RISK MANAGEMENT: APPLYING SYSTEM DYNAMICS SIMULATION TO UNDERSTAND UNINTENDED CONSEQUENCES

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ABSTRACT

We discuss the use of simulation modelling to aid managers in identifying and addressing the unintended consequences that are created by efforts to make changes in a complex system. We propose that unintended consequences can be managed much like risk is in supply chains where the key is to develop methods to identify the sources of unintended consequences, prioritize them, and develop plans to deal with the largest issues. The modeling process we propose focuses on the feedbacks in the interactions of individuals, government and other actors. As an example, we model the unintended consequences of the gun control debate. We show that unintended consequences are driven by feedback loops that create various and predictable unintended consequences. The model highlights those unintended consequences with the most likelihood of occurring, which allows an exploration into how they might be avoided.

INTRODUCTION

The concept of unintended consequences is a widely recognized phenomenon. We see discussions about it connected to virtually every aspect of life. A recent literature search on the topic, restricted to the last 4 years, surfaced almost 30,000 articles referring to the concept. Article topics included government regulation, education reform, medical treatments, and everything in between. The sources of the articles were also quite varied from highly respected, peer reviewed academic journals to less respected publications commonly referred to as tabloids.

The fact that it is widely recognized does not mean it is widely understood; indeed, its omnipresence is strong evidence to the contrary. A common explanation for the widespread occurrence of unintended consequences is that it is impossible to foresee and control all possible outcomes when trying to address issues within a complex environment. As a result those in favor of the changes can use unintended consequences to argue that we need to move forward and adjust as necessary, while those opposed use the same argument to insist that moving forward is rash and dangerous.

On the surface the claims that unintended consequences are unavoidable, are understandable and reasonable. Certainly, when implementing a new restriction on accounting practices such as Sarbanes Oxley it is impossible to see how actors in this system might react and what unintended consequences might emerge [19]. Similarly, when passing a healthcare reform law like the Affordable Healthcare Act the ripple effects are beyond comprehension. There have been over 10,000 articles discussing the unintended consequences of this one act alone in the last 5 years.

While there is truth in the claims that unintended consequences are virtually impossible to predict, the same was true when discussing the concept of risk management. Here, like unintended consequences, the seemingly nebulous concept of risk in areas as complex as supply chains and large scale projects made the effort of trying to manage it seem futile. After all, if something as simple as a small fire in a

manufacturing plant that is put out before the fire department even arrives, can cause a major disruptions in a supply chain [14] how can one hope to 'manage' risk? In addition, who could have possibly foreseen the emergence of pirates off the coast of Somalia disrupting shipping lanes, or volcano eruptions on Iceland grounding air travel across most of Western Europe before they occurred? Nevertheless, the field of Risk Management has become a major area in business today. Organizations like APICS, The Organization for Operations Management, and the Project Management Institute (PMI) offer special courses on the topic and managers can earn certificates in this area.

Of course, we now realize that the value in Risk Management is not in identifying every possible source of risk, but in identifying the most likely sources of risk and proactively developing ways to address the issues or at least adjust to them. Tools and techniques have been developed to assist managers in identifying sources of risk, and prioritizing them to help focus and develop contingency plans. After action reviews are conducted to help managers further refine and evolve their risk management process. In short, the process of proactively thinking about risk has been hugely beneficial to many organizations despite the inability of predicting precisely what might go wrong.

We propose that the same could be done for addressing Unintended Consequences. While we believe there are many similarities, and to some degree overlap, between Risk Management and efforts to address unintended consequences there are also two major differences. First, unintended consequences are commonly the result of how major elements within the system react to imposed changes and the reactions of other elements within the system. For example, a competitor may drop its price to increase its market share causing other businesses within an industry to do the same. Over time as more and more businesses cut prices the unintended consequences are a price war within the industry and the potential of turning the product into a commodity. Second, is that unintended consequences often have a time delay element. In many scenarios the unintended consequence only surfaces after a period of time. As stated in the pricing example above it is over time that the price war causes customers to expect high performance at a low price thus turning the product into a commodity that competes primarily on price

Because of these two important characteristics of unintended consequences the simple brainstorming techniques used to identify major sources of risk are insufficient for unintended consequences. To identify major sources of unintended consequences managers need to use tools that incorporate methods for accounting for complex interactions and changes in behavior over time.

