CONSUMER PROTECTION AND THE ROLE OF GOVERNMENT: EVALUATING CALIFORNIA'S PROPOSED FIRE BARRIER PERFORMANCE STANDARD THROUGH BENEFIT COST ANALYSIS

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Nathan Stephen Fesler

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Abstract

of

CONSUMER PROTECTION AND THE ROLE OF GOVERNMENT: EVALUATING CALIFORNIA'S PROPOSED FIRE BARRIER PERFORMANCE STANDARD THROUGH BENEFIT COST ANALYSIS

by

Nathan Stephen Fesler

The State of California's Bureau of Electronic and Appliance Repair, Home Furnishing and Thermal Insulation (BEARHFTI) is the only regulatory agency that has imposed smoldering safety standards for upholstered furniture. However, this does not address ignition from an open flame. In response to industry input, BEARHFTI is evaluating a fire barrier performance standard that requires a flame-resistant fire barrier to improve the resistance of upholstered furniture to an open flame. The desirability of mandating fire barriers in upholstered furniture for residential use depends upon whether the benefits from pursuing a regulatory requirement exceed the cost of imposing it.

This thesis evaluates the efficiency of California's currently proposed fire barrier performance standard. Through a Benefit-Cost Analysis, I account for the likely future benefits for Californians of the adoption of a fire barrier performance standard, and the likely future costs to furniture manufactures of implementing it for home furniture sold in the state. Using a unique Benefit-Cost framework, the estimated net present value over a 16-year time horizon is negative $836,539,890, suggesting the costs will far outweigh the benefits. Given an inherent level of uncertainty in the model assumptions and data used, a sensitivity analysis was performed to check the robustness of the initial findings to model changes. A range of sensitivity analyses of the

benefit/cost inputs and model parameters indicate the initial negative findings are robust to changes in assumptions. Therefore, I conclude that directly imposing a fire barrier performance standard is not an efficient approach to protecting California consumers against upholstered furniture fire losses caused by an open flame. As a policy alternative, I propose BEARHFTI consider a product warning label requirement to reduce consumer harm from upholstered furniture flammability risk.

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Date

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CHAPTER ONE: INTRODUCTION

Government has long established a role for ensuring basic product safety and consumer protection. The Federal Food and Drugs Act in 1906 was one of the first product safety and consumer protection provisions, and the scope of government oversight since has gradually expanded to thousands of consumer products under the regulatory authority of the U.S. Consumer Protection Safety Commission (CPSC).[1] This trend of government oversight is the recognition that markets do not always adequately protect the consumer in three areas: (1) markets do not always fully inform the consumer of all risks associated with the product, (2) imperfect information lends producers to undersupply quality and safety, and (3) unpriced negative externalities – the unpriced marginal social cost imposed upon third parties from consumer or producer transactions (Darids, 1980; Viscuis *et al.*, 1995; Damania and Round, 2000). While the role of government in ensuring basic product safety and consumer protection is well established, the optimal level of government regulation remains an actively debated public policy question (Damania and Round, 2000).

A focal point to this debate is whether the marginal benefit of additional government regulated product safety exceeds the cost of market interference (Damania and Round, 2000). Marginal benefits from consumer protection are generally measured as the marginal reduction in product caused property losses, and consumer injury or death (Oi, 1974). Given limited resources the public policy consequence is government cannot efficiently regulate all product related consumer accidents or deaths. This recognition that regulation imposes significant costs and not just benefits is reflected in the assigned importance of benefit-cost analysis in federal rule making.

[1] See https://www.cpsc.gov/Safety-Education/Safety-Guides/General-Information/Who-We-Are---What-We-Do-for-You

Federal Executive Order 12866 requires any regulation expecting to impose $100 million dollars or more in economic impacts must require a benefit-cost analysis to quantify if the benefits indeed exceed the costs (Consumer Protection Safety Commission [CPSC], 2012a). More recently in 2012, CPSC expanded its use of benefit-cost analysis by establishing a plan for retrospective analysis to identify product safety and consumer protection regulations that impose costs greater than benefits (CPSC, 2012a). Despite the prominence of BCA in federal rule making, the use of BCA in state policy analysis, let alone retrospective BCA analysis, varies considerably across states.[2]

In particular, California under the provision of the Administrative Procedures Act requires state agencies directly under the executive branch to conduct a Standardized Regulatory Impact Assessment (SRIA) for proposed regulation of $50 million dollars or more in economic impacts (Legislative Analyst Office [LAO], 2017). Included in a SRIA is an option for a BCA; however, a review by the LAO indicates even when a BCA is conducted there are fundamental errors in its application. These errors include inconsistent use of discounted benefits and costs, limited use of sensitivity analysis to account for uncertainty, and a lack of quantified benefits (LAO, 2017). These deficiencies in the application of BCA in California regulatory review highlights the importance of arguments raised by economists Sunstein and Glaeser – statewide regulation needs similar regulatory checks imposed by appropriate use of BCA to what is performed at the federal level.[2] This potential for inefficient regulation in product safety and consumer protection is particularly relevant to upholstered furniture markets. Although CPSC regulates thousands of consumer products, upholstered furniture is notably absent any federal regulation (Consumer Product Safety Commission [CPSC], 2016). Instead the State of California's Bureau of Electronic and Appliance Repair, Home Furnishing and Thermal

[2] See https://www.nationalaffairs.com/publications/detail/regulatory-review-for-the-states

Insulation (BEARHFTI) is the only regulatory agency to impose upholstered furniture safety standards (BEARHFTI, 2013). The primary consequence is the size of California's product markets are often large enough that state regulatory standards, which do not require a BCA, can become de facto national standards.[2] Given California's expansive household market for upholstered furniture, and the potential for upholstered furniture regulation to impose significant costs, there is a particular need for BCA to inform the optimal level of consumer protection.

The purpose of this master's thesis is to demonstrate the role of BCA in evaluating the efficiency of California's currently proposed fire barrier performance standard (see BEARHFTI, 2014). I conducted an *ex ante* BCA to account for the likely future benefits of the adoption of a fire barrier performance standard to the residents of California, and the future likely costs to furniture manufactures of implementing it for home furniture sold in the state.[3] If the benefits exceed the costs, given a reasonable range of sensitivity analyses, then evidence exists regarding the efficiency of adopting a fire-barrier regulation. To the contrary, I find with a high degree of certainty that directly imposing a fire barrier performance standard is not an efficient approach to protecting California consumers against upholstered furniture fire losses caused by an open flame.

This introductory chapter summarizes the history of concerns and institutions that led California to consider an open flame fire barrier in upholstered furniture. Sections in this introductory chapter address: (1) the history of upholstered furniture regulation in California, (2) the economic argument for the possible need of government to require a fire barrier in upholstered

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[3] The likely benefits of which do not include the possible changes in health, and environmental impacts from decreased exposure to flame retardant chemicals. There are two primary reasons: (1) there is no clear policy mechanism that would cause a net change in overall levels of flame retardant chemicals when BEARHFTI does not regulate the use of flame retardant chemicals, and (2) the fire barriers under evaluation are non-flame-retardant cloth composite textiles (BEARHFTI, n.d.a). Thus, toxicity impacts from flame retardant chemicals are not a benefit addressable in this BCA.

furniture, and (3) the ignition sources and losses attributed to upholstered furniture fires[4] in the United States. It concludes with what follows in the remaining chapters in the BCA analysis.

Upholstered Furniture Regulation in California

In 1973, the National Commission on Fire Prevention and Control published a report on *America Burning* that brought increased attention to the concern of residential fires in the United States. Of the nearly one million building fires that occurred nationwide in 1971, nearly 70 percent of them occurred in residential buildings (National Commission on Fire Prevention and Control, 1973). Identified in this report was the underlying causal factor of the absence of any flammability standard for interior home furnishing. The prevailing regulatory sentiment at the time was that the choice of interior furnishings – as opposed to structural building materials and standards regulated by building codes – remain the sole responsibility of a residential occupant. However, the Commission's (1973) report noted a residential occupant could only fulfill this responsibility when there exists an adequate knowledge of combustion hazards of interior furnishings, and an occupant's ability to process this knowledge. To put the latter into context, half of all deaths in residential building fires in the United States from 1985 to 1994 were caused by sleep, or smoking while intoxicated on upholstered furniture (USFA, 1997). Since the Commission felt that adequate knowledge of this risk was not widespread and/or consumers were unwilling to engage in fire safe behaviors even if they possessed this knowledge, they recommended the federal Consumer Product Safety Commission (CPSC) develop regulatory standards to minimize the combustion propensity of interior furnishings. Following these recommendations, California in 1975 became the first, and still only state to require flammability restrictions for residential upholstered furniture sold in its boundaries.

[4] Upholstered furniture fires throughout the remainder of this report will refer to residential building fires where upholstered furniture is the first item to ignite, or as a primary contributing fuel source.

California based its standard (Technical Bulletin 117) from the Federal Test Method Standard 191, Method 5903.2 vertical open flame test. This required the resilient filling materials (namely one-piece foam) used in home furniture to pass both a cigarette smolder test, and a 12 second exposure to an open flame test (BEARHFTI, 2000). In addition, shredded resilient filling materials needed fabric encasement that passed both a three second, and a 12 second open flame exposure (BEARHFTI, 2000). The latter criteria being the result from expected fire behavior interaction between synthetic materials inherent in shredded resilient filling materials, and fabric used to enclose the filling materials. Absent federal CPSC action, and because a sizeable percentage of the country's furniture sales occur in California, Technical Bulletin 117 emerged as a *de facto* national standard for fire protection in upholstered furniture (Consumer Product Safety Commission [CPSC], 2016).

Major elements of Technical Bulletin 117 remained relatively unchanged until 2012. In that year, California's Governor Brown asked BEARHFTI to review the bulletin, considering growing concerns of the prevalent use of flame retardant (FR) chemicals in upholstered furniture to meet the 12-second open flame resilient filling material performance standard (California Legislative Information, 2014). While flame retardant toxicity concerns initiated the review of Technical Bulletin 117, the change to Technical Bulletin 117-2013 was predominantly the acknowledgement of inadequate flammability performance standards for upholstered furniture using chemical retardants. BEARHFTI (n.d.b) indicated in its review of Technical Bulletin 117 that the original bulletin failed to meaningfully address: (1) smoking ignition hazards as one of the leading causes of upholstered furniture fires, (2) the role of upholstered cover fabrics as primary initial contact with an ignition hazard and its interaction with resilient filling materials, (3) National Bureau of Standards and CPSC studies finding insignificant differences between FR treated foam and non-FR treated foam, and (4) predominant role of cigarettes as ignition source in civilian deaths in residential building fires (see also BEARHFTI, n.d.c).

Technical Bulletin 117-2013 subsequently removed the requirement of open-flame ignition testing, and instead modeled the new cigarette smoking performance test standards based on the international ASTM E1353-08 aε1 standard (BEARHFTI, 2013). This standard prohibits specified component assemblies of furniture to: (1) smolder beyond 45 minutes, (2) exceed specified vertical char lengths specified per component assembly during the duration of the cigarette test, or (3) results in open flame combustion. Component assemblies within the scope of Technical Bulletin 117-2013 are the cover fabric, inter-liner (barrier) materials, resilient filling materials, and decking materials in upholstered furniture. If the resilient filling material and/or cover fabric fail the new cigarette performance test standard, then upholstered furniture must include an inter-liner barrier that passes the barrier materials test. Thus, the intent of Technical Bulletin 117-2013 is a reduction in the smoldering ignition of upholstered furniture for residential use, which remains its leading cause (BEARHFTI, n.d.a.).

Despite the substantial regulatory changes in Technical Bulletin 117-2013, industry input during the public comment review period suggested the absence of a standard to address the ignition from open flame sources underestimates this component of risk (BEARHFTI, n.d.a.). In response, BEARHFTI committed to further evaluation of a fire barrier performance standard.[5] The proposed fire barrier standard requires a flame-resistant fire barrier[6] that is not chemically treated with flame retardants, to improve the resistance of upholstered furniture to an open flame (BEARHFTI, n.d.b; BEARHFTI, 2014).

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[5] Performance standards only specify the minimum test requirements, and do not specify materials or manufacturer methods in meeting the standard (BEARHFTI, n.d.b). Under a BCA, assumptions of specific materials and manufacture methods is necessary.

[6] Fire barriers represent a variety of cloth composites, and synthetic materials placed between the resilient filling material and the cover fabric (Davis & Nazare, 2012).

