Model of Driver of Fear-Induced Consumer Avoidance Behaviors Post-Incident

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Abstract: The effects of the terrorist attacks of September 11, 2001 have drawn attention to the psychological consequences of national incidents. Psychological consequences are instantiated by changes in behavior. Changes in behavior can be significant, substantial, and can span a duration that would impact the economy, human safety, and/or infrastructure sectors. This paper describes likely drivers of what is termed "fear-induced avoidance behavior." Fear-induced avoidance behavior is behavior caused by fear or anxiety of an activity, which then causes avoidance of said activity—a prominent example being many people's fear-induced avoidance of flying after the terrorist attacks of 11 September 2001. This paper presents a system dynamics model of the driving forces that induce fear avoidance and the forces that assist in system recovery. This model was not based on any specific historical incident to allow for application of the model to multiple types of incidents. Major components of this model include: Consumer needs; Risk perception; and Consumers' ability to substitute one activity for another (e.g., driving instead of flying). Through the use of the system dynamics framework the authors are able to provide potential non-intuitive policies that could assist in minimizing psychological consequences stemming from national incidents.

Keywords: avoidance behavior, psychological consequence, national security, consumer behavior

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1. Introduction

The effects of the terrorist attacks of September 11, 2001 have drawn attention to the psychological consequences of national incidents. Psychological consequences are instantiated by changes in behavior. Changes in behavior can be significant, substantial, and can span a duration that would impact the economy, human safety, and/or infrastructure sectors. 0

A major challenge in using the term psychological consequence is that it is broad. The 2010 DHS Risk Lexicon defines psychological consequence as an "effect of an incident, event, or occurrence on the mental or emotional state of individuals or groups resulting in a change in perception and/or behavior." [9] This definition includes aspects of psychology that are not practical to measure on a societal scale. These include "mental and emotional state" and "change[s] in perception." Therefore this paper's focus is on observable and significant changes in behavior. Furthermore, these observable changes in behavior must be significant, substantial, and span a duration that would impact the economy, human safety, and/or infrastructure operation.

This paper focuses on better understanding of what is termed "fear-induced avoidance behavior." Simply put fear-induced avoidance behavior is behavior caused by fear or anxiety of an activity causing avoidance of said activity. The avoidance of certain activities have economic consequences.

Fear-induced avoidance behavior differs from the psychological definition of avoidance behavior that is associated with avoidance of social situations due to a psychological disorder. Fear-induced avoidance behavior captures a natural protective response to a perceived risk post-incident. Particular emphasis to fear-induced avoidance is due to a body of literature that has shown that fear-induced avoidance behavior resulting from an incident can have significant consequences in terms of economics, sentiment, and safety.[1] In addition, changes in behavior can have great and unexpected impacts on the functionality of infrastructure and the evolution of infrastructure.

2. Literature Review of Economic Impacts of Consumer Fear-Induced Avoidance

Economic consequences of national incidents arise and propagate by various means, depending on the nature of the disaster and the way it unfolds. In general, the level of economic output can be represented as a function of available capital and labor, and the effects of disruptions can be represented as reductions in the available labor or capital, if there are no significant changes in the population behaviors or the structure of the underlying economy.

Many incidents such as hurricanes, floods, and earthquakes, destroy parts of available capital or the underlying infrastructure and as a result affect the labor availability, thus generating direct and indirect economic losses. It is normally assumed that the population behaviors, aside from immediate response to disruption or the restoration efforts, do not change in a systemic fashion.

This literature review describes evidence that is contradictory to the often-stated economic assumptions that consumer behavior does not change post-incident. Given that a significant fraction of the U.S. gross domestic product (GDP) depends on consumer purchasing behaviors, persistent changes said behaviors have a significant potential to impact GDP.

2.1. Consumer Fear-Induced Avoidance from Pandemics

Outbreaks of infectious diseases are one example where changes in the population behaviors may have significant economic impacts. Dauelsberg and Outkin (2005) demonstrate the effects with a simulation study of a representative city of five million people in the event of a pandemic disease. [7]

They explicitly model the population's response to events, including self-quarantine-related behaviors, as well as hording and latent demand. GDP produced in a particular area was represented with the Cobb-Douglas production functions, where capital and labor are the main determinants of production. The general form for the Cobb-Douglas production function is as follows:

$$q = aK^\alpha L^\beta$$

where:

K is capital;

L is labor; and

a, α and β are positive, appropriately calibrated coefficients.

Dauelsberg and Outkin (2005) used a system dynamics model that explicitly represents the labor and the fraction of capital available and calculates the economic impacts as a function of those parameters and the state of supporting infrastructures. They also showed that the population exhibits behaviors during pandemic situations such as compliance with quarantine measures or self-imposed quarantine. While these measures significantly reduce mortality, they increase the total GDP losses from approximately $17 billion in the stated scenario where no mandatory or self-imposed quarantine occurs to $55 billion, where most of the population imposes a self-

quarantine for a significant period of time. This illustrates the fact that population response is one of the most significant factors affecting the severity of GDP disruption effects.