Fortunately a tool that allows managers to account for these factors does exist – system dynamics simulation. Unfortunately, this tool is not widely understood and consequently it is also underutilized. In this paper we will utilize system dynamics simulation software to build a model representing the area of Gun Control. We then use the model to illustrate how managers could test making changes to an environment to see what unintended consequences may evolve over time.

Our objective here is NOT to provide a solution to the Gun Control debate, but merely to use a well-known, complex issue to illustrate how managers (and others) could use system dynamics modelling to develop a proactive process for addressing unintended consequences. As with risk management the process should serve to both help managers identify the most likely forms of unintended consequences as well as improve, over time, our methods of dealing with them.

THE MODEL BACKGROUND

The gun control debate has raged for decades. Despite the abundance of rhetoric on both sides of the issue, nothing of substance related to US gun laws has changed. On the other hand each time the debate

flairs and rumors that new laws are about to be pushed through, several factors unrelated to gun regulation definitely change. For example, in January of 2013, President Obama and Vice President Joe Biden rolled out a wide-ranging list of executive actions aimed at strengthening gun control. The announcement increased concern among gun owners that they would not be able to purchase guns and ammo. As a result of this concern gun owners rushed to make purchases ahead of any major legal reforms causing gun and ammo sales to skyrocket [2],[3],[4],[8]. Eventually, congress voted down the bill and in reality there was no change to the gun laws [10]. However, in a prime example of unintended consequences, the announcement by President Obama resulted in the number of guns and the amount ammo held by the public to increase dramatically. Ironically, as cited in numerous press articles, President Obama's announcement made him one of the best gun salesmen in history.

In any complex issue there are multiple factors that account for the failure of a change effort, or generate unintended consequences. In this particular scenario the factors may include the interpretation of the Second Amendment, the role of powerful special interest groups both for and against gun control, issues dealing with government imposed limitations on individual constitutional rights and the challenge of creating, upholding/enforcing laws. Richmond [14] called this listing of factors, "Laundry List Thinking" and noted that "It stands in stark contrast to the operational and closed loop viewpoint that characterizes Systems Thinking based mental models." System thinking does not try to identify all the factors at work within a social system recognizing that it would be virtually impossible to do. Instead the field of systemic thinking attempts to define an operational system by describing the major factors that interact to create unintended consequences. That is our intent here. Like the work done in Risk Management we attempt to identify only the major factors related to the Gun Debate, then build a model that allows those factors to interact. We can then manipulate key input variables to see what outcomes emerge. Through various "what if" exercises we can identify potential unintended consequences and the possible ways to mitigate them.

The model developed for this paper was designed to replicate the environment that created the unintended consequences associated with gun legislation described above. It builds off of the work Barry Richmond [13] and is supplemented with information drawn from personal experiences, and popular press articles. The model is composed of the following variables: 1) media coverage of a horrific gun event, 2) pressure to enact gun restrictions as a result of the increased public awareness, 3) counter pressure to defeat such gun restrictions by groups like the NRA, and, 4) the public's response to the increased coverage and rhetoric.

Model Details

Any model rises or falls based on its assumptions. It is tempting to believe that because of the complex equations underlying the model and because of the numerical input and output of the model; the model implies specific solutions. The specific numbers used to create the model are intended to be illustrative and possibly suggestive; not conclusive. Thus, the model allows the user to input base information as well as having the option to manipulate various behavioral assumptions which may stimulate a thoughtful instead of rhetorical discussion of the issue [9].

Figure 1 presents the part of the model that represents the amount of media coverage of related issues. The arrow on the left is labeled "Flow of Gun Events" and this feeds into a box (a.k.a. stock) that is labelled Media Coverage of Gun Issues.