The Role for Government Regulation in Upholstered Furniture

The desirability of mandating fire barriers in upholstered furniture for residential use requires a consideration of multiple factors. The first question is whether the benefits from pursuing a regulatory requirement for a fire barrier standard in upholstered furniture exceed the cost of imposing it. The potential benefit stems from the incremental reduction in civilian deaths, injuries, and property loss. A reduction in the number and/or severity of residential building fires occurs if the fire barrier standard stops the ignition source from causing the residential building fire (see CPSC, 2016 using an analogous approach), and/or a piece of upholstered furniture is less likely to be a primary contributing fuel source for a residential fire not started directly by upholstered furniture.[7] Considering that fire barriers have been shown to reduce peak heat release, slow fire spread, and overall reduce fire severity when upholstered furniture is exposed to an open flame (CPSC, 2012b; Lock, 2016), there is evidence consumers can benefit from fire barriers in upholstered furniture.

A second consideration is whether there is theoretical justification for the necessity of government involvement in trying to prevent fires started, or accelerated by upholstered furniture. A core economic rationale for supporting government intervention in a free-market choice pertains to whether the consumer has all the information necessary to make an informed choice (Darids, 1980; Damania and Round, 2000). More importantly, even if the information is available, it is necessary the consumer incorporates this information in the decision making process (Stoltman and Morgan, 1995). If these conditions do not hold, economists characterize the market as exhibiting imperfect or asymmetric information. These forms of market failure give way to the

[7] It is acknowledge the latter component does not strictly conform to past BCA research designs (see CPSC, 2016). Rather this BCA analysis, consistent with Hall's (2015) approach, will consider residential building fires addressable by a proposed fire barrier performance standard when upholstered furniture is a primary contributing fuel source.

possibility an improvement in the free market outcome can occur through government intervention (Bardach & Patashnik, 2016; Mintrom, 2012).

Imperfect information, arises when consumers lack the necessary information to ascertain differences between goods that affects the utility obtained from consuming them (Hill & Myatt, 2010). In terms of flammability of residential furniture, if consumers cannot differentiate the degree of flammability across furniture pieces, producers of less flammable furniture will not be able to sell it at the needed higher price to cover the additional costs to manufacture it. Conversely, producers of more flammable furniture can sell at the same price as the less flammable furniture, because consumers do not know of differences in the degree of flammability. This result in adverse selection, because the unfettered market shifts towards the production and consumption of more flammable products (Hill & Myatt, 2010).

On the other hand, asymmetric information often occurs when the manufacture maintains an information advantage over the consumer (Hill & Myatt, 2010). In the case of furniture sales, the manufacture is likely to possess significant knowledge of furniture flammability characteristic from their own product testing. The consumer without an unbiased third party (e.g., *Consumer Reports*), or a government agency, will not possess accurate information on the flammability of all residential furniture products available to them. In effect, both imperfect and asymmetric information leads to an increased risk of harm to the consumer, since the associated risks of furniture flammability is likely not known at the time of purchase. Nor is it reasonable the consumer could ascertain the furniture flammability characteristics after purchase.

Even if the consumer was fully informed of these risks by the manufacturer, there is sufficient reason to expect few consumers to act upon this information at the time of purchase. It is well established consumers tend to not practice probabilistic reasoning, or demonstrate limited computational capacity and attention (Cogdon *et al.*, 2011). The latter being particularly relevant when furniture flammability is determined by the individual components and the interactions between fabrics, foams, frame material, and construction (Davis & Nazare, 2012). Therefore, the role of government intervention to mandate a level of consumer protection in markets that exhibit asymmetric or imperfect information is well established (Bardach & Patashnik, 2016).

Solutions to market failure and consumer harm from imperfect or asymmetric information often take the form of regulation through performance or licensing standards (Bardach & Patashnik, 2016; Mintrom, 2012). These are meant to ensure a minimum level of product safety to the consumer. On the other hand, performance standards generate additional costs to taxpayers from government testing and enforcement; and greater material, labor, shipping and compliance costs to furniture manufactures. These costs are either passed forward to consumers in the form of higher prices, or backward to producers in the form of lower profits. Regulation at its worst can result in a form of government failure where the standard of regulation is set so high that the total social cost of government intervention exceeds the social benefits of rectifying a market failure (Mintrom, 2012). Additionally, free market proponents argue that a producer in an unregulated private market faces sufficient incentives to ensure adequate safety in their products. Free market economists point to the development of industry associations who require safety assurances from its members (Shleifer, 2005). Case in point is the Upholstered Furniture Action Council's long-standing development and adoption of fire-related test standards.

Regardless of these competing views on the role of government, public policy analysis takes the perspective that if there is indeed a possible role for government to rectify a clearly denoted market failure, there must also be a level of objective justification before it occurs. Here the legitimate public policy problem is the imperfect and/or asymmetric information that exists regarding the risk of civilian deaths, injuries, and property losses associated with inadequate information on open flame ignition resistance in upholstered furniture. The central question then becomes whether this public policy problem is of sufficient magnitude that the expected benefits of government involvement in specifying an upholstered furniture barrier exceeds the expected costs. A BCA is an integral means of answering this.

Magnitude and Scope of the Upholstered Furniture Fire Problem

As part of an *ex ante* BCA of the proposed fire barrier performance standard for California, it is necessary to ascertain the degree to which varying ignition sources are the cause of residential upholstered furniture fires. Combining this with an inventory of the magnitude of the civilian deaths, injuries, and property losses, it provides a picture of the previous social costs inflicted by upholstered furniture fires. From this the social costs attributed only to upholstered furniture fires caused by an open flame can be isolated, and compared to the leading cause in order to provide context for the possible magnitude of benefits a fire barrier performance standard offers.

Yearly data from the National Fire Incident Report System[8] (NFIRS), and National Fire Protection Association's (NFPA) fire department experience survey, offers a source of the needed information for the entire United States. This combined data set for the period 2006 to 2010, indicates upholstered furniture as the first item to ignite in the United States was the primary cause of an annual average of 480 civilian deaths, 840 civilian injuries, and $490 million (adjusted to 2018 dollars) in property loss (National Fire Protection Association [NFPA], 2013, p. 3). Smoking ignition sources – defined as cigarettes and other lighted tobacco products – are the leading cause that accounted for about 28 percent of upholstered furniture fires as the first item to ignite. Whereas open flame ignition sources – defined as candles, matches, and lighters – accounted for nearly 22 percent of upholstered furniture fires as the first item to ignite. Of these incidences, upholstered furniture ignition from smoking sources accounts for an estimated 57

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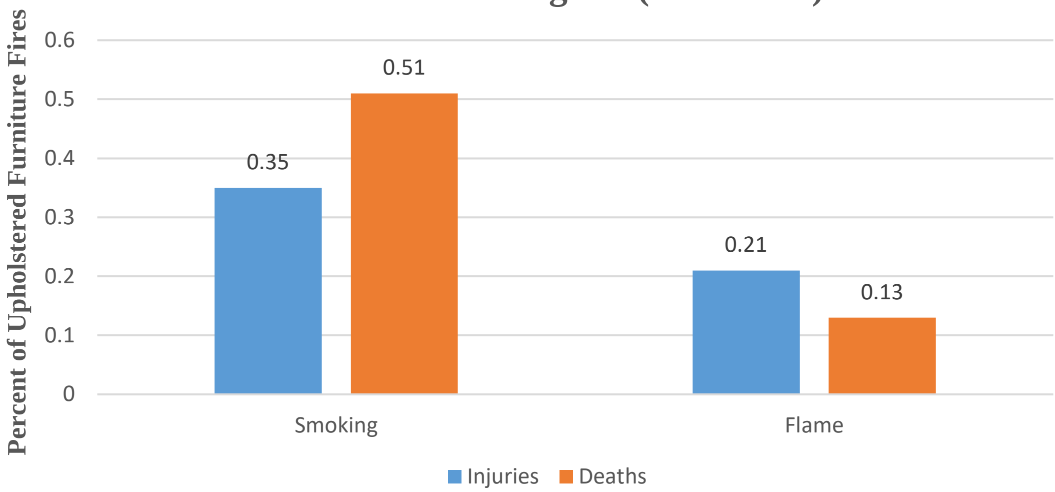
[8] NFIRS is a national database of U.S. fire departments reporting on a standardized range of fire related statistics.

percent of civilian deaths, and open flame ignition accounts for an estimated 13 percent of civilian deaths. Unfortunately, no data exists on civilian injuries caused by upholstered furniture as the first item to ignite within the sub-categories of smoking or open flame ignition sources (NFPA, 2013, p. 6).

The most recent annual data from the 2010 to 2014 combined data set of NFIRS and NFPA fire department experience survey, shows upholstered furniture as the first item to ignite declined to an average of 440 civilian deaths, 700 civilian injuries, and $284 million (adjusted to 2018 dollars) in property losses (Ahrens, 2017, p. 1). Smoking ignition sources – defined as cigarettes and lighted tobacco products – remain the leading cause accounting for an estimated 27 percent of upholstered furniture fires as the first item to ignite. Open flame ignition sources – defined as candles, matches, and lighters –accounted for 20 percent of upholstered furniture fires as the first item to ignite[9] (Ahrens, 2017, p. 22). Figure 1 shows the proportion of civilian deaths and injuries by ignition source when upholstered furniture is the first item to ignite.

[9] Data calculations use a five-year average from 2010 – 2014, and do not reflect per capita adjustment.

Figure 1. Civilian Losses when Upholstered Furntiure is the First Item to Ignite (2010-2014)



Source. Ahrens, M. (2017, February). Home Fires That Began With Upholstered Furniture. Numbers are subject to rounding

In terms of civilian deaths caused from upholstered furniture as the first item to ignite in a residential building fire, smoking ignition sources account for an estimated average of 51 percent of the civilian deaths, and open flame ignition account for an estimated average of 13 percent of the civilian deaths (Ahrens, 2017, p. 26). Concerning civilian injuries caused from upholstered furniture as the first item to ignite in a residential building fire, smoking ignition sources account for an estimated average of 35 percent of the civilian injuries, and open flame account for an estimated average of 21 percent of the civilian injuries[10] (Ahrens, 2017, pg. 22, 28-29). These estimates from NFIRS and NFPA are in stark contrast to the limited estimates provided by the USFA on upholstered furniture as the first item to ignite in a residential building fire. Of all residential building fires reported to NFIRS between 2008 and 2010, cigarettes are cited 86 percent of the time, but only 13 percent is attributed to upholstered furniture (USFA, 2012a).

[10] Data calculations for both civilian deaths and injuries use a five-year average from 2010-2014, and do not reflect per captia adjustment.

Unfortunately, the USFA in its most recent fire statistic publications do not include further upholstered furniture analysis (USFA, 2012; USFA, 2012a; USFA, 2016).

However, if upholstered furniture as a principle contributor to flame spread in a residential building fire is considered in addition to the first item ignited, the 2006 – 2010 estimates of average civilian deaths, injuries, and property losses respectively increase to 610 deaths, 1,120 injuries, and $650 million dollars (adjusted to 2018 dollars) (NFPA, 2013, p. 8). This more expansive accounting of property losses, civilian deaths, and injuries is important, considering upholstered furniture's potential total heat release and time to flashover (BEARHFTI, n.d.b; Lock, 2016).

The cited USFA fire and National Fire Protection Associations (NFPA) estimates, derived from the National Fire Incident Report System (NFIRS) and supplemented by NFPA's fire department experience survey, are not estimates drawn from a random sample. Instead, these result from a tabulation reflecting around three-fourths of fire department through voluntary participation (Thomas & Butry, 2016). Subsequently, estimates derived from either data set warrant a level of caution. Among the limitations is the inherent sampling error involved in the NFPA's survey that only covers local fire departments, and NFIRS voluntary database. This further extends to differences in apportioning the magnitude of unclassified/unknown/not reported causes of residential fires to known categories. In addition, fire statistics contain an inherent level of measurement error. The accuracy of determining fire characteristics of any given residential building fire at the operational level changes based upon methodological definitions used to gather this data (USFA, 2012; NFPA, 2013; NFPA, 2016).

Understanding these limitations does not mean, however, that we cannot use the estimates produced by NFIRS or NFPA to make reasonable approximations of the true population parameters concerning upholstered furniture fires. For example, knowing about decreased smoking trends in the United States adult population, and passage of cigarette ignition propensity legislation in all 50 states, suggest an *a priori* expectation of further decreases in smoking ignition as a cause in residential building fires. The long-term smoking ignition statistics from NFIRS exactly demonstrates this (U.S. Fire Administration, 1997). Therefore, there are several conclusions relevant to the BCA offered here. First is cigarettes are consistently the predominate cause of upholstered furniture as the first item to ignite. These consumer related losses relate to the existing Technical Bulletin 117-2013, and are not addressable by the fire barrier performance standard under evaluation. This is followed by a secondary hazard from open flame ignition, while never the leading cause, accounts for a sizeable portion of total civilian injuries and deaths in upholstered furniture fires. This highlights the importance of needing further analysis as to the reasonable expected benefits of further regulation of fire barriers in relation to the estimated costs. Especially when isolating consumer losses to the state level. Given the California specific framework for this BCA, data on property losses, deaths, and injuries attributed to upholstered furniture is needed. This data is available from the NFIRS, and will be discussed later in this paper.

