacency Based Categorizations

In this set of analyses, counties adjacent to a Metropolitan Area are considered "suburban" and counties that are not adjacent to a Metroplitan Areas are considered "rural".

- summed permits/avg population ratio

Adjacency Base Categorizations no-NYC

A one way between groups ANOVA was run to compare the differences between the 3 categories of the Adjacency based approach to categorization (Rural, Suburban, and Urban). The ratio of Cook's Index to the Summed Permits/Average Population was the DV. This model was significant at the p<.05 level [F(2,54)=4.061, p= 0.0228]. The effect size estimate is η^2 = 0.069944

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found no significant pairwise comparisons. Tukey-Kramer found that Urban was larger than Suburban. The LSD comparisons likewise found that Urban was larger than Suburban.

Adjacency 2 Degrees Urban No-NYC

A one way between groups ANOVA was run to compare the differences between the 4 categories of the Adjacency based approach to categorization (Rural, Suburban, and Small Urban, and Megalopolis). The ratio of Cook's Index to the Summed Permits/Average Population was the DV. This model was significant at the p<.05 level [F(3,53)=2.962, p= 0.0404]. The effect size estimate is η^2 = 0.052929

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found a significant difference between Suburban and Small Urban such that Small Urban was larger than Suburban. Tukey-Kramer and the LSD comparisons mirrored this result.

Adjacency 3 Degrees Urban No-NYC & Adjacency + City Size (megasuburbs) No-NYC

Both of these categorizations failed to meet the critical value for significance. Though the Megasuburb categorization returned a p-value of 0.0573, and was thus at the threshold for significance. Regardless, both of these categorizations returned non-significant models.

- Averaged Rates

Adjacency Base Categorizations no-NYC

A one way between groups ANOVA was run to compare the differences between the 3 categories of the Adjacency based approach to categorization (Rural, Suburban, and Urban). The ratio of Cook's Index to the Averaged Permit rate was the DV. This model was significant at the $p<.05$ level [$F(2,54)=4.061$, $p= 0.0224$]. The effect size estimate is $\eta^2 = 0.070248$

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found no significant pairwise comparisons. Tukey-Kramer found that Urban was larger than Suburban. The LSD comparisons likewise found that Urban was larger than Suburban.

Adjacency 2 Degrees Urban No-NYC

A one way between groups ANOVA was run to compare the differences between the 4 categories of the Adjacency based approach to categorization (Rural, Suburban, Small Urban, and Megalopolis). The ratio of Cook's Index to the Averaged Permit rate was the DV. This model was significant at the $p<.05$ level [$F(3,53)=2.977$, $p= 0.0397$]. The effect size estimate is $\eta^2 = 0.053183$

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found a significant difference

between Suburban and Small Urban such that Small Urban was larger than Suburban. Tukey-Kramer and the LSD comparisons mirrored this result.

Adjacency 3 Degrees Urban No-NYC & Adjacency + City Size (megasuburbs) No-NYC

Both of these categorizations failed to meet the critical value for significance. Though the Megasuburb categorization returned a p-value of 0.0565, and was thus at the threshold for significance. Regardless, both of these categorizations returned non-significant models.

- Taken Together

The Adjacency categorization found significant results after New York City Counties were removed. The general finding in the full models that "Small Urban" "Megalopolis" and "New York City" maximized the effect size were confirmed here, with models offering more categorizations than "Small Urban" and "Megalopolis" found to lose significance. The effect sizes in general are weaker than the full models, but these models establish at least three things: First, that the models as a whole are not dependent on New York City to be found statistically significant. Second, that the strongest findings are mirrored regardless of whether New York City is included. Third, it demonstrates that the sometimes significant difference between Suburban and Small Urban exists firmly without the extreme values of New York City influencing the pairwise comparisons.

One final thought these analyses leave is that the Megasuburb category may bear further research. These models were at the edge of significance despite the severe disadvantage of the statistical power at work. The analyses using the entire data set found no evidence and here there is largely no evidence. However, future research into the megasuburbs may be fruitful given a large enough sample size.