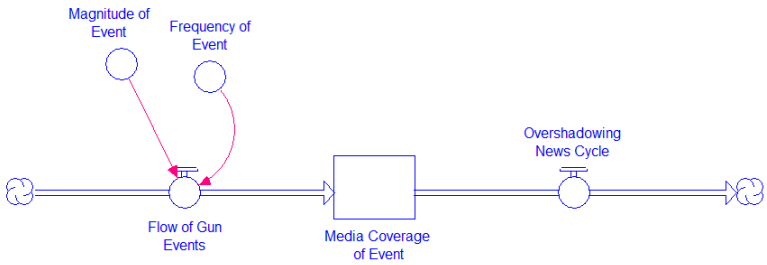

FIGURE 1

The amount of media coverage of gun related issues is driven by the frequency and magnitude of gun events like the Sandy Hook Elementary shooting. If several gun related tragedies take place, or one horrific event such as the shooting at the Sandy Hook, media coverage increases. Simulation users can alter the input variables Magnitude of Event, and/or Frequency of Events to manipulate the amount of media coverage of gun related issues. However, media coverage is also influenced by other news worthy events which create increasingly shorter news cycles. As an example, following the massacre at Sandy Hook, we saw North Korea explode a nuclear device, a meteor hit Russia, the Pope resigned, the Boston Marathon was attacked by bombs, a chemical plant blew up in Texas etc. These events overshadowed the gun event and thus reduce media coverage. Even trivial events like a celebrity wedding reduce the coverage by the media of a gun event and therefore its impact factor on the discussion. To simulate this phenomenon the user of the model is asked to indicate the magnitude of the event and the frequency that such events occur to impact the flow that increases media coverage. In addition, the user can also manipulate the rate of overshadowing issues to impact the flow that draws down media coverage. Thus the user can simulate various conditions that both increase and decrease the media coverage of gun events.

Of course media coverage by itself is not a major issue; it is the interaction with other variables that create the environment where unintended consequences occur. For example, a surge in media coverage increases political pressure to enact legislation that restricts public access to firearms and ammo. The pressure to pass gun laws is reduced as the event falls out of the news cycle and as the political will to ban is reduced by counter pressure from gun advocates. These relationships are shown in Figure 2.

Again the user can manipulate various input rates (reduction rate, political pressure per event, rate of pressure increase/decrease with respect to politics involved in the discussion) to change the level of political pressure to change gun laws (i.e. the box labelled *Political Pressure to Ban*). For example, the circle in Figure 2 labeled *Pressure Multiplier* is an input variable that user can manipulate to increase or decrease the amount of political pressure in the environment. As the political pressure to ban builds a backlash from current gun owners and manufacturers occurs. Responsible gun owners take great offence at being lumped, by various pundits and politicians, into the same category as the perpetrators of gun violence events. Because gun owners' account from between 40 to 60 percent of the population in many states, their negative response to the pressure to ban significantly reduces the political will to change the gun laws. A letter written to President Obama and signed by 1100 Green Berets outlines the frustrations of gun holders and serves as a good example of a predictable response by those opposed to increased gun legislation [7].

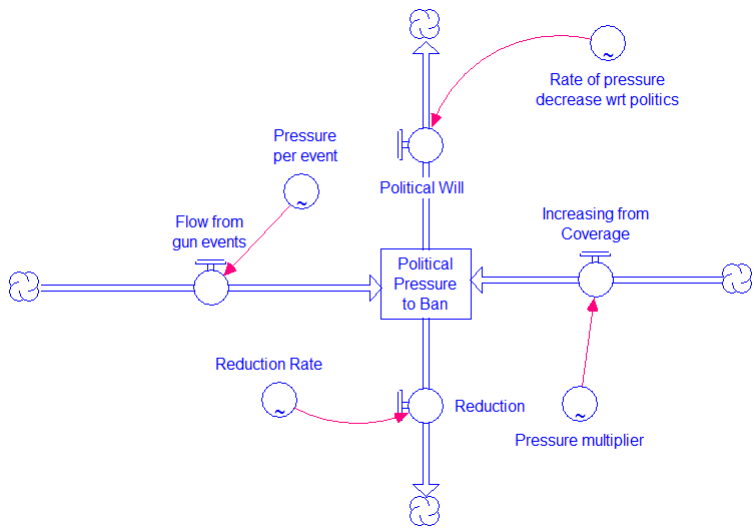

FIGURE 2

Another factor that impacts political will to change gun laws is the amount of anger and frustration focused at politicians over the issue. The proposed restrictions caused by gun events, creates a flow of mistrust/anger towards politicians in general and in the specific. This part of the model is shown in Figure 3.