What Follows

The chapter that follows contains a review of the literature relevant to completing the desired BCA of the use of non-chemical fire barriers in residential furniture in California. The third chapter of this report contains a description of the methodology used in the benefit cost analysis (BCA). From that the fourth chapter offers the data used to complete the analysis and the results. The fifth chapter is devoted to a robustness/sensitivity analysis of the primary BCA conclusion. The final chapter concludes with a discussion concerning the policy implications.

CHAPTER TWO: LITERATURE REVIEW

The use of benefit cost analysis (BCA) to evaluate the efficiency of a regulatory fire safety standard for upholstery furniture is well established (see Dardis, 1980a; Dardis, 1980b; CPSC, 2008; Jaldell, 2013; McNamee & Anderson, 2015). The benefits consistently calculated in such BCAs represent the incremental decrease in societal cost from reductions in fire caused deaths, injuries, property, and content loss attributed to requiring the fire safety standard under evaluation. The expense of implementing the fire safety determines its cost. The BCA literature associated with a regulatory fire standard indicates that the enforcement costs, compliance costs, and incremental increases in manufacturing costs from the implantation of the standard are relevant (Dardis, 1980b; CPSC, 2008). [11]

The purpose of the following literature review is to offer a better understanding of the information and methodology needed to conduct a BCA on the inclusion of fire barriers in upholstered furniture to meet a proposed fire standard. I divide this literature review into four relevant themes: (1) fire barriers and risk reduction, (2) product life cycle, (3) value of a *statistical life* and *statistical injury*, and (4) discount rate.

Fire Barriers and Risk Reduction

Central to a BCA that evaluates the desirability of a fire barrier safety standard for upholstered furniture, is the estimated incremental reductions in societal costs from deaths, injuries, and property loss likely to occur after the implementation of the proposed fire safety standard. Underlying this estimation is the effectiveness of fire barriers in reducing furniture

[11]Dardis (1980a) includes the loss of *welfare* from regulation as a societal cost of imposing a fire safety standard. In economic terms, an upholster furniture price increase from regulation translates to a loss in *consumer* and/or *producer surplus*. This accounts for the fact that some consumers forgo the purchase of upholstered furniture, or producers supply less upholstered furniture after an imposed fire barrier raises its price. I do not consider these losses in this BCA for two reasons: (1) the necessary data to measure this is not available (2) Fuguitt & Wilcox (1999) recommend against including the change in social welfare in a BCA.

flammability. The knowledge necessary to understand fire barrier efficacy is the interaction between fire barrier materials, and construction mechanisms used to achieve open flame resistance. I then follow this with a review of the methodology used to determine the resulting reduction in risk from improved open flame resistance.

Fire barriers provide flame resistance in upholstered furniture by preventing or delaying flame propagation, and limiting thermal penetration to the underlying resilient filling materials (Davis & Nazare, 2012). Necessary for this thesis is to consider only open flame resistance; an important distinction given fire barriers that provide cigarette ignition resistance does not necessarily translate to open flame ignition resistance, and vice versa (Babrauskas & Krasny, 1985). How effective a fire barrier is in providing open flame resistance is largely dependent upon the fabric and its construction characteristics (Davis & Nazare, 2012).

A fire barrier is typically an individual fabric component, or a fabric composite that takes on the form of individual or laminated layers (Davis & Nazare, 2012). The fabric components of an upholstered piece of furniture range from; (1) natural fibers like wool and cotton; (2) synthetic fabrics such as rayon (semi-synthetic), nylon, polyester; and (3) composites that can blend any number of fabric combinations with products like fiberglass (Damant, 1995; Davis & Nazare, 2012). How these fabric components relate to flame resistance depends upon whether the fabric will ignite, char, or melt/shrink when exposed to flame (Davis & Nazare, 2012). A fire barrier should not ignite unless ignition triggers a chemical release that induces flame suppression or flame quenching (Davis & Nazare, 2012; Davis *et al.*, 2013). For example, fire barriers that melt or shrink generally compromise the integrity of the fire barrier, leading to flame exposure (gaps/holes) and significant thermal penetration to the resilient filling materials. Whereas charring fabrics typically provide a physical barrier between an open flame and the resilient filling material. A char barrier can lower the heat release and reduce volatile gases that aid flame propagation. However, charring fabrics that are prone to oxidation, and lack char strength (brittle char formation) can lead to thermal and flame penetration of the fire barrier (Davis & Nazare, 2012).

The construction of fabric used as fire barriers is equally important. Woven, knitted, or nonwoven represents a categorization of different construction methods. All else equal, knitted fire barriers are the least desirable as they are more prone to split open under open flame exposure than woven or nonwoven fire barriers (Davis & Nazare, 2012). Comparing woven and nonwoven fire barriers, the open flame resistance properties depend significantly on the permeability and thickness of a fire barrier. Highly porous woven fire barriers allow greater thermal penetration through greater air/gas permeability. Similarly, low thickness (loft) fire barriers demonstrate greater thermal penetration and fire barrier deformation (weight loss). Therefore, low permeability and higher thickness (loft) fire barriers tend to demonstrate better flame resistance properties (Davis *et al.*, 2013).

The usefulness of any given fire barrier is contingent upon many factors. This is complicated further when moving away from fire barriers as a separate component, and instead evaluating the efficacy of fire barriers as a small-scale composite or full-scale assembly. For example, if the cover fabric is of a highly flame-resistant material, then a fire barrier would not have to achieve the same level of flame resistance to pass a fire barrier standard compared to a cover fabric that is cigarette ignition resistant, but not resistant to open flame (CPSC, 2005). Consequently, examination of the efficacy of fire barriers employs full furniture testing, or small-scale composite assembly – constituting of a frame, standard polyurethane foam, fire barrier, and standard cover fabric (see CPSC, 2005; CPSC; 2012, Davis *et al.*, 2013; Lock *et al.*, 2016). Given the proposed fire barrier standard only requires a small-scale composite assembly (see

BEARHFTI, 2014), I restrict the review to fire barrier performance studies using small-scale composite assemblies in testing.

Davis *et al.* (2013) examines 19 different fire barriers using a small-scale composite assembly comprised of standard polyurethane foam per NIST specifications, fire barriers pinned to the foam, and a cover fabric composition of 77 percent rayon and 23 percent polyester. This is subject to an open flame for 20 seconds. Unsurprisingly, most nonwoven high-loft fire barriers demonstrated lower heat transfers during the 90-second test period with an average temperature less than 225 degree Celsius. In comparison, most of the thin woven and knitted fire barriers demonstrated an average thermal response over the test period above 225 degrees Celsius, with a fire barrier reaching a maximum of 300 degrees Celsius. To juxtapose the characteristics of the worst and best performing non-flame-retardant fire barriers in allowing heat transfer, consider fire barrier 19 and fire barrier seven. Fire barrier 19 comprises of a glass fiber woven construction with an average thickness of 0.3 mm, allowing a total heat transfer of 70.3 total MJ/m^2.[12] Whereas, fire barrier 7 is a carbon fiber nonwoven construction with an average thickness of 7.2 mm, and a total heat transfer of 4.6 MJ/m^2. What determine the performance difference is predominately the choice in fire barrier thickness, considering fire barriers containing either carbon, or glass fibers with woven/nonwoven construction demonstrated the lowest peak heat release rates of less than 15kW/m^2.[13] When examining fire barriers with flame retardant treated organic fibers with varying thicknesses, these were the worst performing fire barriers with peak heat releases in excess of 100kW/m^2 (Davis *et al.*, 2013).

Alternatively, the Consumer Protection Safety Commission (CPSC, 2005) evaluated the efficacy of fire barriers using a measure of mass loss of the standard polyurethane foam and

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[12] A joule is a standard unit of energy, which a megajoule (MJ) is a million joules. Thus, MJ/m^2 refers to the amount of energy transfer (heat) per meter squared of fabric.

[13] A watt is the rate of energy transfer. A watt is equal to one joule per second.

varying significantly both the fire barrier and cover fabric combinations. CPSC tested over 1800 different composite assemblies, comprised of 41 different cover fabrics, and 14 woven/nonwoven fire barriers. The test involved an open flame application for 70 seconds and observation for 25 minutes. A highly dense (18.3oz/yd2) ceramic woven fire barrier paired with 100 percent cotton velvet cover fabric demonstrated less than five percent mass loss of the polyurethane foam. While a nonwoven sheet barrier of significantly less density at 3oz/yd^2 paired with either 100 percent cotton velvet, or 100 percent rayon cover fabric, demonstrated over 25 percent mass loss of the foam in less than 10 minutes.

Both of the previous studies offer two relevant conclusions. First, fiber choice needs to demonstrate a level of inherent flame resistance properties to limit peak heat release (Davis *et al.*, 2013). This is consistent with the conclusion noted in Davis & Nazare (2012), where a fire barrier that incorporates a woven glass fabric yields lower average peak heat releases. Moreover, Davis & Nazasre (2012) indicate fire barriers that rely on low-loft polyester batting can actually increase the flammability of the composite assembly. In terms of time to flashover[14] (approximately 1000kW), limiting the total peak heat release of upholstered furniture is critically important for an open flame fire scenario. Second, regardless of fiber choice the fire barrier needs to have sufficient thickness and density to limit heat transfer to the underlying foam (CPSC, 2005; Davis *et al.*, 2013; Davis & Nazare, 2012). The most flammable material to aid in flame propagation, and release of toxic volatile gases are resilient filling materials such as foam (CPSC, 2012b).

While not all fire barriers provide the same level of flame resistance, the previous literature clearly concludes that fire barriers on average provide some additional level of open

[14] Flashover is the near simultaneous flaming ignition of all combustible contents in a given space. A peak heat release of 1000kw often defines a standard fire scenario (see Babrauskas & Krasny, 1985). However, the total peak heat release to create a flashover is dependent upon numerous factors such as dimensions of the room, fuel load, ventilation assumptions, etc. (Guillaume *et al.*, 2014).

flame resistance (see CPSC, 2005; CPSC, 2012b; Damant, 1995; Davis & Nazare, 2012). To determine whether the cost of achieving this level of flame resistance in upholstered furniture is justified by its benefits, one must determine the expected value of benefits from improved open flame resistance. In a BCA, the expected value of benefits equals the dollar value assigned to deaths, injuries, and property losses, multiplied by the probability that an inclusion of a fire barrier in upholstered furniture prevents these losses. CPSC (2008) references this as the change in *risk reduction probability*. A review of the existing BCA literature that evaluates the efficiency of fire safety standards indicates the approach to estimating risk reduction probability varies significantly.

Dardis (1980a) offers the most basic approach to calculating the risk reduction probability evaluation of the efficacy of smoke detectors in reducing residential building fire losses. Dardis chooses a risk reduction probability of 0.45 for deaths and 0.30 for injuries based on a personal communication with the National Bureau of Standards (Dardis, 1980a). In simpler terms, 0.45 indicates the appropriate use of smoke detectors reduced the number of residential building fire deaths by 45 percent. Jaldell (2013) offers a more precise approach in the evaluation of fire sprinklers in reducing elderly home fire losses by examining incidence data. Using United States home data from 2002 through 2005, Jaldell (2013) calculates homes with fire sprinklers, as compared to homes without fire sprinklers, demonstrated a 100 percent decrease in fatalities, 57 percent fewer injuries, and 32 percent less property damage. Furthermore, American fire statistics from 2003-2007 showed restaurants and bars with fire sprinklers decreased fatalities by 100 percent and warehouses/offices by 75 percent. McNamee & Anderson (2015) also use incidence data to estimate the risk reduction probability from flame retardant use in television fires. However, as noted in CPSC (2008), no fire barrier standard exists to allow for a before and after comparison of upholstered furniture fire incidence data. CPSC (2008) instead made reasonable judgements from prior fire barrier studies when estimating risk reduction probabilities of 0.51 for severely ignition prone cellulosic material, 0.25 for moderately ignition prone cellulosic material, and zero for all other categories (p. 11722). This means an open flame standard for upholstered furniture results in a 51 percent reduction in societal costs attributed to severely ignition prone cellulosic material, and only a 25 percent reduction in societal costs attributed to moderately ignition prone cellulosic. If we assume that all upholstered furniture exhibits an average risk reduction probability based on the above distribution, an average risk reduction probability of 0.19 is reasonable for all upholstered furniture.

The lack of available incident data to approximate the risk reduction probability highlights a significant limitation inherent to a BCA of a fire barrier standard applied to upholstered furniture. Moreover, the available BCA studies fail to mention the fire barrier assumptions used when making judgements on the resulting risk reduction probabilities (CPSC, 2008). As previously mentioned the predictive performance of any given fire barrier is determined by a complex set of factors. Therefore, the reported risk reduction probabilities noted in this BCA will also depend upon the judgements noted in CPSC (2008), and take on a range of reasonably expected risk reduction values.