Many studies estimating economic impacts from an avian influenza discuss the possibility of shifts in consumer spending. In a presentation given at the Brookings Institution in October of 2006, Warwick McKibbin explains that for his results "in the minor scenarios, it is actually the human response rather than the labor changes that drive the economic changes."[15] Table 1 summarizes the reductions in GDP caused by consumer spending reductions for various pandemic studies.[3] In most of these studies researchers assumed a consumer spending reduction or reallocation, which leads to a reduction in GDP.

Table 1. GDP losses attributable to consumer spending reductions [4]

Pandemic Influenza Economic Studies	Scope	Annualized reduction of GDP	
		Low	High
Asian Development Bank	Asia (excl. Japan)	1.15%	6.50%
Lowy/Brookings Institution[1]	U.S.	0.01%	0.80%
BMO-Nesbitt Burns	Global	0.7%	2.3%
Congressional Budget[2]	U.S.	0.5%	2.0%
Douglas, Szeto and Buckle[3]	New Zealand	3.6%	4.5%
James & Sargent	Canada	0%[4]	0.4%
Jonung & Röeger	Europe	0.5%	
Kennedy, Thompson, & Vujanovic	Australia	1.6%	
National Infrastructure Simulation and Analysis Center (Baseline)	U.S.	0.2%	2.2%

Notes for Table: (1) Confined to Agriculture, manufacturing, and services. (2) Actual amount varies by industry (3) One scenario was conducted; the range represents the industry range. (4) Assuming Full Demand Reallocation

The literature justifies an expected consumer response similar to the World Bank by explaining that individuals would "avoid infection by minimizing face-to-face interactions, resulting in temporary reductions in consumer expenditures for services such as tourism, mass transportation, retail sales, hotels and restaurants."[2] This is consistent with the definition of fear-induced avoidance behavior.

Many of these studies rely in part on evidence from Severe Acute Respiratory Syndrome (SARS) when determining the magnitude of behavioral changes. In the Forster and Tang analysis of SARS, they describe the outbreak as a 'crisis of fear' wherein "the infrastructure of Hong Kong was fully functional but the normal activities of citizens were severely curtailed by fear of infection". [11]

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[3] The authors made a sincere effort to present this data consistently; however, some discrepancies likely remain as studies have used different approaches, models, and assumptions.
[4] Table References: [2] [15] [6] [5] [10] [18] [13] [14]

But other incidents, including Bovine Spongiform Encephalopathy (BSE), or Mad Cow Disease, hurricanes, and the terrorist attacks of 11 September 2001 in the United States also provide evidence of a quantifiable change in consumer behavior.

2.2. Consumer Fear-Induced Avoidance from Food and Agriculture Sector Incidents

In a study on consumer reactions to Mad Cow Disease, the Pennings et al. noted, "behavior of consumers in a crisis situation is not always consistent with the true level of risk they face." [17] The authors collected survey data from shoppers in the United States, Germany, and the Netherlands. They were focused on why consumers change their behavior and whether marketers or policymakers would have any influence to contain the reaction. They decoupled consumers' choices on beef consumption into differences among risk perceptions and risk attitudes. If the probability of an incident is accurately known, then risk perception is likely to have a greater influence on consumer behavior. In this case, public policy and marketers have the opportunity to influence decisions through providing clear information regarding the risks. However, if risk attitudes dominate decisions, there is little that can be done to change consumer behavior, other than eliminate the risk. Another study on Mad Cow Disease found evidence that scientists had a greater avoidance of beef products following the BSE outbreak than the public at large, suggesting that more informed consumers would be more risk adverse. [12]

A study by the Food Policy Institute in 2003 analyzed economic factors involved with agro-terrorism. [19] This study showed that eliminating all sources of uncertainty is not sufficient to regain consumer confidence and return demand to initial levels. The authors commented on the potential limited ability to generalize this statement to non-food products due to the strong link that is often made between eating a food product and becoming sick. [19]

L. Calvin, et al., studied a case of decline in demand for raspberries after a Cyclosporiasis outbreak was discovered in Guatemala. Despite many controls placed by Guatemala and the United States, the perceived risk outstripped the benefit even when raspberry prices were heavily discounted. By the year 2000 only 77 out of 369 Guatemalan raspberry farms remained. [3]

This evidence suggests that consumers do change their behavior in response to changes in their perceived risks; however, the underlying assumptions concerning the magnitude and extent of behavioral changes are by no means certain, especially when trying to tie the fear that people will have during a pandemic to hypothetical changes that people make in actual purchases and work habits. Few studies have attempted to quantify the assumptions of consumer behavior with non-survey data.

One exception is the study by Sargent and James who looked at the available data from SARS, the 1918 pandemic, and other less severe pandemics. While the authors acknowledge people must have been scared during these outbreaks, they found little evidence to suggest consumers dramatically changed their spending habits. They found for the 1918 pandemic there was little effect on retail sales, external trade, financial markets, or bankruptcies. Other researchers support the Sargent and James findings that humans are exceptional at adapting to extreme circumstances. The positive responses that occur after the negative effect are likely to outweigh the initial shock. They criticize research that predicts large negative impacts because the analysis ". . . rarely considers the response to disaster impacts as part of the same event." [18]

2.3. Consumer Fear-Induced Avoidance from Terrorism Incidents

Terrorist attacks represent major shocks for a country's economy and are beyond the control of consumers and firms. Terrorist attacks can have severe consequences, both at the macro and the micro level. Macroeconomic analysis is useful in understanding the economic implications of terrorism at a national level, but it cannot shed light on the effect of the fear of terrorism on consumer spending at the individual and household level. However, consumer's economic decisions in response to natural and manmade events that cause fear and adversity can have important implications for aggregate consumption.