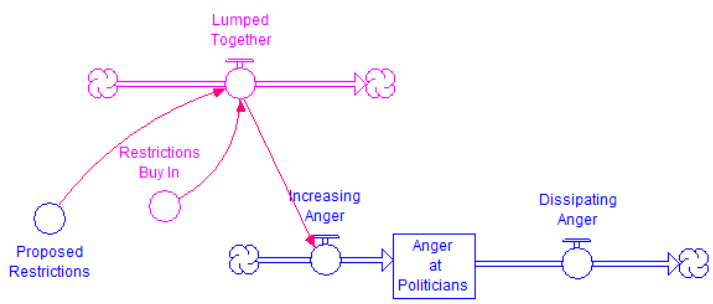

FIGURE 3

Anger at politicians increases the political influence of various gun lobbies like the NRA who directly represents thousands of members who vote in elections. Nothing terrifies a legislator more than the specter of not being re-elected. At one point, while gun control legislation was being written, the NRA recorded 8,000 new memberships per day. While those who favor increased gun laws probably also experience anger and frustration at politicians for their failure to enact stronger laws they lack the political focus and clout of associations like the NRA so they have less impact on this part of the system.

Consequently when gun control advocates make statements that demonstrate a lack of knowledge about guns, gun handling, and the law abiding gun community it causes the dynamics of this part of the system to kick in [7]. As the pro-gun law rhetoric ramps up, the concern by gun owners that the government will disarm its citizens causes the anti-gun law lobbyists to start maneuvering to ensure no gun laws will get passed. Figure 4 shows the dynamics of this aspect of the system which kicks in to counter the pressure to increase the regulation on guns.

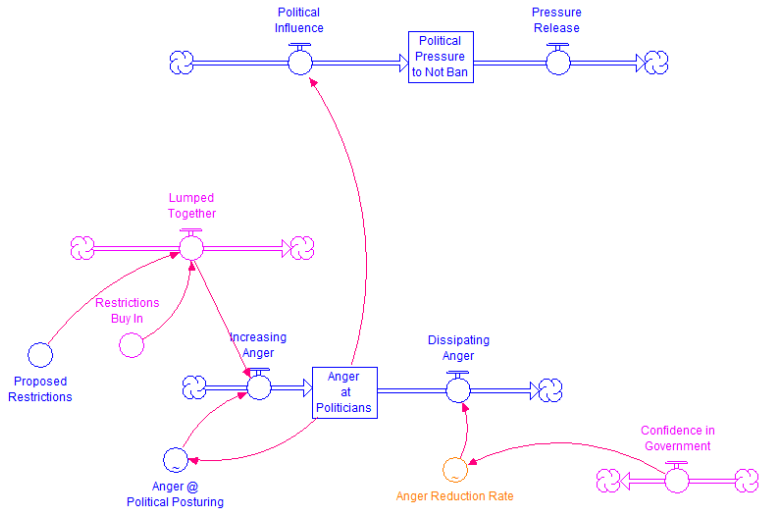

FIGURE 4

One unintended consequence created by the dynamics discussed in this part of the model is the increase in the number of NRA memberships and other gun organizations which results in the gun lobby becoming more powerful. Another, unintended consequence of increased gun law rhetoric is an ever more increasing number of guns sold to private citizens. As an example, during this last round of gun law debates more guns and ammo were sold than in any other period of history [2] [3]. Figure 5 shows this phenomenon by linking the anger/mistrust of politicians stock to an increasing demand rate, which in turn drives a standard systems inventory model.

In the years following the 9/11 attacks several events have led to a significant decrease in U.S. citizen's confidence in the government. Of specific concern to this model is gun owner's confidence that government will protect their Second Amendment Rights. High levels of anger at politicians and the low levels of confidence in the political process fuels an increasing gun and ammo purchase rate.