Product Life Cycle

As a general BCA principle, the full time horizon to consider is determined by the useful lifetime of the product under evaluation (Fuguitt & Wilcox, 1999). Specific to the study of fire barriers in upholstered furniture, CPSC (2008) notes the average life cycle of upholstered furniture is 16 years. Given the average product life cycle of a new piece of furniture is 16 years, it is important to know the year within this product life cycle that a benefit or cost occurs. The reason being that a benefit or cost realized later in time in the benefit/cost stream is worth less than one occurring sooner (Fuguitt & Wilcox, 1999). This represents the *time value of money*, understood as $1 in the bank today, earning an annual interest rate of three percent, is worth $1.03 a year later. Hence, $1 promised a year from now is only equivalent to $0.97 ($1/1.03) today, because that is the amount lost from not earning a three percent annual interest rate. The costs of implementing a fire barrier standard largely occur at the time of manufacturing. However, the benefits of a fire barrier standard only accrue after the consumer purchases upholstered furniture subject to the fire barrier standard. Thus, a specific framework accounts for the timing of benefits to consumers throughout the time horizon.

The most simplified method regarding benefit realization is to assume that the benefits of a fire barrier standard occur in each year of the product's life cycle and remain constant. Thus, the same level of benefits realized in year one will be the same amount of benefits realized in year 16; less the discounting factor in time period t. This approach works fine for a single piece of furniture, but is overly simplistic when modeling the benefits to consumers across the entire upholstered furniture market. McNamee *et al.* (2015) provides a method of doing this, using the assumption that in any given year, society replaces consumer products at the rate equal to the inverse of the product life cycle. Under this assumption, if upholstered furniture has a 16 year product life cycle, only 6.25 percent of existing upholstered furniture is replaced in a given year. Therefore, it will take 16 years for full replacement of all upholstered furniture prior to the imposition of a fire barrier standard, with upholstered furniture containing fire barriers. Alternatively, CPSC (2008) utilizes a product population model to calculate the likelihood the upholstered furniture item would remain in use in years after purchase. Presumably this would be a theoretically more accurate approach, but CPSC (2008) reported no information on the detailed methodology underlying the derivation of their model. In the absence of this information, McNamee *et al.* (2015) provides a peer reviewed framework for benefit realization.

Value of a Statistical Life and Statistical Injury

The value of a benefit cost analysis (BCA) pertaining to a fire barrier safety standard is that it offers a comparable valuation of the likely benefits to society, to the likely costs of the fire barrier safety standard. For this BCA, the valuation is only comparable if the benefits of life and injury measured in the same units as the costs. Naturally, the measurement of costs occurs in dollars. Thus, the issue is how to determine the dollar value of potential lives saved, or potential injuries prevented from the imposition of an upholstered furniture fire barrier safety standard. Economists have dealt with this issue by determining a typical consumer's willingness to pay for reducing mortality and injury risk (Fuguitt & Wilcox, 1999; Viscusi, 1993).

Inherent in this process are two related but distinct valuations: value of a statistical life, and the value of a statistical injury. How either is valued depends upon the valuation concept used. The two concepts widely used are willingness to pay (WTP) and willingness to accept (WTA) (Fuguitt & Wilcox, 1999). WTP estimates elicit the maximum amount an individual is willing to pay for reducing risks of death or injury. Whereas, WTA is the minimum amount of compensation an individual is willing to accept to bear risks of death or injury (Fuguitt & Wilcox, 1999). Moreover, the nature of the risk and characteristics of the population sampled impact the empirical valuations of a statistical life (VSL) and injury (VSI) (Viscuis, 1993). Therefore, I provide a review of these key determinants from a sample of the economic literature to apprise the impacts to value of statistical life and injury.

Jaldell (2013) indicates the growing recognition in the body of literature that WTP varies depending upon the individual's perceived level of risk, and the familiarity of the specific risk context. Carlsson *et al.* (2010) asked 5000 respondents through a mail survey to evaluate their willingness to pay for risk reductions in traffic, drowning, and fire related deaths. Respondent's WTP for reductions in fire and drowning risk were one-third of that of automobile risk reduction. Savage (1993) also notes the degree of knowledge about the risk context produces a statistically significant lower WTP for reducing risk in domestic fires, than that of stomach cancer, road, and aviation accidents. This does raise an important question as to whether it is appropriate to use WTP estimates derived from non-fire related risk contexts that are unlikely to share the same level of perceived risk and respondent knowledge. For example, the CPSC (2008) study of an open flame standard in upholstered furniture relied upon the often cited five million dollars for the value of a statistical life based on extensive research using labor market data on increased compensation accepted to bear greater risk in an occupation (Viscuis, 1993). The issue becomes whether risky professions, and the compensation paid to bear the higher risk, can accurately approximate the mortality and injury risks from residential building fires.

The differences in the value of a statistical life also extend to the valuation concept used (Fuguitt & Wilcox, 1999). Behavioral economics suggest WTP estimates are lower than WTA due to loss aversion (Cogdon *et al.*, 2011). Individuals on average perceive losses more intensely than gains, and accordingly place more value on the potential to incur a loss as measured by WTA (Cogdon *et al.*, 2011; Fuguitt & Wilcox, 1999). Cumming *et al.* (1986) reviewed valuation studies and found WTA estimates can differ upwards of 1.6 to 16.6 times WTP estimates. Alternatively, Kniesner *et al.* (2014) finds that employees in their labor market sample fail to demonstrate statistically significant differences between willingness to pay (WTP) for increased workplace safety, and willingness to accept (WTA) for less workplace safety. Despite the extensive economic literature in estimating the value of a statistical life, there is a lack of consensus as to the approach that best approximates the true population parameter for any given mortality risk reduction context. Thus, a brief review all three approaches with a focus on the empirical strengths and weaknesses is provided.

The economic theory underlying the approach of using labor market data to calculate WTA is the fundamental premise that risky jobs will command a compensating wage differential in the labor market (Viscuis, 1993). To estimate the compensating wage differential requires a hedonic wage regression model at the individual unit of analysis, holding constant education, experience, and other causal factors that also explain wages. This isolates the average compensation needed to take on a unit increase in the chance of death or injury. The strength of this hedonic approach is the available data based on observable wage-risk tradeoffs in the labor market. However, the weaknesses specific to this hedonic approach are WTA changes from regression specification choices (differences in variables, linear, non-linear, and structural equation approaches), limitations in the available control variables for some labor market data sets (omitted variable bias), endogeneity bias, and inherent variance in WTA preferences (sample bias) across workers in any given sample used (Viscuis, 1993).Variance in WTA preferences based on the sample characteristics is especially relevant when factors like age and income/wealth substantially alter the value of a statistical life (Jenkins *et al.*, 2001).

The alternative to the hedonic approach just described is to use revealed preferences of risk reductions in non-labor market data. The economic theory of this approach suggests consumer choices in product markets reveal preferences on the tradeoff between risks and benefits (Viscuis, 1993). On one hand, the strength of this approach is the risk context studied can reflect a closer approximation to the risk reduction context in policy oriented benefit-cost analyses. For example, inherently related to a consumer's willingness to pay for a reduction in fire fatality risks, is the WTP to pay to have smoke detectors installed appropriately throughout the residence. On the other hand, the main criticism of this approach is consumer choices that reflect discrete safety decisions, such as purchasing a smoke detector, are less likely to reflect a consumer's total willingness to pay for safety. As a result, economists often consider a non-labor market-based value of a statistical life to reflect the lower bound of values (Viscuis, 1993).

Lastly, *contingent valuation* is an approach that utilizes a hypothetical market scenario to estimate a respondent's willingness to pay for risk reduction, or the willingness to accept additional risk (Viscuis, 1993). It is a contingent valuation because respondents have no requirement to follow through on their surveyed preferences. To estimate the WTP, survey methods can range from directly asking respondents opened ended WTP question(s) for the avoidance of a specific risk (after given the annual chance of it happening) using a bidding schedule of dollar value, or a referendum question that asks whether they would be willing to pay a specific amount (Fuguitt & Wilcox, 1999). The primary strength of contingent valuation is the ability to tailor the risk context without constraint from the availability of market data. However, the drawbacks to this approach stem from the primary use of a survey format. Survey weaknesses can include starting point bias, strategic bias, respondent's use of approximate values, inadequate simulation of a market experience, respondent comprehension of the survey tasks, and to the extent respondent answers reflect the absence actual market behavior (Viscuis, 1993).

Because the three methods of using WTP, WTA, or contingent valuation yield a range of values for a statistical life, Table 1 below offers a summary of the values derived from the literature across all three valuation methods. The values for a statistical life reported here range from $1.1 million to $8.3 million, with average value of a statistical life at $3.7 million across all studies. In the context of what is widely held as an acceptable range of three to seven million (see CPSC 2008; Viscusi, 1993), 3.7 million is at the lower bound of the acceptable range.

Sunstein (2004) is critical of using a uniform range for the value of a statistical life for all BCAs, and instead believes VSL should reflect the specific risk context. If only accounting for fire mortality risk, the two values for a statistical life found in the previous literature are $1.4

million and $2.5 million.[15] While theoretically focusing just on fire mortality risk is desirable for this BCA of upholstered furniture, there is a level of uncertainty associated with relying on only two research studies. Further, this conflicts with guidance memos issued by federal agencies. The Office of Management and Budget in 2003 endorsed acceptable values of statistical life ranging from one to ten million (U.S. Department of Transportation, 2016). While the U.S. Environmental Protection Agency notes their default guidance for the value of a statistical life at 7.4 million.[16] This disparity of values suggests no single value provides the "best" estimate of the value of a statistical life. Instead, I adopt a sensitivity approach that accounts for both the risk context, and a range of values to examine the influence VSL estimates have on determining if the benefits of a fire barrier safety standard exceed its costs.

[15] These dollar values are in the year calculated in. To apply them in a contemporary BCA, I will adjust valuations to "real" (inflation adjusted) dollars.

[16] See https://www.epa.gov/environmental-economics/mortality-risk-valuation#whatvalue.

Table 1

Summary of Literature on the Value of a Statistical Life

Authors	**Sample Characteristics**	**Risk Context**	**Method**	**Valuation Concept**	**Value of a *Statistical Life***
Gerking & Schulze (1988)	*Sample:* 2130 completed households surveys *Sample Characteristics:* controlled for age, income, race, gender, education, and if union member	Ranked job fatality risk	Contingent Valuation	WTP	3.4 million
Garbacz (1991)	Sample: Time Series data with interpolation from 1968 – 1985 Sample Characteristics: fire deaths per million households, income, price of medical care, cigarette consumption, population age, race, fire department spending, time trend, wood and alcohol consumed per household, risk factor	Fire fatality risks without smoke detectors	Non-Labor Market Data	WTP	1.4 to 2.5 million
Scotton (2013)	Sample: Panel data on 84,336 workers from the National Bureau of Economic Research's Merged Outgoing Rotation Group for year 2006 Sample Characteristics: risk factor, income, age, gender, marital status, education, location, industry, and occupational characteristics	Occupational fatality Risk	Labor Market Data	WTA	8.0 million
Gayer *et al.* (2000)	Sample: 16928 households Sample Characteristics: housing hedonic characteristics, proportion under 19, race, school quality, year, education, tax rate, distance to superfund, risk factor	Cancer fatality risk from Superfund cite	Non-Labor Market Data	WTP	4.7 million
Kniesner *et al.* (2014)	Sample: Panel data (PSID) of 2036 men from 1993-2001 Sample Characteristics: job characteristics, location characteristics, age, marital status, race, work hours, income, risk factor	Occupational fatality risk	Labor Market Data	WTA	7.7 million to 8.3 million
Carlsson *et al.* (2010)	Sample: 1900 completed household surveys in 2007 Sample Characteristics: household characteristics, income, city, education, smoke detector, experience with fire accident(s), risk factor	Traffic, Drowning, and Fire fatality risks	Contingent Valuation	WTP	Fire: 2.2 million Drowning: 2.1 million Road Traffic: 3.3 million
Jenkins *et al.* (2001)	Sample: Cross Sectional data from Consumer Reports and national population subgroups in 1997 Sample Characteristics: purchase price, population characteristics, time, disutility, risk factor	Bicycle fatality risk	Non-Labor Market Data	WTP	Age 5-9: 1.5 to 2.7 million Age 10-14: 1.1 to 2.6 million Age 20-59: 2.0 to 4.0 million

The willingness of individual to pay a dollar amount (WTP) to avoid bearing a non-fatal injury shares many of the same considerations and determinants just noted for the value of a statistical life (Viscusi & Aldy, 2003). In fact, research has shown the value of a statistical life for an individual is highly correlated with the value she places on a statistical injury (Viscusi & Aldy, 2003). Despite the similarities, it is worth noting several differences found in the literature regarding the methods employed to estimate the value to society of avoiding a statistical injury.