Degeneffe et al. (2006) sought to understand the reactions of U.S. consumers in the event of disasters or terrorist events. They surveyed consumers, men and women ranging in age from 24-65 from Chicago, IL and Maplewood, MN to gauge attitudes across the U.S. [8]

Survey respondents were asked to indicate how concerned they are about six specific terrorist incidents including:

- Attack on public transportation;
- Biological or chemical agent in a crowded area;
- Contamination of a common food product;
- Attack using passenger aircraft;
- Disruption of electric power grid; and
- Destruction of national monuments.

Across all modes of attack the greatest level of concern was for attack on public transportation. All respondents expect another attack similar to the terrorist attacks of 11 September 2001 to occur during their lifetimes; however, there was no indication of consumers changing their daily behaviors because of the possibility of terrorist events. [8]

Christelis and Georgarakos (2009) investigated the effects of terrorist events on household spending and consumption switching. The authors relied on data from the 2002 U.S. Health and Retirement Study to locate factors that influence consumer insecurity, expectations about terrorism, and spending patterns. Respondents to this survey are U.S. residents who were age 50 and older between April 2002 and January 2003. The respondents were asked the following three questions:

- How much -if any- have the events of September 11 shaken your own personal sense of safety and security: have they shaken it a great deal, a good amount, not too much, or not at all?
- What do you think is the percent chance that there will be a major incident of bio-terrorism in the United States in the next five years, directly affecting 100 people or more?
- What do you think is the percent chance that you, yourself, will be a victim of bio-terrorism in the next five years?

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The researchers found that gender influenced fears related to physical threats; women were more concerned about physical safety than men. The distribution of the answers to the three terrorism-related questions varied across the different socio-economic variables. [4]

Christelis and Georgarakos (2009) also found that anxiety due to terrorism and the expectation of being a victim are greater for those with the following characteristics:

- Less than 65 years old;
- Female;
- Depressed;
- Non-white;
- Low educational achievement;
- Low income;
- No military service;
- Religious; and
- Live in New England, Mid-Atlantic, or the Southeast. [4]

The expectation of a bioterrorist attack in the United States was positively correlated with higher education, depression, regular use of the Internet, and larger economic resources. [4] The authors found that the overall effect of terrorism on household spending is ambiguous and suggest examining consumption switching among goods since terrorism may influence individuals to spend differently among consumer goods. Among all expenditures [5] the researchers found that consumers tended to spend more on vehicles costs and less on recreation and public transportation when expecting terrorism or bio-terrorism events. [4]

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[5] "expenditures" refers to food at home, alcohol, food outside home, medical expenses, clothing, vehicles costs, gasoline, public transportation, and recreation.

3. Model of Fear-Induced Avoidance

An abstracted system dynamics model of the underlying factors that cause fear-induced avoidance behaviors was developed. This model serves as a prototype that combines several salient aspects of fear-induced avoidance behaviors. The most relevant system structures characterized include the driving forces that induce avoidance as well as the forces that assist in system recovery. This model was not based on any specific historical incident to allow for application of the model to multiple types of incidents.

The underlying reference mode that the authors targeted is a sudden drop in the performance of a specific activity and eventual recovery of the performance of said activity. The term "activity" is used as a generalized term for activities that people might avoid due to an incident. These activities could include things such as airline travel, the use of public transit, or tourism to a certain location. An example of the target model behavior is the de-seasonalized time series graph of airline travel pre- and post the terrorist attacks of 11 September 2001 shown in Figure 1.
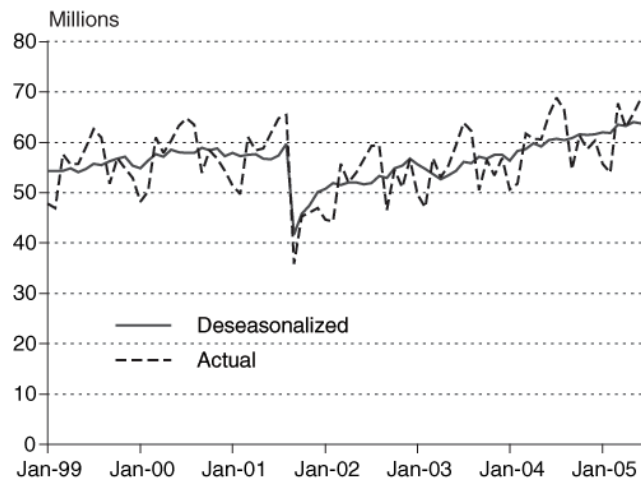

Figure 1. U.S. Airline Passengers January 1999 to January 2005 [6]

The authors designed the model to explain the underlying causes of fear-induced avoidance behavior. They developed the Fear-Induced Avoidance Model to provide decision support on ways to reduce fear-induced avoidance behaviors and to improve the recovery from fear-induced avoidance behaviors. The model is for use on a case-by-case basis to explain the potential for fear-induced avoidance behaviors and it can be parameterized for specific incidents.