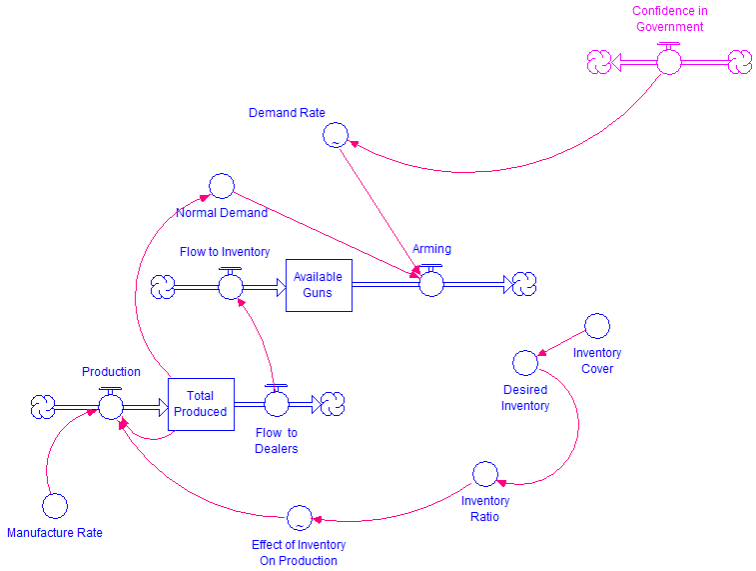

FIGURE 5

The full model allows the user to make several changes to input variables with respect to events leading to gun restrictions and counters to restrictions. Figures 6-A and 6-B present the full model with all of the linkages (action connectors shown in red). Figure 6-A shows the combination of Figures 1 and 2 discussed above. In the upper right hand corner of the figure is a box called "Political Pressure to Not Ban" which is the link in the model to Figure 6-B. Figure 6-B is the aggregation of Figures 4 through 6 discussed above. The starting point is to define the magnitude and frequency of events discussed in Figure 1 and shown in the bottom left hand section of Figure 6-A. The Magnitude of Event is an evaluation of the impact the event has on the general public psyche. This might tie to the identity of the victims of the violence, competing news for the day, location, numbers involved etc. The Frequency of the Event is how often these events occur, in months. The history of gun events over the last 30 years shows these events on average occur every 6 months.

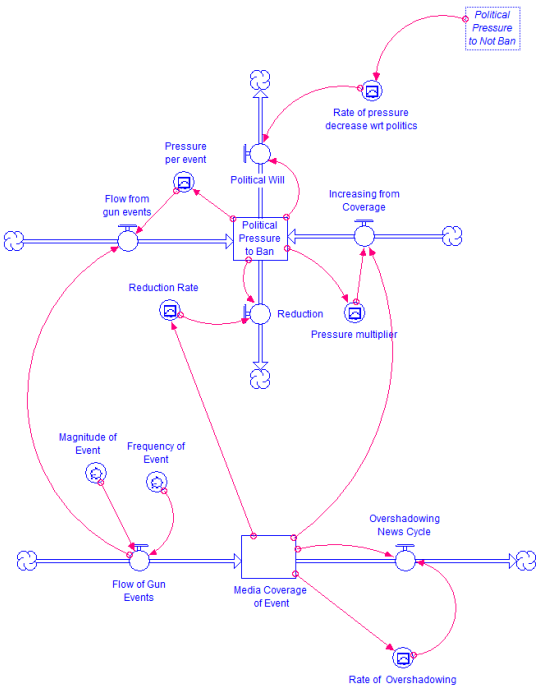

FIGURE 6A

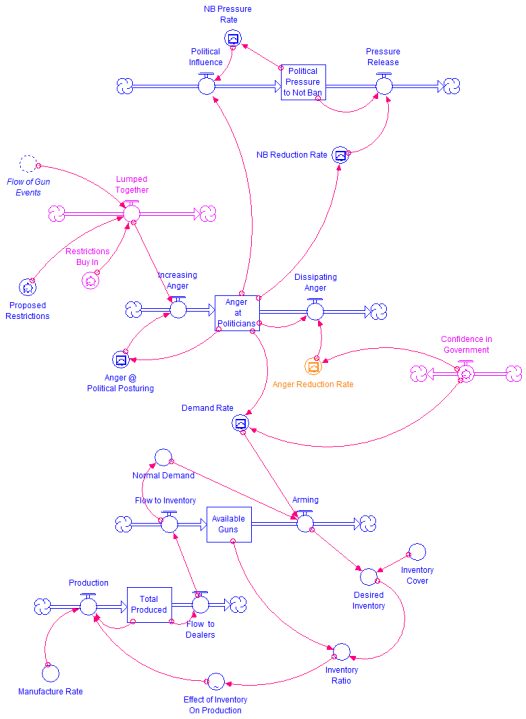

FIGURE 6B

Confidence in Government (shown in the right hand side of Figure 6-B) is the level to which the people of the US put their faith in their government. Public trust in government has recorded a steady decline since 1958. There was a brief surge in the late 1980s and again following the 9/11 attacks, with sharp declines following both. It is now at its lowest level in 55 years [12].