The cost of a statistical injury must reflect the value lost from lower quality of life, pain and suffering, and reduced income potential after the injury (U.S. Department of Transportation, 2009). As a result, the value of a statistical injury is highly sensitive to the risk and injury context (Viscuis, 1993). There are three approaches used to estimate the value of a statistical injury: WTP, interpolation, and damage cost. WTP often relies upon the previously described method of contingent valuation where the questioner informs the individual of the details of an injury, and then offers the maximum willingness to pay to avoid the described injury.

A second approach, adopted by the U.S. Department of Transportation (2011), relies on interpolation based on the value of a statistical life. The justification for this being that WTP estimates are not possible over an entire range of disabilities that could occur for something like a burn injury. The basis for interpolation using fixed proportional factors is the Abbreviated Injury Scale (AIS) to calculate the value of a statistical injury. AIS is a global severity classification system that combines the body part(s), percent body surface area, and injury severity to classify non-fatal injuries into five categories: AIS 1 (minor), AIS 2 (moderate), AIS 3 (serious), AIS 4 (severe), and AIS 5 (critical). For example, a third-degree burn covering more than 50 percent of body surface area is assigned a critical injury level (AIS 5), which is 59 percent of the value of a statistical life (U.S. Department of Transportation, 2011). The principle drawback of this approach is its reliance on the assumption that the value of a statistical life remains highly correlated with the value of a statistical injury, and that AIS weights are accurate estimators of the true population parameter for WTP for fire injury avoidance.

The third approach is to use the damage cost method, which estimates the value of a statistical injury by aggregating the realized direct and indirect costs of an injury. Stacey and Smith (1979) provided a framework for calculating the damage cost of non-fatal fire injuries as the summation of hospital costs, disability costs, rehabilitation costs, psychological costs, work loss costs, and legal costs. These costs further require adjustment by age, body part injured, and severity of injury. CPSC (2008) employed a similar approach with a minor variation to include visitor transportation and lost earnings (Mcloughlin & McGuire, 1990). The strength of the damage cost method is that it relies on actual realized costs from non-fatal injuries. However, its notable weakness is the required access to detailed contemporary injury data. In the absence of this data, the limitation of using past estimates are significant, because differences in costs for non-fatal injuries over time are explained by a variety of health care factors beyond just inflation.

Ideally, a range of studies and methods for burns, anoxia, and other fire related injuries would be available for review. However, there are only a limited number of previous studies devoted to estimating the value of a statistical injury for fire risks, and even fewer are applicable to injuries consistent with residential building fires (Viscusi, 1993). Using contingent valuation, Viscusi & Magat (1987) report an average respondent’s WTP to avoid a hand burn at about $1 million. Conversely, the damage cost approach employed by CPSC (2008) indicates a national weighted average of around $150 thousand dollars for burns and anoxia injuries. While the interpolation approach indicates an AIS 5 injury consistent with third degree burns of more than 50 percent of the body surface is 59 percent of the value of a statistical life. If a value of statistical life is $2.5 million, the value of statistical injury for a third degree burns is then $1.48 million.

The disparity of injury values and the lack of replicated research presents a challenge in making objective conclusions. Instead of judging the accuracy of the injury values reported, it is more useful to examine which method better accounts for the distribution of non-fatal injury severities attributed to upholstered building fires. This is because just considering the direct costs alone, differences between severities of burns can vary significantly. I conclude the U.S. Department of Transportation's (2011) AIS method allows an accounting of a large range of fire related non-fatal injuries due to matching with available incidence data specific to California to estimate a reasonable average value of a statistical injury.[17]

Discounting Rate

Inherent in any benefit cost assessment (BCA) is the requirement to discount future benefits and costs to obtain comparable values in present day terms. As previously discussed, a dollar today has a greater value to an individual than the same dollar received in the future. Furthermore, the value placed on that dollar given in the future is less and less as the time of the future period increased. Thus, it is appropriate that any future benefit or cost is discounted to its present values in order to comparably aggregate dollar values over the time horizon. Unfortunately, there is not a consensus on the exact discount rate to use (Fuguitt & Wilcox, 1999). What follows is a discussion on the merits of using either the *social opportunity cost of capital*, or the *social time preference rate* as the basis of a discount rate, and the associated range of reasonable discount rates found in the literature or specified by federal agencies.

A BCA of a fire barrier performance standard in upholstered furniture requires framing the discount discussion firmly in a public policy context (Fuguitt & Wilcox, 1999). The basis for using the social opportunity cost of capital is the perspective that public policy decisions represent forgone alternative investments of government funds. The discount rate can then be

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[17] See http://www.mymedal.org/index.php?n=Military.290401.

based on various real rates of return (i.e. adjusted for inflation) of public securities that share similar risk and duration characteristics to the public policy alternative (Fuguitt & Wilcox, 1999). By extension, this approach requires directly relating the social return of public investment to returns generated by private investment. In economic theory, rates of return in perfect capital markets would align with the social rate of return of alternative public investments. Yet, market distortions invariably create divergences between market rates, and the social rate of return of public investment (Feldstein, 1964). The rate of return paid on a public security is an imperfect proxy to a discount rate because they reflect macroeconomic factors, cyclical trends, uncertainty, and volatility. Therefore, most regard the social opportunity cost of capital as the upper bound of the true social discount rate (Moore *et al.*, 2013). Alternatively, as noted in Fuguitt & Wilcox (1999), the social time preference rate offers a more accurate reflection of the social discount rate.

The social time preference rate is simply the collective willingness of society to forgo current consumption for future consumption (Fuguitt & Wilcox, 1999). There are two principle arguments that indicate the individual time preference rate is higher than society's time preference rate. First, society not only represents the collection of all current individuals, but future generations as well. When society evaluates the willingness to forgo current consumption for future consumption, it is more than just independent individual decisions to save, but a decision to save that considers the welfare of future generations. Second, preferences for future generations are unlikely captured in market behavior based on individual consumption. Since society reflects more than just individuals, society is more likely to discount the future at a lower rate (Fuguitt & Wilcox, 1999). Using a discount rate that measures society's preferences to save for future generations is more theoretically sound. The challenge resides in the lack of observed market behavior for this purpose. This has primarily led to three different approaches to determining the social time preference discount rate.

The first approach is purely normative and based on ethical considerations of future generations that argue for a zero or even negative discount rate (Tabi, 2013). This perspective presumes it is unethical to discount the wellbeing of future generations (zero discount rate), or that the wellbeing of future generations should deserve greater weight over the current generation (negative discount rate). A reliance on revealed preference is the basis of the second approach, and generally employs the mathematical equation: Social Time Preference Rate (STRP) = p + e*g; where (p) is the pure rate of time preference (value of current consumption over future consumption), (e) is the elasticity of the marginal utility of consumption, and (g) is the growth rate of per capita consumption (Tabi, 2013). Finally, the third approach relies on stated preferences of surveyed individual when asked to choose between pairwise choices (now verses future), or through open ended questions (Tabi, 2013). Regardless of the approach, the social time preference rate is generally less than the individual time preference rates observed in public securities (Fuguitt & Wilcox, 1999).

With a lack of consensus on whether the social opportunity cost of capital, or the social time preference approach best approximates the true social discount rate, an objective approach is to use a range of reasonable discount rates to determine if the conclusion regarding benefits verses cost of a fire standard is sensitive to the choice of discount rate. Table 2 offers a summary of discount rates previously calculated using both the social opportunity cost of capital and social time preference rate. As noted in the table, the social discount rate falls between 2.6 and 8.0 percent. CPSC (2008) and McNamee *et al.* (2015) reported the widest range of discount rates. Respectively determining the sensitivity of their findings to three and seven percent discount rates, and a three and 10 percent discount rates. Dardis (1980b) only considered a discount rate of 10 percent, whereas Jaldell (2013) restricted the analysis to only a three and four percent discount rate.

At the federal level the BCA guideline set forth by the Office of Management and Budget suggests a single discount rate of seven percent for BCA. The Environmental Protection Agency (2016) expands the discussion of discounting further to specify a three percent discount rate based on the alternative rate of return of government backed securities, and a seven percent discount rate if using the opportunity cost of capital. Overall, the distribution of discount rates reported suggests three conclusions for the selective sensitivity analysis. First, the range of discount rates for the upper bound is between six and ten percent, with a consensus of seven percent. Second, the range of discount rates for the lower bound is between 2.6 and three percent, with a consistent use of three percent. Therefore, a reasonable sensitivity analysis to use in a BCA is discount rates of three, five, and seven percent.

Table 2

Literature Review Summary of the Discount Rate

Author(s)	**Valuation Concept**	**Method**	**Average Discount Rate**
Moore *et al.* (2013)	Social Time Preference Rate	Revealed Preferences	2.6 – 5.4%
Tabi (2013)	Social Time Preference Rate	Stated Preferences	2.9 – 5.0%
Kula (1984)	Social Time Preference Rate	Revealed Preferences	5.3%
Burgess & Zerbe (2011)	Social Opportunity Cost of Capital	Rate of return on U.S. non-financial corporate sector	6.0-8.0%

Conclusion

As identified in this review of the literature, there is no single approach to addressing the major BCA themes regarding: (1) fire barriers and risk reduction, (2) product life cycle, (3) value of a statistical life and injury, and (4) discount rate. Underlying the disparity in research approaches to BCA is the challenge in applying theoretical concepts to existing data. Take for example the risk reduction probability component of this BCA. The risk reduction probability forms the basis for estimating the benefits in reduced societal costs of upholstered furniture fire related deaths, injuries, and property damage. Underlying any risk reduction probability requires assumptions about the distribution of upholstered furniture cover fabric; an interaction variable that determines in part the level of reduced risk from fire barriers. Currently existing data on upholstered furniture characteristics and trends is lacking. This challenge of imperfect data further extends to the value of statistical injury and product life cycle adjustment. As assumptions are required in most applied BCA to inform decision makers, the requirement to explicitly state assumptions and outline the subsequent impacts to the analysis is necessary. Likewise, to avoid unduly influencing the BCA, I will include a range VSL, VSI, risk reduction probabilities, and discount values to demonstrate whether the benefits exceed the costs of a fire safety standard for upholstered furniture.

CHAPTER THREE: METHODOLOGY AND MODEL SPECIFICATION

As described earlier, a benefit cost analysis (BCA) of California's proposed fire barrier safety standard for upholstered furniture requires an accounting of both the benefits to the consumers of these products, and the costs to the producer if implemented. Formerly stated, the benefits are the incremental reductions in residential fire caused civilian deaths, injuries, and property loss because of the standard. Whereas costs arise from the incremental increase in testing, compliance, financing, manufacturing costs, and state enforcement costs from implementation of the standard. The challenge to operationalizing this is bridging the existing methodology in previous research to existing data sources that inherently limit the scope of some methods. This increases the importance that assumptions used in the methodology are stated, and when relevant I outline the impacts to the analysis. I divide this discussion into three parts: (1) benefit consideration, (2) cost considerations, and (3) model specification.

Benefit Considerations

To generate the necessary monetary estimates of the benefits from reducing upholstered furniture fires in residential structures, it is first necessary to understand the magnitude of fires in California attributable to this cause. I do this by considering a subset of residential building[18] fires in California addressable by the proposed fire barrier safety standard involving upholstered furniture. The incidence of these comes from the National Fire Incident Reporting System (NFIRS) data specific to California in years 2010 through 2016. The use of this subset of NFIRS data requires the establishment of a baseline based upon the following criteria of: (1) fire origin, (2) exclusion of intentional/arson fires, and (3) case wise deletion of unknowns on heat source and item first ignited (NFPA, 2013; CPSC, 2016).

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[18] Residential consists of single and multi-family, manufactured, mobile, and duplex dwellings.

For the first criterion of fire origin, I restrict the area of fire origin – as categorized by NFIRS 2015 Reference Guide[19] – to the dining room, common room, den, family room, living room, lounge, bedroom, music room, recreation room, sitting room, basement, garage, carport, other functional area, other structural area, and other area of fire origin. Using this baseline, we identify two fire scenarios addressable by the proposed fire barrier safety standard: (a) upholstered furniture as the first item to ignite by an open flame source, and (b) upholstered furniture as the material contributing most to flame or fire spread. In the fire scenario (a), I use the category of upholstered furniture as the first item to ignite; this being different from non-upholstered chair, bench, wooden furniture, appliance housing, and other furniture categories. I purposefully do this because it is unknown whether fire departments treat the other furniture category as well-defined furniture items that do not fit the other listed categories or as an unknown category when the furniture not identified. NFPA (2013) concludes that without further assessment of how fire departments interpret this category, it is not possible to know what percentage of upholstered furniture items fall under other furniture. I take the conservative approach by excluding the other furniture category in the primary analysis, and later evaluate the impact of inclusion through a sensitivity analysis.