Micropolitan Based Categorizations

In this set of analyses, counties that qualify as "Micropolitan" are given their own category as this may signify a unique point on the Rural-Urban Continuum. Those counties that are neither "Metropolitan" or "Micropolitan" are joined together into the category "Suburb". Originally there was a single county that was "Rural" but a single county filling a category would preclude most statistical analysis. Therefore this was added into the "suburb" category.

- summed permits/avg population ratio

Micropolitan Base Categorizations no-NYC

A one way between groups ANOVA was run to compare the differences between the 3 categories of the Micropolitan based approach to categorization (Suburb, Micropolitan, and Metropolitan). The ratio of Cook's Index to the Summed Permits/Average Population was the DV. This model was significant at the $p<.05$ level [$F(2,54)=4.044$, $p= 0.0231$]. The effect size estimate is $\eta^2 = 0.069671$

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. All three follow up analyses (Dunnett's modified Tukey-Kramer, Tukey-Kramer, LSD) agree that there is a significant different such that Metropolitan was greater than Suburb.

Micropolitan 2 Degrees Urban No-NYC

A one way between groups ANOVA was run to compare the differences between the 4 categories of the Adjacency based approach to categorization (Suburb, Micropolitan, Small Urban and Megalopolis). The ratio of Cook's Index to the Summed Permits/Average Population

was the DV. This model was significant at the p<.05 level [F(3,53)=2.951, p= 0.0409]. The effect size estimate is $\eta^2 = 0.052743$

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found a significant difference between Suburban and Small Urban such that Small Urban was larger than Suburban. Tukey-Kramer mirrored this result. The LSD comparisons found that Small Urban was larger than Suburban but also that Small Urban was larger than Megalopolis. This is out of step with previous models which found that counties closer to the extreme Urban were greater than counties closer to the Rural.

Micropolitan 3 Degrees Urban No-NYC

This categorization failed to meet the critical value for significance. Splitting the "Small Urban" into "City" and "Small City" resulted in a nonsignificant model and obviates the explication of that failed model.

- Averaged Rates

Micropolitan Base Categorizations no-NYC

A one way between groups ANOVA was run to compare the differences between the 3 categories of the Micropolitan based approach to categorization (Suburb, Micropolitan, and Metropolitan). The ratio of Cook's Index to the Averaged Permit Rate was the DV. This model was significant at the p<.05 level [F(2,54)=4.072, p= 0.0225]. The effect size estimate is $\eta^2 = 0.07012$

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. All three follow up analyses (Dunnett's modified Tukey-Kramer, Tukey-Kramer, LSD) agree that there is a significant different such that Metropolitan was greater than Suburb.

Micropolitan 2 Degrees Urban No-NYC

A one way between groups ANOVA was run to compare the differences between the 4 categories of the Adjacency based approach to categorization (Suburb, Micropolitan, Small Urban and Megalopolis). The ratio of Cook's Index to the Summed Permits/Average Population was the DV. This model was significant at the $p<.05$ level [$F(3,53)=2.972$, $p= 0.0399$]. The effect size estimate is $\eta^2 = 0.053098$

The significant ANOVA meant that follow up analyses were run with each method's alpha level set to at alpha = 0.05. Dunnett's modified Tukey-Kramer found a significant difference between Suburban and Small Urban such that Small Urban was larger than Suburban. Tukey-Kramer mirrored this result. The LSD comparisons found that Small Urban was larger than Suburban but also that Small Urban was larger than Megalopolis. This is out of step with previous models which found that counties closer to the extreme Urban were greater than counties closer to the Rural.

Micropolitan 3 Degrees Urban No-NYC

This categorization failed to meet the critical value for significance. Splitting the "Small Urban" into "City" and "Small City" resulted in a nonsignificant model and obviates the explication of that failed model.

- Taken Together

The micropolitan results without New York City mirror each other across the two dependent variables as almost all other analyses have. The general finding in the full models that "Small Urban", "Megalopolis", and "New York City" maximized the effect size were confirmed here. Models offering more categorizations than "Small Urban" and "Megalopolis" lost significance. The effect sizes in general are weaker than the full models, but these models establish at least three things: First, that the models as a whole are not dependent on New York City to be found statistically significant. Second, that the strongest findings are mirrored regardless of whether New York City is included. Third, it demonstrates that the sometimes significant difference between Suburban and Small Urban exists firmly without the extreme values of New York City influencing the pairwise comparisons.

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