Finally, the model allows the user to input the level of proposed restrictions, from minor to total ban; and also manipulate the level of "buy-in" to the restrictions (from 0 to 100%). These inputs are shown in Figure 3 and in the top left hand portion of Figure 6-B. While some individual gun holders privately and sometime publically support some reasonable restrictions, the overall buy-in of the central voices of gun holders (NRA and other gun groups) remains at zero because of the maxim "if you give an inch, they will take a mile" [6] [18]. This belief is reinforced by statements like the one that appeared in a Washington Post Editorial [5], two days after the Federal Assault Weapons Ban went into effect, "... no one should have any illusions about what was accomplished. Assault weapons play a part in only a small percentage of crime. The provision is mainly symbolic; its virtue will be if it turns out to be, as hoped, a stepping stone to broader gun control." Many who oppose further gun regulation remember and

still refer to this statement demonstrating the long life span of consequences from any strong language in this environment.

The model also contains several "behavioral rates" that can be manipulated by the user. For example, the rate of overshadowing by other news events is a graphical function which shows that the more immediate a gun event, the lower the rate of overshadowing by other news events. As an event becomes "old news" the rate of overshadowing increases. Thus, from the point an event drops out of the news cycle the political pressure to "do something," falters as national attention is focused elsewhere, yet the impact in terms of gun and ammo sales along with increased fear by anti-gun legislation lobbying groups continues on.

Analysis

A benefit of the modeling process is that we can simulate many scenarios, allowed by user inputs, and observe the models response to the inputs. This model has a large number of behavioral parameters that can be modified by the user, however the analysis discussed in this paper will focus only on the user inputs that are at the nominal control of policy makers. Specifically we will look at three scenarios.

The first scenario postulates no gun events and no legislation on gun control and total trust in government. We examine this scenario because this paper focuses on unintended consequences in general and the unintended consequence of a significant arming of the American populace in particular. In order to appreciate what those unintended consequences might be we use this first scenario as our base line for comparison to other scenarios where we move away from this ideal situation.

Figure 7 presents two graphs that show that with no gun control proposals there is obviously no pressure to pass such laws and no push back from the gun advocates. However gun purchase and arming of the populace continues to take place at a historic rate of 1.41% per month or 13-14% per year. This is consistent with what actually has happened during times like these in history [2].

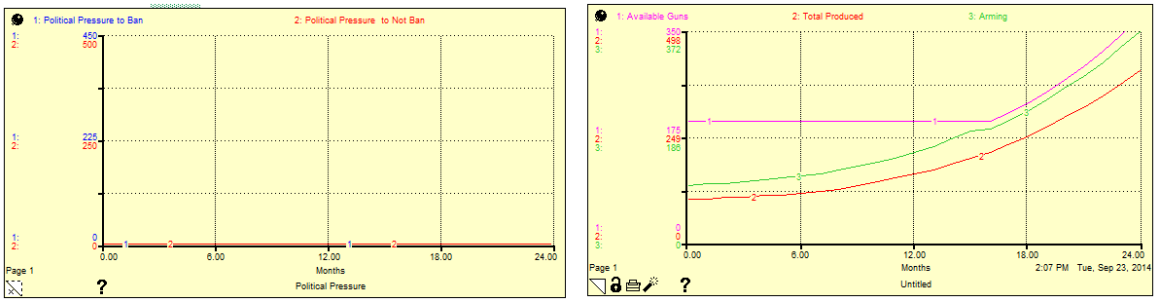

Figure 7

A second scenario assumes a modest gun event (event level of 20 on a scale of 100), confidence in government remains at 0, as in the first situation, but still a high buy-in to the restriction by the gun community. The time series graphs are shown in Figure 8. Now there is modest pressure to enact some legislation and no pressure to counter the legislation. The second graph in Figure 9 shows little change from the same from the first scenario shown in Figure 7.

We need to understand this buy-in phenomenon since it is fundamental to participative management, which is commonly used in business today. Participative management has two components relevant to this analysis. One component is that decision makers pull in ideas from all levels of a company including front line workers and those who have direct contact with people outside the organization (e.g.

customers and vendors etc.), because they have the insights and information that decision makers need. The second component is that when decision makers involve all parts of an organization in the decision making process it removes many of the common causes of resistance to change. The model indicates that when gun advocates are engaged in the process, credible gun legislation may be possible. Currently, such involvement does not exist in the "real world." In fact, the vitriol and rhetoric on both sides of the debate have made it impossible for any moderate voice to be heard [6] [18].