Consequently, there are fewer counted residential furniture building fire caused, property loss, deaths, and injuries in the primary analysis. Of the cases identified as upholstered furniture as the first item to ignite, I then classify cases resulting from open flame ignition – heat sources defined by NFIRS categories of matches, lighter, candle, flame used for lighting, and heat from other open flame sources. Noteworthy is that the inclusion of other open flame heat sources has no impact on the calculation of civilian deaths or injuries. This process accounts for part of the

[19] See https://www.usfa.fema.gov/downloads/pdf/nfirs/NFIRS_Complete_Reference_Guide_2015.pdf.

number of civilian deaths, injuries, and total property loss addressable by the proposed fire barrier standard for upholstered furniture.

Fire scenario (b) carries over the same methodology with three exceptions. First, and foremost, is the need to identify which residential building fires exhibited significant flame or spread of fire (fire spread). Adopting the approach outlined by Hall (2015), I use fire spread categories listed as confined to room, floor, building, and beyond building of origin. Secondly, I then classify these residential building fire cases by upholstered furniture items contributing most to flame or fire spread. To avoid double counting, I exclude cases also identified as upholstered furniture as the first item to ignite. This distinction identifies only residential building fires where upholstered furniture is not the first item ignited, but as the principle material contributing most to fire or flame spread. I include this second set of residential building fire cases, because upholstered furniture not engineered to resist ignition from open flame sources, but ignited from another item, is still a contributing factor in total heat release potential and time to flashover (Hall, 2015; Lock, 2016). The third exception is the use of ignition sources. Given the classification of upholstered furniture as not the first item to ignite, I expand the allowable list of ignition sources to include open flame, smoking materials, operating equipment sparks/heat, hot or smoldering objects, static discharge, multiple heat sources, and other heat sources. I then aggregate both fire scenarios to form the total annual property loss, civilian deaths, and injuries addressable by the proposed fire barrier standard for upholstered furniture.

With this aggregated fire data, I derive monetary valuations that represent the total societal costs from residential upholstered furniture fires. The most straightforward valuation is property loss – measured as the loss in property and contents of the home – in 2018 dollars. A monetary value for civilian deaths requires the use of a statistical value of life. Both Jadell (2013) and Savage (1993) find the willingness to pay for risk reductions of fire related deaths are statistically lower than those used in transportation, health, and environmental applications. Garbacz (1991) reports estimated values of a statistical life for fire fatalities between 1.4 million and 2.5 million in 1985 dollars. Accordingly, I take these lower and upper bound estimates and inflation adjust them to 2017 dollars using the national CPI index to yield a minimum of $3.3 million, and maximum of $5.8 million. I then multiply this range of values for a statistical life by the expected number of civilian deaths saved from the proposed fire barrier safety standard.

To estimate the monetary value for civilian injuries, I use the Department of Transportation's (2011) method of interpolating the value of a statistical injury from the value of a statistical life. This approach is particularly relevant when there are minimal WTP studies on the range of fire injuries for an average residential building fire. Based on the severity of injury, a fixed proportion of the value of statistical life yields the corresponding value of a statistical injury. The varying severity of injuries and the corresponding injury factors is based on the Abbreviated Injury Scale (AIS). AIS is a global severity classification system that combines the body part, percent body surface area, and injury severity to classify non-fatal injuries into five categories: AIS 1 (minor), AIS 2 (moderate), AIS 3 (serious), AIS 4 (severe), and AIS 5 (critical). For each AIS category there is a fixed proportional factor of the value of a statistical life that represents the average value for the range of injuries that fall within each AIS category (U.S. Department of Transportation, 2009). I map the range of reported injuries that occur from residential upholstered furniture fires to the corresponding AIS categories. However, due to a lack of publicly available fire injury publications, I use the NFIRS 2013-2015 report on civilian fire injuries in residential buildings as a proxy for upholstered furniture fires in California (USFA, 2017). In other words, I assume the injury profiles in residential building fires is mostly indifferent to causes and ignition sources, and the proportion of injuries do not change substantially from year to year.

USFA (2017) attributes an average of 40.9 percent of civilian injuries to smoke inhalation, 6.2 percent to breathing difficulty or shortness of breath, 24.1 percent to thermal burns, 13.1 percent to combined thermal and inhalation injuries, and 15.7 percent attributed to other symptoms not associated with fire caused injuries. The reported body parts affected are 25.1 percent to the upper extremities, 11.3 percent to multiple body parts, 8.7 percent to the lower extremities, and 54.9 percent to all other body parts (USFA, 2017). To make reasonable judgements about assigning fire injuries to an AIS score, I combine AIS trauma scores for listed injuries, NFIRS body part data, burn body surface area percentages, and basic medical knowledge.

Smoke inhalation injuries (independent of smoke inhalation caused deaths) without serious thermal and chemically induced damage to the respiratory tract are generally not life threatening with proper treatment.[20] A first responder is likely to deliver oxygen into a fire victim's respiratory track through nose/mouth/throat, and observation follows at a hospital. If carbon monoxide poisoning is a factor, then the patient undergoes hyperbaric chamber treatment.[21] Based on this, I surmise that smoke inhalation injuries should most likely receive an AIS score of two. I find this analogous to other AIS 2 injuries, such as large lacerations, or compound factures to the digits that would also require hospitalization for non-life-threatening treatment.[22] I further assume that breathing difficulty is a subset of smoke inhalation, and associated with significant direct damage to the respiratory tract. This form of injury can require immediate intubation, and predispose individuals to complications.[23] This subset condition of smoke inhalation should receive an AIS Score of a three, which reflects an assumed more serious nature of this condition. Thermal burns AIS scores are heavily dependent on the percent of body

[20] See https://www.webmd.com/lung/smoke_inhalation_treatment_firstaid.htm#1
[21] See https://www.webmd.com/lung/smoke_inhalation_treatment_firstaid.htm#3
[22] http://www.traumascores.com/index.php/scores2/16-allgemein/105-104
[23] https://www.webmd.com/lung/smoke_inhalation_treatment_firstaid.htm#4

surface area (BSA); the greater the BSA, the greater the score. The AIS scores for burns are as follows: second and third degree burns between 10-20 percent BSA receive an AIS score of two; second and third degree burns between 20-30 percent BSA receive an AIS score of three; and second and third degree burns between 30-50 percent BSA receive an AIS score of four.[24]

To relate the reported body parts affected to BSAs, I use the medical rule of nines – the percent BSA assigned to burns of major extremity parts for anterior and posterior orientations.[25] To simplify the possibilities, I assume both anterior and posterior orientations to a body extremity affected. I assign the arm a BSA of nine percent, and the leg a BSA of 18 percent. When the effect occurs on both legs and arms, I respectively allocate a corresponding BSA of 36 percent and 18 percent. For all other body parts, the BSAs range from 9-18 percent. NFIRS data does not attribute body parts to any one injury. Moreover, thermal burns do not indicate the burn status between first, second, and third-degree burns. Therefore, I assume the majority of reported body parts reported reflect thermal burns of second and third degrees, and approximate the range of BSAs of the 24.1 percent of thermal burns reported. Consequently, the BSA for upper extremities range from 9-18 percent, and receive a burn AIS score of two. Thermal burns to the lower extremities can account for BSA's of 18-36 percent, which we assume on average best fits an AIS score of 3. Multiple body parts, such as the chest, abdomen, and back, would account for a BSA of 36 percent. Likewise, another scenario involving the legs and abdomen would account for a BSA of 36 percent. While I cannot state which of the possible combinations account for multiple body parts, I find it reasonable to assume this category best fits an AIS score of a four. For all other body parts, thermal burns do not exceed the 10-20 percent BSA range, and is consistent with an AIS score of two. Lastly, in my assessment, injuries involving both smoke inhalation and

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[24] http://www.traumascores.com/index.php/scores2/16-allgemein/105-104

[25] See https://www.emedicinehealth.com/burn_percentage_in_adults_rule_of_nines/article_em.htm

thermal burns do not automatically increase the AIS score. A conservative approach is to assume an AIS score of two.

I use the preceding information to develop a weighted VSL factor, and the corresponding value of a statistical injury for each fire related injury. The VSL factor alone likely does not account for the frequency of sustaining these specific injuries, which influences consumer valuations of avoiding/preventing an injury. Accordingly, I weigh each VSL factor by the injury occurrence, and sum across injuries to derive the weighted average value of a statistical life. For illustrative purposes, Table 3 below describes the methodology concept discussed. For example, if using a $3 million value for a statistical life (VSL), the corresponding value of a statistical injury is $183,000 dollars.

Table 3

Methodological Overview of the Value of a Statistical Injury

(1) Injury Type	(2) Injury Occurrence	(3) AIS Score	(4) VSL Factor	(5) Weighted VSL Factor (2 x 4) / (∑ of 2)	(6) VSL (millions)	(7) Value of Statistical Injury (6 x 5)
2nd-3rd degree Thermal Burns 10-20% BSA	0.241 x .80 = 0.193	2	0.047	0.011	$3,000,000	$33,000
2nd-3rd degree Thermal Burns 20-30% BSA	0.241 x 0.087 = 0.021	3	0.105	0.003	$3,000,000	$9,000
2nd-3rd degree Thermal Burns 30-50% BSA	0.241 x 0.113 = 0.027	4	0.266	0.009	$3,000,000	$27,000
Both Smoke Inhalation and Thermal Burns	0.131	2	0.047	0.007	$3,000,000	$21,000
Smoke Inhalation	0.409	2	0.047	0.023	$3,000,000	$69,000
Difficulty Breathing	0.062	3	0.105	0.008	$3,000,000	$24,000

Source: NFIRS 2013-2015 Report on Civilian Fire Injuries in Residential Buildings.

Cost Considerations

To evaluate the real change in marketed resource costs for upholstered manufacturers in implementing the proposed regulation, I consider several important cost factors. These cost factors involve the incremental increase in state enforcement, testing, compliance, financing, fire barrier material, and labor costs. To derive the requisite monetary estimates for each cost input, I utilize data from CPSC (2008), BEARHFTI's fire barrier cost data, and considered estimates from stakeholder interviews. Next, I present the physical dimensions used in our upholstered furniture scenario and follow that with the cost methodology for each cost input.

Upholstered Furniture Dimensions

For this analysis, upholstered furniture includes chairs and sofas. As a fire barrier is located between the cover fabric and the resilient filling material, I need to distinguish whether the whole or only a part of the upholstered furniture would require a fire barrier. A reasonable assumption is a fire barrier will encompass upholstered furniture's seating cushion, back cushion(s), and the sides of the armrests. While it is possible that the entire upholstered furniture item may need a fire barrier under some testing standards, a review of the currently proposed BEARHFTI barrier standard requires only a small-scale composite test (as opposed to full scale test) of the fire barrier material and resilient filling material to an open flame.[26] Under this standard, it is unlikely manufactures would need to encase the entire upholstered furniture item in a fire barrier. Consequently, I adopt the CPSC (2008) estimates of the upholstered furniture dimensions needing a fire barrier. CPSC (2008) assumes an upholstered chair requires one seating cushion, and two seating cushions for an upholstered sofa. Each cushion requires one linear yard of fire barrier material. Other furniture components, including back cushions, require four linear yards for an upholstered sofa, and two linear yards for an upholstered chair (CPSC, 2008). The

[26] See http://www.bearhfti.ca.gov/industry/proposed_flame_test.pdf

total length of fire barrier material assumed is thus six linear yards for an upholstered sofa, and three linear yards for an upholstered chair.

Fire Barrier Material and Labor Costs

BEARHFTI provided a list of 19 non-chemically treated fire barriers available in the commercial market. Also provided was a lower and upper bound estimate of the costs per fire barrier type. I use the midpoint value between the average of the lower and upper bound estimates as the baseline estimate for the cost of a fire barrier per linear yard. Importantly, CPSC (2008) states that a common industry practice is the use of a polyester batting between the cover fabric, and resilient filling material for the seating cushion. I assume the fire barrier will likely replace the polyester batting. Accordingly, I adjust the fire barrier cost per linear yard to be less the polyester batting material cost, when calculating the fire barrier material cost for the seating cushion only. This requires the separate calculation of the cost of fire barrier for the other furniture components.

Labor costs account for the expected incremental increase in labor time to incorporate the fire barrier material in the upholstered furniture manufacturing process. I derive this estimate using the incremental increase in minutes per hour for an upholstered sofa and chair, multiplied by the California statewide average hourly rate for furniture finishers.[27] The California Employment Development Department estimates furniture finisher's statewide average hourly wages at $16.14 for first quarter 2017. Additionally, I assume an upholstered sofa will require more time to incorporate fire barrier material. Interviews conducted with multiple representatives of furniture manufactures confirm that on average an upholstered sofa will require 30 min to

[27] See http://www.labormarketinfo.edd.ca.gov/cgi/dataanalysis/areaselection.asp?tablename=oeswage.

upholster a fire barrier, and 15 min for a chair. [28] I use these estimates in the labor cost calculation.