3.1. Causal Loop Diagram

The basic overview of the model structure is captured in the causal loop diagram (CLD) within Figure 2. The model itself contains many more variables and parameters that codify the model logic, ensure unit consistency, and allow for model testing not shown in the figure. Relationships between variables use the "S" (same direction) and "O" (opposite direction) conventions as opposed to "+" or "-". Figure 2 is referenced and explained in greater detail in sections 3.1.1 – 3.1.4.
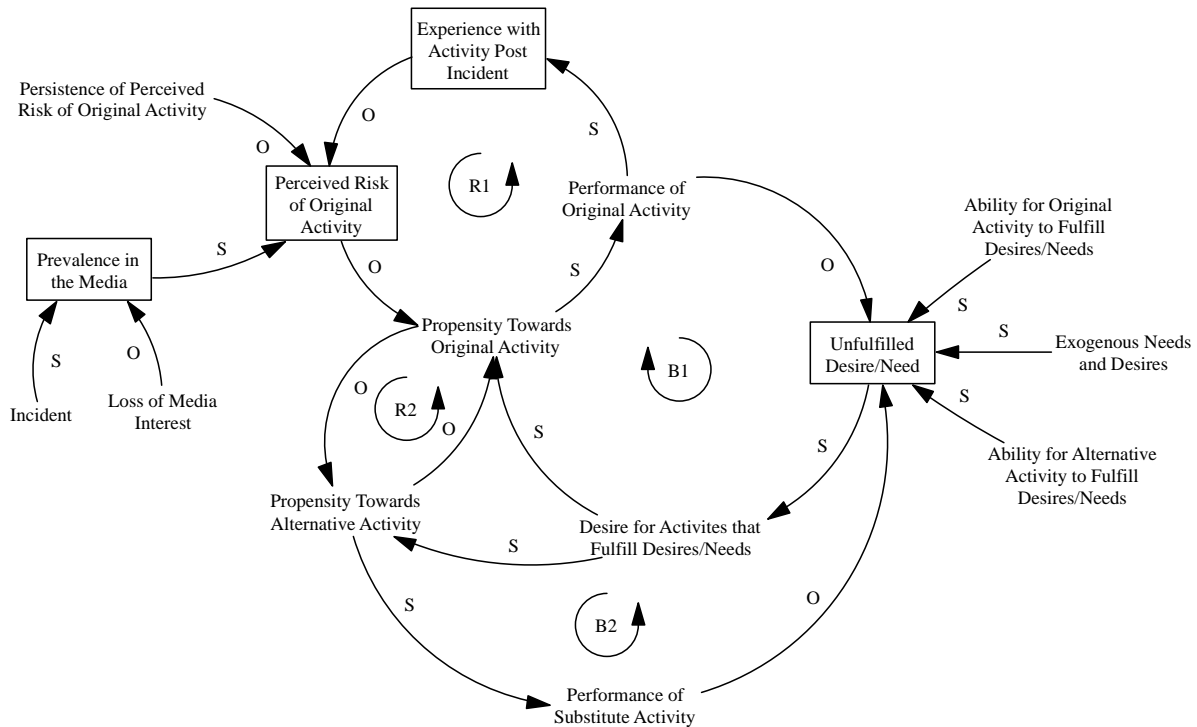
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[6] Figure source: [16]

Figure 2. Causal loop diagram of Fear-Induced Avoidance Model

3.1.1 B1: Original Activity Meeting Desires Loop

The first major loop within the model is balancing loop B1. This loop describes the needs and desires of consumers or individuals and the means by which the original activity meets those desires for said individuals. In the model the authors defines the "original activity" as the activity that is carried out prior to the incident and that could be impacted by the incident.

In this model needs and desires are generically defined. In reality the variety of needs and desires can be large and can span fundamental needs of food and water, which have a measurable quantity, to something that is soft and difficult to measure such as need for social interaction. In the model, needs and desires (variable "Unfulfilled Desire/Need") create consumer demand for an activity that fulfills those needs and desires (variable "Desire for Activities that Fulfill Desire/Need"). This increases a consumer's propensity for performing an activity that fulfills those desires (variable "Propensity Towards Original Activity"). Finally, the actual performance of the original activity (variable "Performance of Original Activity") fulfills the consumer's backlog of needs and desires (variable "Unfulfilled Desire/Need").

3.1.2 R1: Incident Causes Increased Perception of Risks Decreasing Performance of Original Activity

The second major loop within the model is self-reinforcing loop R1. This loop describes the impact of an incident on the performance of the original activity. An incident occurs (variable "Incident"). The media broadcasts this incident and the prevalence of the incident in the media

(variable "Prevalence in the Media") drives the overall perception of risk when performing the original activity (variable "Perceived Risk of Original Activity"). Due to the increase in perceived risk the propensity for performing the original activity (variable "Propensity Towards Original Activity") is lowered.

If it were the case that there were no other means for meeting a person's needs and desires, then eventually the backlog of an individual's or consumer's needs and desires would force them to perform the original activity. If this were the case, every time an individual or group of individuals performed the original activity, they would increase their experience with the original activity post-incident (variable "Experience with Activity Post Incident"). As the number of times the original activity is performed post-incident increases, an individual's experience with performing the activity reduces their perceived risk of performing that activity. In addition, individuals in the system can choose to share their positive experience with others causing the performance of the original activity to recover more rapidly in general.