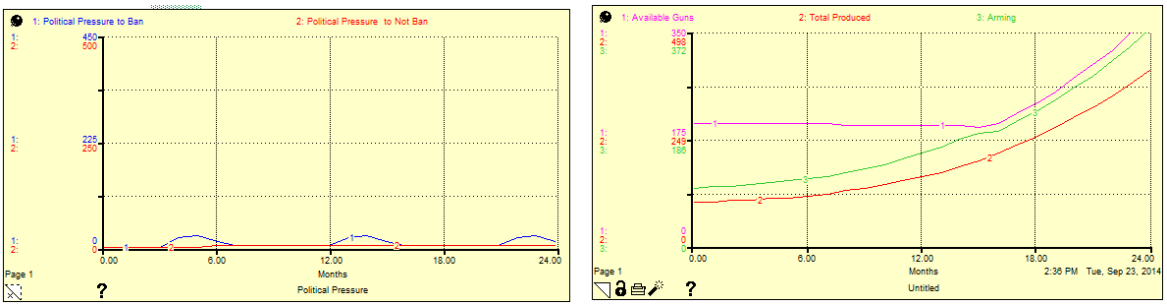

Figure 8

Scenario 3 proposes a significant gun event (70 on a scale of 100) which occurs twice over 24 month period, the resulting push for strict gun legislation, the lack of trust in government and the near zero buy-in by gun advocates. The results of the model are show in Figure 9. Political pressure to ban immediately jumps but quickly tapers off as the pressure to not ban becomes stronger.

The political pressure to ban again jumps on a second event and the pressure to not ban ballons.to not ban becomes very significant. Meanwhile, in the second panel of Figure 9, available guns drop perceptively as firearm sales escalate dramatically. This mirrors the events following the push for gun bans in 2013. Gun store shelves were emptied and prices soared for firearms. Continuing into the future the growth in production is increased above its historical rate by the demand fueled both by anger at politicians, and mistrust of government. The arming is only limited by the production capacity of the gun industry. Thus the president's unintended consequence of his proposal came to fruition, and he became the best gun salesman the industry has known.

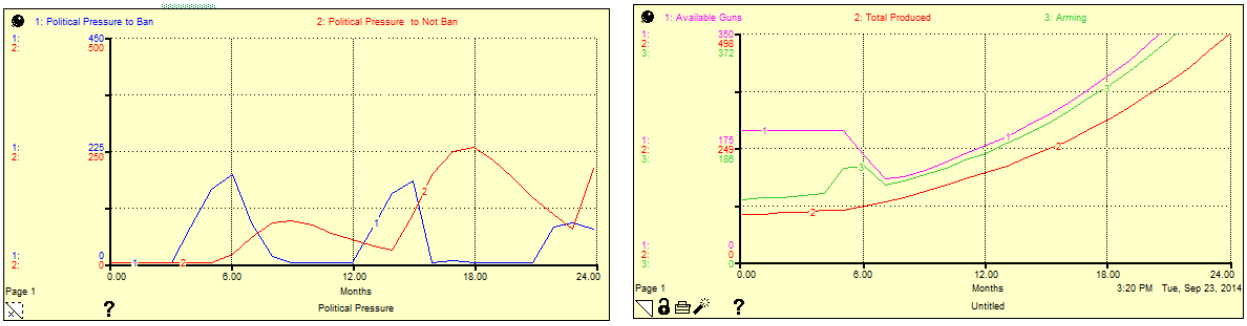

FIGURE 9

CONCLUSION

The shift from single event cause and effect thinking, to systems (dynamic) thinking, is hard. It is both hard to learn and to achieve. One way to learn and show the benefits of a more holistic process is to apply systems thinking/modeling to real world events. The development of a simulation model such as the one presented above is helpful in making this transition. Morecroft [11] suggests that in contrast to event thinking, a systems thinker examines the critical aspects of a problem through time. That is, a

systems thinker recognizes that the behavior of a system at one point in time influences the system's behavior in the future. Morecroft notes: "Of particular significance are puzzling dynamics, performance through time that people experience but do not want or intend. Some of the most interesting and intractable problems in society and business appear this way."