Testing and Compliance Costs

In a BCA application, it is standard to compare the cost of implementing a proposed regulatory standard against the costs of the existing regulatory compliance. Currently, upholstered furniture manufacturers must test and keep compliance records for upholstered furniture meeting the TB 117-2013 smoldering ignition standard. Under the proposed fire barrier standard, upholstered furniture manufacturers would need to perform an additional test and keep separate compliance records. Thus, it is important that I explicitly account for this additional testing and compliance costs required with an open flame standard. Without reliable data that could account for frequency and cost of testing/record keeping, I inflation adjust the CPSC (2008) estimates to 2017 dollars. I assume the consistency of these estimates across furniture types.

Financing Costs

CPSC (2008) assumes that sellers of furniture use inventory financing as a form of asset-based lending, allowing a business to use inventory to obtain a revolving line of credit. If total furniture costs increase, then inventory financing costs also increase. Since material costs of fire barriers alone will increase the cost of upholstered furniture, I incorporate this cost input into the benefit-cost model. To calculate financing costs I multiply the interest rate by the total incremental increase in costs to upholstered furniture. I use the average between the CPSC (2008) estimate of 10 percent, and our interview estimates of 3.5 and 7.0 percent.

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[28] I conducted a phone interview of eight upholstered furniture industry representatives provided by BEARHFTI. The topics discussed ranged from fire barriers, length of time to incorporate a fire barrier, upholstered furniture dimensions, cost estimates, and expected product life cycles. Each industry representative granted their permission to have discussions recorded through written notes, including cost estimates when provided.

State Enforcement Costs

A task designated to the Bureau of Electronic and Appliance Repair, Home Furnishing and Thermal Insulation (BEARHFTI) is the testing of upholstered furniture to ensure regulatory compliance.[29] Currently, BEARHFTI ensures upholstered furniture compliance with TB 117-2013 for the residential market. The imposition of a fire barrier performance standard by BEARHFTI will add an additional test requirement, and in turn increase the cost of enforcement. For budget years 2016-2018, BEARHFIT reports that the program expenditure for Home Furnishings and Thermal Insulation will remain constant at about $4.8 million (BEARHFIT, 2017). Without further information on testing and related enforcement expenses, I assume the incremental increase in state enforcement costs fall within the range of an additional 0.5 to 1.5 percent.

Upholstered Furniture Benefit-Cost Model Specification

Once the benefits and costs are calculated, the principle of benefit-cost analysis is to aggregate the benefits and costs in present values (NPV) over the time horizon. Before this aggregation can occur there are important model considerations. First is whether to conduct the analysis in nominal or real (inflation adjusted) dollars. Since I have no reliable way of predicting the future inflation rate, I present the BCA in constant 2017 dollars using the national CPI index. I chose the year 2017, because I need to begin with a hypothetical year of start for which CPI information is available.

A second consideration in the formulation of a BCA is the timing of benefits and costs. The period of resources first committed determines the start date of a BCA. Technical Bulletin 117-2013 established a one year grace period to allow adequate time for upholstered furniture businesses to comply with the new regulatory standards (BEARHFTI, n.d.a). Accordingly, this

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[29]See http://sbp.senate.ca.gov/sites/sbp.senate.ca.gov/files/BEARHFTI%20Background%20Paper.pdf.

results in incentives for furniture manufactures to quickly comply in order to develop a supply of furniture that meets the regulatory standard at the conclusion of the grace period. Whereas, most consumers are likely to only acquire upholstered furniture in compliance with the standard at the conclusion of the grace period. Consequently, I assume the costs are incurred in period zero (i.e. starting year 2017), followed by the benefits incurred in time period one.

A third consideration for a BCA is whether the absolute value of future benefits and costs should remain constant throughout the full time of the analysis. As noted earlier, the benefits of this regulation are due in part to a reduction in residential injuries and deaths; but as described earlier, these have exhibited a downward trend since 1985 (USFA, 1997; USFA 2017). Conceivably this could warrant a downward adjustment in the absolute benefits expected over the time horizon. However, to do this requires an extrapolation beyond the range of existing data. Such an extrapolation assumes the future reflects a past trend line; an assumption that is often tenuous. Instead, I chose a more conservative approach, and project a constant absolute benefit and cost over the time horizon.

A fourth consideration is to decide if upholstered furniture exhibits homogenous or heterogeneous flammability characteristics. Homogenous flammability characteristics allow the use of an aggregated average value for benefits and costs. Alternatively, upholstered furniture that exhibit heterogeneous flammability characteristics requires average values per category, which then require a weighted aggregation to determine total benefits and costs across all furniture. CPSC (2008) in their BCA differentiated between upholstered furniture types by the type of upholstery cover material; including: (1) severely ignition prone cellulosics[30], (2) moderately ignition prone cellulosics, (3) low ignition prone cellulosics, (4) thermoplastics[31], and (5)

[30] Cellulosics are a synthetic derivative of cellulose; a natural occurring polymer from plant fibers.
[31] Thermoplastics are a synthetic plastic polymer that softens and melts at high temperatures, and hardens when cooled.

leather/wool/vinyl coated. Under this approach, CPSC (2008) determined the total estimated benefits to society from an open flame ignition standard for severely ignition prone cellulosic material ranged between $9.0 and $11.1 million, but thermoplastic cover materials results in zero benefits to society. This deviates significantly from a homogenous assumption, which assumes the same range of benefits to all upholstered furniture. Unfortunately the BCA application of different cover fabric flammability characteristics by CPSC (2008) required funded surveys in 1981, 1984, 1995, 1997, 2001, and 2006. To replicate this approach for the current upholstered furniture market would require the extensive use of industry surveys to determine the current distribution of cover fabric materials used in California's upholstered furniture market, or the use of broad estimates from representatives of furniture manufactures. Absent this data, I assume homogenous flammability characteristics when calculating the benefit stream.

Lastly, a BCA requires that the calculated benefits and costs share the same unit of analysis. The unit of analysis for benefits is a residential household in California that will have less death, injuries, and property damage, through the adoption of a fire barrier regulation. Costs of the fire barrier regulation relate to upholstered furniture, so I assume a fixed number of upholstered sofas and chairs in a typical California household. I start with a baseline where California household have two upholstered chairs and one upholstered sofa. The expected number of households then determines the total cost to all of California in a given year buying new furniture.[32]

The following formula is a representation of the previous description:

$$\text{NPV} = \sum_{t=0}^{T=16} \frac{\sum(B_{it})}{(1+d)^t} - \frac{(C_t \text{ x } P_t)}{(1+d)^t},$$

$$B_{it} = [(S \text{ x } P(r)) \text{ x } P_t],$$

[32] The United States Census Bureau (2016) estimates the average number of California households from 2010 through 2016 at 12,668,236 million.

$C_t = (F \times U \times H)$,

Where:

$\mathbf{B_{it}}$ is the sum of i[th] households realizing an average annual benefit in time period t,

S is the average societal costs from upholstered furniture fire related civilian deaths, injuries, and property loss,

P(r) is the risk reduction probability,

$\mathbf{C_t}$ is the average annual societal cost in time period t,

F is the constant average incremental increase in state enforcement and manufacturer incurred testing, compliance, financing, and furniture costs,

U is the assumed average number of two upholstered chairs and one sofa per household,

H is the average number of California households from 2010 through 2016,

$\mathbf{P_t}$ is the percent households who turnover furniture in time period t, determined by inverse of the product life cycle,

d is the real discount rate,

T is the time horizon determined by the product life cycle.

For clarity on this assumed process of household replacement of upholstered furniture, I offer an example based on a product life cycle of 16 years. In time period one, one-sixteenth of households realize an average annual benefit discounted by one year. In time period two, the next one-sixteenth of households realize an average annual benefit discounted by time period one, plus the prior one-sixteenth of households realizing the average annual benefit discounted by time period two. This pattern continues until after 16 years, when all California households have replaced their pre-furniture barrier furniture, and are obtaining the benefits of the fire barrier regulation. By doing this, the model accounts for two factors: (1) households obtain the benefit of more open flame resistant upholstered furniture over the life of the product, and (2) households can only realize the benefit at the time of purchase and use. If households obtain furniture containing fire barriers in time period ten, those households should not have the same benefit as households who obtained the same furniture in time period one. It is important to note a benefit-cost analysis assumes a finite period. Therefore, only households in time period one will fully realize the benefits over any given time horizon scenario greater than one.

In contrast, the annual cost of implanting this regulation from period zero to 16 is constant. It is equal to the average cost in state enforcement and manufacturer incurred testing, compliance, financing, and furniture costs for the new upholstered sofa, and two new upholstered chairs bought by one-sixteenth of all California households.

CHAPTER FOUR: DATA CALCULATIONS AND FINDINGS

This chapter summarizes the benefit and cost data that provide the basis for calculating the net present value (NPV) of the proposed fire barrier performance standard. Included is a discussion of the benefit and cost drivers that significantly impact the findings. I then present the range of net present value outcomes based on the proposed BCA model.

Benefit and Cost Data

As previously discussed, the benefits of the proposed fire barrier performance standard are the marginal reduction in upholstered furniture fire caused civilian losses. This BCA utilizes the CAL FIRE Incident Reporting System data set from 2010 through 2016, providing a large sample of 23,506 residential building fires. Of the residential building fires reported, only those involving upholstered furniture as the first item to ignite from an open flame, or as the primary contributing material to flame/fire spread are addressable by the fire barrier performance standard. Table 4 below provides the total annual fire losses for civilian deaths, injuries, property and content losses reported to CAL FIRE from 2010-2016. On average 19 upholstered furniture fires occur each year resulting in zero civilian deaths, two civilian injuries, $874,427 in property losses, and $275,140 in content losses. In contrast to national level data for upholstered furniture fires (see NFPA, 2013; Ahrens, 2017), this accounting of reported civilian losses is substantially lower.

Table 4

Combined Residential Upholstered Furniture Fire Scenarios for California

Year	Incident Count	Property Loss	Content Loss	Civilian Injuries	Civilian Fatalities
2010	20	$1,150,949	$205,647	1	0
2011	31	$1,279,238	$553,167	8	1
2012	17	$468,183	$82,977	1	0
2013	28	$1,345,063	$520,045	0	0
2014	12	$987,017	$302,672	0	0
2015	13	$379,574	$101,570	0	1
2016	13	$510,963	$159,900	2	0
Average	**19**	**$874,427**	**$275,140**	**2**	**0**

Note. All valuations reported are in constant 2017 dollars

In Table 5 below, the benefit data calculations that serve as the basis for calculating the net present value of benefits (NPV) are provided. The impact of zero civilian deaths and two civilian injuries are reflected in the average societal cost of $1,683,123. In the context of California this points to an insignificant policy problem when you consider more than 12 million households own some type of upholstered furniture. Further, fire barriers are not reasonably expected to mitigate 100 percent of all fire losses. As a result, the expected benefit to California from a fire barrier performance standard (colored in green) is $319,793 dollars before discounting. Similarly, Table 6 summarizes the cost data that serves as the basis for calculating the net present value of costs (NPC). The total cost of an upholstered chair or sofa is the sum of the material costs, plus the labor, testing, compliance, and inventory costs. Of these upholstered furniture cost components, the main driver is the cost of fire barrier materials, which account for 72 percent of the total average chair and sofa cost. This is followed by the assumption each households will replace on average two upholstered chairs and one upholstered sofa. Thus, the expected cost to California households from a fire barrier performance standard (colored in red) is $989,690,668 dollars before discounting.

Table 5

Summary of Benefit Data Calculations used in BCA

Data Input	Average Whole # Frequency	Average Dollar Value[1]	Lower Bound Dollar Estimate[1]	Upper Bound Dollar Estimate[1]	Source(s)
Value of a Statistical Life		$4,373,404	$3,271,409	$5,841,801	Garbacz (1991)
Value of a Statistical Injury		$266,778	$199,556	$356,350	Garbacz (1991); Department of Transportation (2011); USFA, 2017
Upholstered Furniture Fire Civilian Deaths[2]	0	$0	$0	$0	CAL Fire Incident Reporting System (CAIRS) 2010-2016
Upholstered Furniture Fire Civilian Injuries[2]	2	$533,556	$399,112	$712,700	CAL Fire Incident Reporting System (CAIRS) 2010-2016
Upholstered Furniture Fire Property Loss[2]		$874,427			CAL Fire Incident Reporting System (CAIRS) 2010-2016
Upholstered Furniture Fire Content Loss[2]		$275,140			CAL Fire Incident Reporting System (CAIRS) 2010-2016
Average Societal Cost		$1,683,123	$1,548,679	$1,862,267	
Risk Reduction Probability		0.19	0.19	0.19	CPSC 2008
Benefit of Upholstered Furniture Regulation to CA		**$319,793**	**$294,249**	**$353,831**	

Note. All valuations reported are in constant (inflation adjusted) 2017 dollars. All residential building fires involving upholstered furniture as the first item to ignite, and as a contributing source. Excludes “other furniture.”