It is important to note that in the model, the perception of risk of the original activity decreases over time due to lowered prevalence of the incident in an individual's memory as time passes (via variable "Persistence of Perceived Risk of Original Activity"). However, the lowering in the perception of risk does not necessarily mean the return of consumers to the original activity. This is consistent with Turvey et al. who showed that eliminating all sources of uncertainty is not sufficient to regain consumer confidence and return demand to initial levels.[19] The authors posit that the return to the original activity is, therefore, driven by individuals' needs and desires. This will be further explained in the following sections.

3.1.3 R2: A Substitute Activity

Christelis and Georgarakos (2009) suggest that terrorism may influence individuals to spend differently among consumer goods. [4] Loop R2 considers this possibility. This loop provides the feedback structure to enable individuals to choose between the original activity and an alternate activity (variable "Propensity Towards Original Activity" vs. variable "Propensity Towards Alternative Activities"). The model makes some simplifying assumptions in terms of the ability to adopt an alternate activity:

- There exists an alternate activity that can meet all or some of the needs and desires that the original activity met;

- The alternate activity has the capacity to handle all or most of the original activity's demand; and

- Individuals choose between one activity or another.

The second assumption is particularly important, since it might not be possible for the alternative activity to meet the overall demand the original activity met. If this were the case, additional model structure would need to be added to account for system capacity and reduction of quality as congestion in the system increases.

3.1.4 B2: Substitute Activity Adopted

Given an incident, the propensity to perform the original activity is decreased. As this occurs, people begin to perform alternative activities to meet their needs and desires. A common

example is following the attacks of 11 September 2001 people chose to drive instead of flying. The performance of the substitute then meets the needs and desires of individuals (to a degree).

Despite the fact there are alternative means for accomplishing a goal, alternative activities are rarely perfect substitutes. That is, the performance of the alternative activity rarely offers all of the benefits of the original activity. For example, teleconferencing into a meeting offers some of the benefits of attending, until lunch occurs and people have individual conversations. Teleconferences are a great money and time saving device for attending a presentation, but tend to be terrible devices for networking during breaks. However, it is possible an alternative activity may offer some additional benefits. For example shopping online is more convenient than shopping in a physical store or mall.

When an incident occurs it is important to understand the effectiveness of the activity to meet individuals' needs. Given an incident, there are two possibilities in the model:

- The alternative activity does not fully meet the significant set of needs and desires of an individual and, therefore, individuals will migrate back to the original activity, given a certain backlog of needs, desire, or reduction in the perception of risk with the original activity; or

- The alternative activity does meet or is an improvement on the original activity and, therefore, individuals do not migrate back to the original activity due to the perceived risk, as well as the fact that the activity might be an improvement over the original.

Parameters (variables "Ability for Original Activity to Fulfill Desires/Needs" and "Ability for Alternative Activity to fulfill Desires/Needs") drive the effectiveness of the alternate activity on meeting desires. These parameters are tested in the model demonstration section.

3.2. Model Structure

The following section includes some of the key equations included within the model as well as some sample model runs and the implications of parameter changes. To see an overview of the Vensim model diagram please see Appendix A.

3.2.1 Key Equations and Graphical Functions

Most of the model structure is quite simple. The most important equation in the model is perhaps the flow that controls the movement of population performing "Activity A" the original activity and "Activity B" the alternative activity. The equation for this variable is as follows:

$$Movement\ Between\ A\ and\ B\ = \frac{[(B - B_{Min}) * D_{Unmet} - MAX(0, (A - A_{Min}) * Risk_A)\ ]}{Time\ Constant_{From\ A\ to\ B}}$$

Where:
A is the current population in Stock A that performs Activity A
B is the current population in Stock B that performs Activity B
A_{min} and B_{min} are exogenous minima placed on Stock A and B
D_{Unmet} is the effect of unmet demand that allows for people to adopt Activity B

Admittedly this formulation is perhaps too simple for a situation with more than one alternative. Additionally, this formulation places minima for populations in activity A and B. This could be improved by creating a structure that endogenously induces minima, however, this may require further characterization of the need and desires structure within the model.

An additional and important note about the formation is that the risk perception of Activity A (once an incident occurs) lingers in the model and can either be reduced exogenously through a time constant or endogenously through the performance of Activity A post-incident. State variables are present to represent both the prevalent perception of risk as well as the performance of Activity A post-incident.

Several variables are instantiated as graphical functions. These include the following variables:
- Effect of Unmet Demand by A on Adopting B

- Graphical Function for Propensity to Perform Activity

- Graphical Function on Effect of Perceived Risk on Propensity for Activity

These graphical functions are used to represent key effects from one variable to another. "Effect of Unmet Demand by A on Adopting B" is used to capture the effect on relevant populations to adopt B vs. staying with A. This variable allows for a new steady state where people permanently adopt B.