In this paper we have examined the issue of the unintended consequences of actions; the known about but unknown effect of decision/policy making. We have suggested that modeling can provide insights to complex social and/or management problems. As an example we have built a model around the gun control debate. It is probable that we did not get the entire set of variables properly defined, or all aspects of the system incorporated into the model. As a mathematician once pointed out "the best model of a cat is a cat. Everything else is leaving out some sort of detail. How pertinent that detail might be will depend on exactly what problems we're trying to solve and on how precise an answer we require."[17]

So while our model may be far from perfect, it provides a starting point for further refinement. As with the field of Risk Management, much value comes from the effort to think through the elements of the system and how they fit together. Then work to improve their methodology over time. Similarly, managers can develop dynamic simulations to help understand unintended consequences. Then they can work with the model and study the system it is meant to replicate to further refine the details and improving its ability to provide insights. The real failure stems from continuing to complain about the complexity of our systems and our inability to understand them.

REFERENCES

[1] Adams, L., *The Second Amendment Primer: A Citizen's Guidebook to the History, Sources and Authorities for the Constitutional Guarantee of the Right to Keep and Bear Arms*. Delaware: Skyhorse Publishing, 2013.

[2] Bureau of Alcohol, Tobacco, Firearms and Explosives, Statistics http://www.atf.gov/statistics/index.html

[3] Carter, Zach, "Gun Sales Exploded In The Year After Newton Shooting, *Huffington Post*, 12/13/2013 http://www.huffingtonpost.com/2013/12/06/gun-sales-newtown_n_4394185.html

[4] Cooper, Michael, "Sales of Guns Soar in U.S. as Nation Weighs Tougher Limits," *New York Times*, January 11, 2013. http://www.nytimes.com/2013/01/12/us/as-us-weighs-new-rules-sales-of-guns-and-ammunition-surge.html?_r=2&

[5] Editorial, "Hyping the Crime Bill," *Washington Post*, September 15, 1994 Final Edition.

[6] Frazier, James, "Gun Writer Fired for Piece Questioning Second Amendment's Reach", *Washington Times*, November 7, 2013. http://www.washingtontimes.com/news/2013/nov/7/longtime-gun-writer-guns-ammo-fired-piece-question/?page=all

[7] Hinton, Jeff, "Protecting the Second Amendment – Why All Americans Should Be Concerned" http://www.professionalsoldiers.com/forums/showthread.php?t=40772

[8] Lott, John R, "Obama's Impact on US Gun Sales, A Warning About Using NICS Checks to Measure Gun Sales," February 24, 2014, *Crime Prevention Center*, http://crimepreventionresearchcenter.org/2014/02/obamas-impact-on-us-gun-sales-a-warning-about-using-nics-checks-to-measure-gun-sales/

[9] McClurg, A. J., "The Rhetoric of Gun Control," *American University Law Review*, Fall 1992, pp. 53-93.

[10] McWhinnie, E., "Obama's Gun Control Efforts Boost Firearm Sales, *USA Today*, May 5, 2013.

[11] Moorcroft, J., *Strategic Modeling and Business Dynamics.* West Sussex, England: John Wiley & Sons, Ltd., 2007.

[12] Pew Research Center for the People and The Press. "Section 1:Trust in Government 1958-2010, 4/18/2010, http://www.people-press.org/2010/04/18/section-1-trust-in-government-1958-2010/

[13] Richmond, B. "Guns at School: Systems Thinking Perspective", *ISEE Systems*, 2001

[14] Richmond, B. "Dynamics of Fear", *ISEE Systems*, 2001

[15] Richmond, B., "An Introduction to Systems Thinking", *ISEE Systems*, 2004.

[16] Scheffi, Y., *The resilient Enterprise: Overcoming Vulnerability for Competitive Advantage.* Cambridge, Massachusetts: MIT Press, 2007.

[17] Silver, N., *The Signal and the Noise.* New York, New York: The Penguin Press, 2012.

[18] Somaiya, R. "Banished for Questioning the Gospel of Guns", *New York Times*, 1/4/2014, http://www.nytimes.com/2014/01/05/business/media/banished-for-questioning-the-gospel-of-guns.html?_r=0

[19] Shane, S., "Small Businesses and Big Unintended Consequences" *The American: The Online Magazine of the American Enterprise Institut*e, January 12, 2011.