The "Graphical Function for the Propensity to Perform Activity" serves as means to delay the desire for wanting to purchase goods immediately when a desire is instantiated. It defines a threshold limit for when a backlog is not tolerable for acquiring a desired good or service. This is to say when a person desires something; immediate satisfaction for that desire is not necessarily required. People are willing to batch needs and desires and then perform an activity to simultaneously (and more efficiently) fulfill those desires (e.g. if you run out of jam you may not immediately head out to the store until you need more important goods like butter and bread).

The last graphical function is perhaps the most important "Graphical Function on the Effect of Perceived Risk on the Propensity for Activity A." This variable serves as a major component to control the movement of a population towards the (temporary) adoption of activity A. Depending on the size of an incident, the perception of risk towards performing activity A may be negligible or large. With the graphical function presented, smaller incidents have hardly no impact on the performance of activity A and much larger incidents might have a large and potentially proportional effect on the performance of Activity A. This formulation may not be correct, and in future efforts to develop this model, it might be worth studying how alternative graphical functions may impact the dynamics of the model.

Screenshots of graphical functions are included in Appendix B.

3.2.2 Model Demonstration

The significance of model output is currently viewed in terms of the percentage of people who are performing the original activity versus an alternate activity. Figure 3. shows the switch from activity A to activity B during the incident (at day 10) and the eventual recovery. The time scale is notional. In this simple model the population shift is immediate, whereas in reality it might take time for individuals to find alternative activities. This is a simplifying assumption, although delays can be added in future developments of this model.
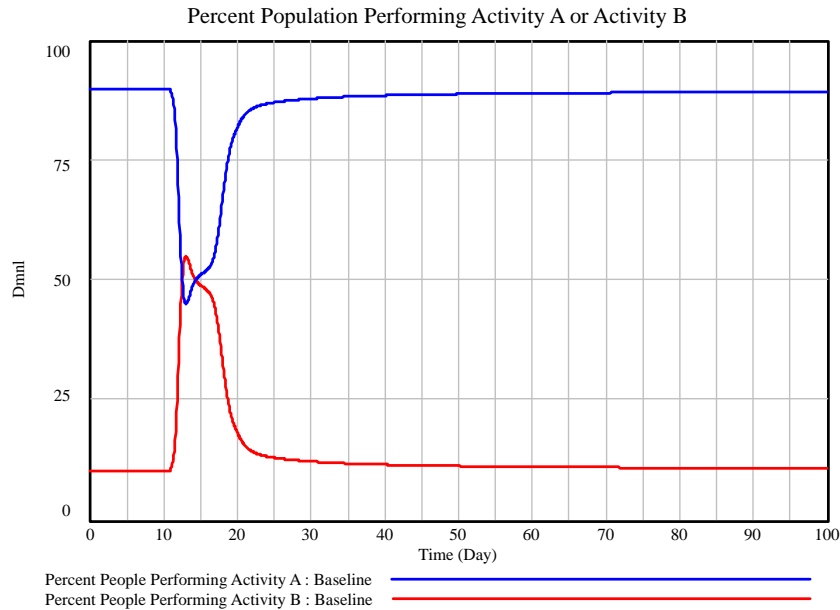
Figure 3. Percent of population performing activity A and activity B.

As a test, analysts varied the size of the incident in the model. The incident size is a parameter in the model that is supposed to represent the extent and the overall scope of the incident in a single number. The baseline is represented by an incident of size 20. In Figure 4 the authors varied incident size value (10, 40, 100 respectively). The size value changed the depth and scope of avoidance of activity A. This is expected, as a larger incident would logically result in more avoidance than a smaller one. The overall shape of the avoidance and recovery curve changes with risk perception. Risk perception is more easily overcome for a smaller incident than a larger incident.

Larger incidents have an initial deeper dip and then recover slightly and stagnate at a lower level. This particular shape is due to an initial shock that causes more individuals to halt their performance of activity A. However, because activity B is not a perfect substitute to activity A (see Section 3.2.2.1 for more information), individuals return to activity A to meet some of their needs and desires, causing a mild recovery in performance until risk perception of activity A is reduced.
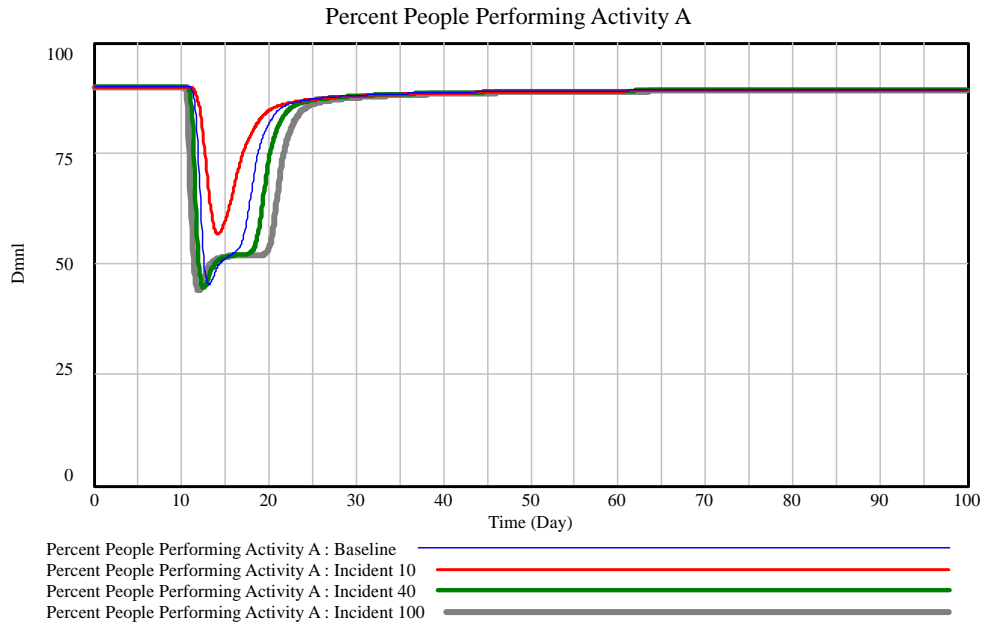
Figure 4. Impact of varying incident size

3.2.2.1   *Impact of the Effectiveness for Alternative Activity to Meet Needs and Desire*

The effectiveness of activity B to meet needs and desires greatly impacts the recovery of activity A. In Figure 5 the authors varied the effectiveness of activity B to meet the needs and desires of individuals. Baseline is set at 0.01. As the effectiveness for activity B to meet the needs and desires increases, activity A recovers less.

As stated in previous sections, there is no structure in the model that accounts for the ability for activity B to handle the demands of activity A (which would also be a factor); however, Figure 5 is instructive as to the driving forces for the recovery of an activity post-incident. While perception of risk is an important variable that can control whether performance of activity A occurs or does not, the backlog of needs and desires is what drives consumers and individuals to perform an alternate activity.

Percent People Performing Activity A

Percent People Performing Activity A : Baseline
Percent People Performing Activity A : Desire 0_1
Percent People Performing Activity A : Desire 0_5
Percent People Performing Activity A : Desire 1
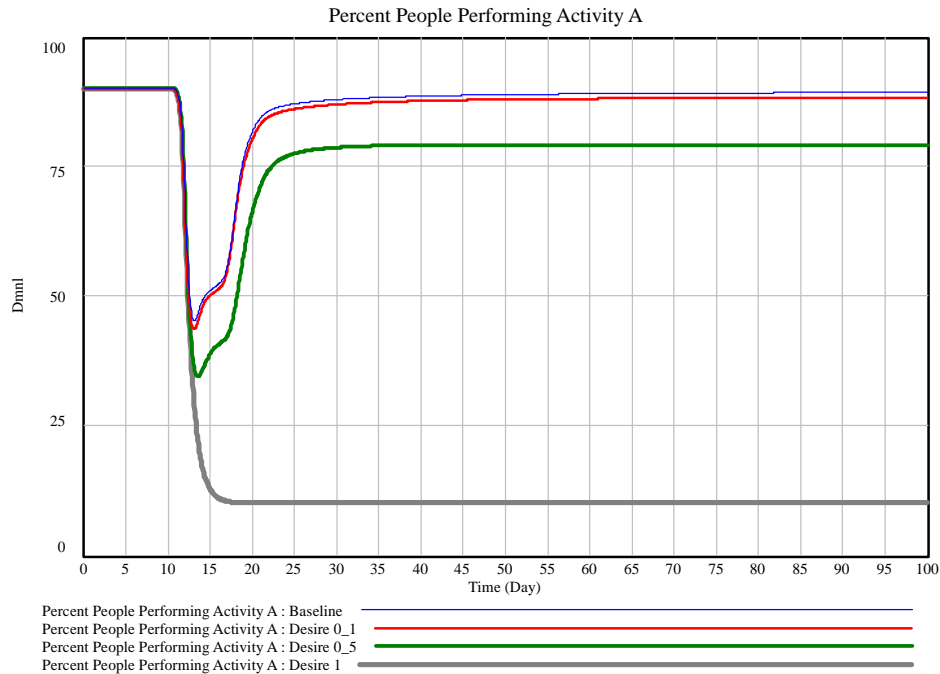
Figure 5. Impact of varying the effectiveness of Activity B to meet needs

3.2.3 Future Development

Currently the model has few data requirements; however, further testing and validation of the model does require data. Data needed to further model testing and validation include:

- Data on the reduction of performance of an activity after an incident (e.g., the post-9/11 flight data set),

- Data of alternate activities rising after an incident (e.g., increase in driving),

- Data on the perceived risks of performing the original activity (e.g., survey data on fear and perceived risks of flight), and

- Data on needs and desires (e.g., Bureau of Economic Analysis [BEA] data on travel expenditures).

Additionally, further improvements to the model structure and further review of the relevant literature (including psychology and marketing) may allow for improvement of model structure.

Once structural improvements are complete, future development of this model could include an implementation in agent-based frameworks to provide further insight into how the interaction of various individuals following the logic outlined in this model would impact the emergent behavior.

4. Conclusions

In this paper the authors performed a literature review, developed salient causal links between relevant variables, and developed a model that explains the major facets and causes of fear-induced avoidance behaviors. This kind of behavior has been documented to cause significant impacts after a national incident occurs. Key examples of fear-induced avoidance behavior include the post the terrorist attacks of 11 September 2001 airline travel avoidance as well as other prominent national and international incidents. While this model is still in its initial development stages, the authors believe that the following dynamics play a key role in causing fear-induced behaviors:

- Risk perception is a major driver of fear-induced avoidance, however, simply reducing the perception of risk will not mean a return to the previous levels of activity. Simply providing individuals and consumers a reminder that the activity they are avoiding is safe may not be sufficient to have them return to pervious levels of activity.

- People perform certain activities because it meets a desire or need. Given sufficient knowledge of, access to, and capacity of an activity people will nominally flock to the most "efficient" means to meet their needs and desires. The notion of efficiency here is not only bounded but differs from person-to-person. As the reader might have their own likes and needs for certain goods and services the authors might have different ones. These needs an desires can be as tangible as a car to the need for social interaction. The underlying needs drive the purpose of why people will perform certain activities.

- The authors posit that the driver for consumers returning to previous levels of activity is dependent on their continued demand for goods or services that the activity the consumers are avoiding met.

- If there exists an alternate means of performing activities that consumers avoid post-incident, and these alternate means are near perfect substitutes, then the incident may catalyze a permanent transition to the less risky or more effective of the two activities. This might have some important policy implications.

- Ultimately, most activities are not perfect substitutes (i.e., driving is not a perfect substitute to flying, online shopping is not a perfect substitute to shopping at the mall), therefore most consumers will return to their previous activity, given the same needs, desires, and sufficient elapsed time. However, an important factor not included in the model is the fact that incidents can induce changes in consumer spending as there may be less overall economic activity as a result of an incident. This is an important dynamic that needs further investigation.

These dynamics give insight into potential policies that could be pursued to mitigate the psychological consequences of an incident. Given the fact that incidents may influence individuals to spend differently among consumer goods [4] there are some effective policies to counter act psychological consequences post-incident.

Currently governments pursue a risk reduction regime to reduce the perception of risk. It has been documented that simply reducing risk does not reduce the perception of risk [17] Additionally, it has been shown that eliminating all sources of uncertainty is not sufficient to regain consumer confidence and return demand to initial levels.[19] While reducing actual risk

and informing the public that the risk has been reduced are important aspects of post-incident response, equally important (and perhaps more effective) is to remind individuals why the activity that they are avoiding provides them a real and perceivable benefit to any adopted alternatives. Additionally, logical arguments regarding risk are useful, strategies targeting affect are as important as reducing risk.

It is also possible that if no policy is enacted to respond to an incident, in the long-term the consumers will return to the original activity. This would be true given no viable alternatives are available, needs have not changed, or the activity is still available to be performed.

Further development and testing of this model is required to verify the accuracy of these claims. Additional information regarding pre-incident priming would be useful as it may lead individuals to be more psychologically resilient to incidents – preempting psychological consequence. Formulating a model that would adequately represent the avoidance of a certain historical incident (such as 9-11 or food contamination issues) may also provide more insights within those areas of study.

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Appendix A: Diagram of Model Structure

Time for Media to Loose interest

Media Coverage for Impacts

Prevalence of Media Coverage for Incident

Media Losing Interest in Incident

Media Interest of Incident

Incident Pulse

Incident Size

Incident Time for Occourance

Length of Incident Evolution

Perceived Risk of Activity A from the Incident

Persistence of Risk Perception

Decreased Risk Perception

Increased Risk Perception

Risk Perception from Incident in Media

<Risk Perception Reduction Through Increasing Activity A>

Total Percent People

<Percent People Performing Activity A>

<Percent People Performing Activity B>

Risk Tolerence for Activity A

Effect of Perceived Risk on Propensity for Activity A

Graphical Function on Effect of Perceived Risk on Propensity for Activity

Performance of Activity A Since Incident

Activity A Since Incident

Empty Activity A Since Incident

<TIME STEP>

Risk Perception Reduction Through Increasing Activity A

Level of Performance of Activity A After Incident that Reduces Risk Perception

Minimum Percent Performing B

Minimum Percent Performing A

Normal Activity B

Percent People Performing Activity B

Movement btwn A and B

Percent People Performing Activity A

Cumulative Activity B

Performing Activity B

Time to Move Between A and B

Effect of Demand on Activity

Effect of Unmet Demand by A on Adopting B

Graphical Function for Propensity to Perform Activity

Normal Actvity A

Threshold for Unmet Demand leading to Adoption of B

Demand for Activity to Meet Desires

Performing Activity A

Cumulative Activity A

Desire Threshold Level

Activity A Effectiveness on Desire

Desire 1 Demand for Activity

Activity A Effect on Desire

Activity B Effectiveness on Desire

<Performing Activity B>

Desire In

Backlog Desire

Desire Met

Exogenous Desire

Desire Persistence Time

Activity B Effect on Desire

20

Appendix B: Screenshots of Graphical Functions

Graph Lookup – Graphical Function on Effect of Perceived Risk on Propensity for Activity

Input	Output
0.1	0
0.2	0.05
0.3	0.1
0.4	0.25
0.5	0.5
0.6	0.75
0.7	0.9
0.8	0.95
0.9	0.98
1	1

New

Export
Print

Y-max: 1

Dmnl

Y-min: 0

Import Vals   X-min: 0.1   x=0.7122   y=0.1619   X-max: 1   Reset Scaling

OK   Clear Points   Clear All Points   Cur->Ref   Clear Reference   Ref->Cur   Cancel