Table 6

Summary of Cost Data and Calculations used in BCA

Data Input	Average Frequency	Average Dollar Value	Lower Bound Dollar Estimate	Upper Bound Dollar Estimate	Source(s)
Fire Barrier (LY) Cost		$4.92	$4.68	$5.16	BEARHFTI
Fire Barrier (LY) Cost less Polyester Batting		$4.27	$4.03	$4.51	BEARHFTI; CPSC (2008)
Number Seating Cushions per Chair	1	$4.27	$4.03	$4.51	BEARHFTI; CPSC (2008)
LY other Chair parts	2	$9.84	$9.36	$10.32	BEARHFTI; CPSC (2008)
Number Seating Cushions per Sofa	2	$8.54	$8.06	$9.02	BEARHFTI; CPSC (2008)
LY other Sofa parts	4	$19.68	$18.72	$20.64	BEARHFTI; CPSC (2008)
Chair Material Costs		$14.11	$13.39	$14.83	BEARHFTI; CPSC (2008)
Sofa Material Costs		$28.22	$26.78	$29.66	BEARHFTI; CPSC (2008)
Labor Cost per Chair	15min	$4.04			Interviews; CA EDD
Labor Cost per Sofa	30min	$8.07			Interviews; CA EDD
Testing Cost per Chair or Sofa		$0.01			CPSC (2008)
Compliance Cost per Chair or Sofa		$0.13			CPSC (2008)
Inventory Financing Cost per chair		$1.28	$1.23	$1.33	Interviews; CPSC (2008)
Inventory Financing Cost per Sofa		$2.55	$2.45	$2.65	Interviews; CPSC (2008)
Total Manufacturing Cost per Chair		$19.57	$18.80	$20.34	
Total Manufacturing Cost per Sofa		$38.98	$37.44	$40.52	
Chairs per Household	2				
Sofas per Household	1				
Upholstered Furniture Cost per Household		$78.12	$75.04	$81.20	
State Enforcement Estimated Costs		$48,150	$24,075	$72,225	BEARHFTI (2017)
California Households	12,668,235				ACS 2010-2016
Cost of Upholstered Furniture Regulation to CA		**$989,690,668**	**$950,648,429**	**$1,028,732,907**	

Note. All valuations reported are in constant 2017 dollars. Labor assumes $16.14 hourly wage. Financing assumes 0.07 interest rate.

Results

In Table 7, each row provides the net present benefits (NPB), the net present costs (NPC), and the net present value (NPV) outcomes calculated from the baseline BCA data using average values. In addition, I vary the value of the benefit and cost input data by the lower and upper bound estimates provide earlier, to offer an initial assessment of the impacts of discount rates, values of statistical life and injury, manufacturing costs, and state enforcement costs. The decision criterion relevant for a single policy evaluation is whether the present value of the net benefits over the time horizon exceed the costs (greater than zero). The range of NPB's for all outcomes presented resulted in $1,721,712 – $2,534,975 million dollars over the 16-year time horizon. Whereas the range of NPC's for all outcomes presented resulted in $620,693,130 – $871,921,994 million dollars over the same 16-year time horizon. The NPB minus the NPC determines if the NPV is positive or negative. The BCA model indicates the NPV ranges from negative $618,971,418 to negative $869,387,020 million dollars. This demonstrates the expected benefits of a proposed fire barrier performance standard for upholstered furniture <u>fail</u> to exceed the expected costs of imposing it over a 16-year time horizon. This does not mean however, these NPV outcomes are demonstrated to be robust to large changes in benefit/cost inputs or model assumptions. If changes to input data or model assumptions demonstrate a change in the original NPV outcomes, I am less confident the results are accurate. To test the certainty of the model results, I offer in the next chapter an alternative fire loss baseline, results of a sensitivity/switching analysis, and the degree of change necessary in the inputs to yield a positive NPV. Collectively this will demonstrate how robust the negative NPV results are to changes in model assumptions and magnitude of inputs changes.

Table 7

Summary of Net Present Value Outcomes over a 16 year Time Horizon

Outcome	Values Used	NPB (in 2017$)	NPC (in 2017$)	NPV (in 2017$)	Decision Criteria: NPV > 0
1[a]	Average Values in Table 5 & 6	$2,291,118	$838,831,008	- $836,539,890	No
2[a]	Lower Bound Values in Table 5 & 6	$2,108,109	$805,740,021	- $803,631,912	No
3[a]	Upper Bound Values in Table 5 & 6	$2,534,975	$871,921,994	- $869,387,020	No
4[b]	Average Values in Table 5 & 6	$1,871,177	$646,184,415	- $644,313,238	No
5[b]	Lower Bound Values in Table 5 & 6	$1,721,712	$620,693,130	- $618,971,419	No
6[b]	Upper Bound Values in Table 5 & 6	$2,070,337	$671,675,699	- $669,605,362	No

Note. [a] calculations used a 3% discount rate and [b] calculations used a 7% discount rate

CHAPTER FIVE: SENSITIVITY ANALYSIS OF QUANTITATIVE FINDINGS AND QUALITATIVE ANALYSIS OF UNCERTAINTY

This chapter summarizes the factors of uncertainty related to data inputs or models assumptions. Included is a sensitivity analysis that presents the range of net present value outcomes, and the degree of change needed to obtain a net zero NPV result. I then present findings from qualitative interviews of key stakeholders to assess uncertainty from a different perspective – whether BCA as a methodology is viewed as inherently flawed in its estimation of benefits and costs.

Sources of Uncertainty

Objective BCA investigates the impacts of uncertainty, potential bias in the data, and assumptions used (Fuguitt & Wilcox, 1999). Inherent to the benefit and costs data used here is a level of uncertainty stemming from: (1) limited public data, (2) measurement and sampling error, and (3) the difficulty in predicting future values. In addition, a BCA model can favor positive or negative net present value outcomes, depending on the timing of the benefits and costs over the time horizon.

The most practical method to assess the impacts of the three types of uncertainty noted, and the timing of benefits/costs, is the use of sensitivity analysis on key factors (Fuguitt & Wilcox, 1999). A sensitivity analysis for BCA holds all other variables constant, changes the value of one variable used in the BCA at a time, and checks the impact of this on the net present value of calculated benefits minus costs. If no change occurs in the decision criterion from reasonable changes to variables, the BCA model is considered robust to a reasonable degree of uncertainty (Fuguitt & Wilcox, 1999).

Due to the number of parameters in the model, I restrict the sensitivity analysis to factors or variables that have significant impact to the benefits and costs. Additionally, a sensitivity analysis should have a degree of divergence from the baseline used in the primary analysis to provide a meaningful comparison. Given that the benefits of a fire barrier regulation for upholstered furniture is dependent upon the magnitude of fire losses observed, I first explore an alternative baseline of fire losses. From this baseline I then assess what happens to NPV when: (1) changing the upholstered furniture fire losses baseline, (2) changing the civilian death and injury occurrences, (3) changing the risk reduction probability, (4) changing the discount rate (5) changing the time horizon, and (6) changing the cost of upholstered furniture.

In addition to the range of sensitivity analyses provided, I assess the uncertainty in the research approach itself. This type of uncertainty falls outside what a sensitivity analysis can account for, and speaks to a broader debate about the use of BCA in public policy decisions.[33] This level of uncertainty is generally derived from what is not measured, or accounted for in the monetization requirement of BCA; namely hard to measure non-market based benefits or costs (Fuguitt & Wilcox, 1999). I explore this type of uncertainty through qualitative interviews of key stakeholders examining two themes: (1) accuracy of BCA methodology, and (2) the perceived value of BCA in regulatory analysis.

Changing the Upholstered Furniture Fire Losses Baseline

Historically, fire statistics exhibit a fair degree of uncertainty due to unknown fire characteristics, measurement, and sampling error (USFA, 2012; NFPA, 2013, McNamee & Anderson, 2015; NFPA; 2016). Unknown data represents a sizeable portion of the uncertainty in fire statistics (Thomas & Butry, 2016). A primary cause of this unknown data is reported fire cases with one or more unknown fire characteristics (Hall & Harwood, 1989). More recently, NPFA (2013) raised the issue of whether fire departments treat the category *other furniture*, either as well-defined furniture items that do not fit the other listed categories, or as an unknown

[33] See http://www.ase.tufts.edu/gdae/Pubs/rp/Ack_UK_CBAcritique.pdf.

category. In the latter case, the relevant impact to the BCA is the potential underestimation of reported fire statistics. The challenge is to what degree the unknown data impacts the civilian caused deaths, injuries, property, and content losses from upholstered furniture ignited by an open flame.

The statistical approach consistently used in fire data to account for unknowns is to proportionally allocate fire characteristics of unknown fires across known fire cases (USFA, 2012b; Thomas & Butry, 2016). In effect, this approach simply scales up the known proportions of fire characteristics equally, but at the cost of assuming the unknown data contains the same share of fire characteristics found in known cases (Hall & Harwood, 1989; USFA, 2012b; Thomas & Butry, 2016). The previous baseline BCA adopted a conservative approach of case-wise deletion of fire cases with reported unknowns on item first to ignite, heat source, and in the case of the second fire scenario, material most contributing to flame or fire spread. Moreover, I treated *other furniture* at face value, and not as an unknown category. To better account for this inherent uncertainty with case wise deletion and other furniture, I propose an aggressive approach in allocating fire losses coded as other furniture.

Under this alternative baseline, I incorporate all other furniture as the first item to ignite, or as the material contributing most to flame or fire spread, using the same methodology requirements for both fire scenarios. The primary reason for this approach is proportionally allocating unknown data in categories of item first to ignite, or heat source, would only produce minor changes in the fire data (Hall & Harwood, 1989). As noted in Table 8, this approach significantly increases the upholstered furniture caused fire losses considered addressable by the fire standard. Table 9 reports a new summary of net present value outcomes, including both lower and upper bound values. The range of net present value outcomes for all scenarios still reflect negative net present values of $609,622,622 – $835,093,049 million dollars over the 16-year time horizon.

Table 8

Combined Alternative Fire Scenarios in California using Other Furniture Category

Year	Incident Count	Property Loss	Content Loss	Civilian Injuries	Civilian Fatalities
2010	117	$5,682,574	$1,409,740	8	5
2011	110	$3,644,189	$1,242,905	13	3
2012	85	$4,875,448	$2,543,939	9	2
2013	97	$4,205,388	$1,113,966	14	0
2014	69	$3,801,951	$1,097,082	3	0
2015	64	$1,856,314	$548,547	0	2
2016	77	$4,232,166	$857,413	8	2
Average	**88**	**$4,042,576**	**$1,259,085**	**8**	**2**

Note. All valuations reported are in constant 2017 dollars

Table 9

Summary of NPV Outcomes of Alternative Fire Loss Baseline

Outcome	Values Used	NPB (in 2017$)	NPC (in 2017$)	NPV (in 2017$)	Decision Criteria: NPV > 0
1[a]	Average Benefit and Cost values	$22,028,374	$838,831,008	- $816,802,633	No
2[a]	Lower Bound Benefit and Cost Values	$18,296,199	$805,740,021	- $787,443,822	No
3[a]	Upper Bound Benefit and Cost Values	$27,001,453	$871,921,994	- $844,920,541	No
4[b]	Average Benefit and Cost values	$17,990,773	$646,184,415	- $628,193,642	No
5[b]	Lower Bound Benefit and Cost Values	$14,942,672	$620,693,130	- $605,750,459	No
6[b]	Upper Bound Benefit and Cost Values	$22,052,332	$671,675,699	- $649,623,368	No

Note. All results use a 16 year time horizon. [a] calculations used a 3% discount rate and [b] calculations used a 7% discount rate

Changing the Civilian Death and Injury Occurrences

Two crucial factors to determining the overall benefits are the number of annual civilian deaths and injuries. Given this, it is reasonable to consider significant shocks to the number of civilian deaths and injuries to evaluate its relative impact on net present value outcomes. Table 10 below provides a range of sensitivity outcomes from the alternative fire loss baseline, with the necessary model assumptions noted in the Appendix. The exception is outcomes five and six where I provide an evaluation of the combined effect of worst case scenario for each of the injury, death, property, and content loss that occurred during 2010 through 2016. Even under these large fire loss scenarios, the range of NPV outcomes only vary between negative $570,968,315 and $815,350,048 million dollars over a 16-year time horizon. As an important point of reference, holding all other variables constant, only at a total of 132 to 140 residential home deaths, or 2,127 to 2,241 residential home deaths yield a net present value outcome greater than zero. If all four fire loss categories increase proportionally from worst case values, only at an increase greater than 1000 percent does the calculated net present value rise to greater than zero.

Table 10

Sensitivity Analysis of Civilian Deaths and Injuries over a 16-year Time Horizon

Outcome	Value(s) Used in Sensitivity	NPB (in 2017$)	NPC (in 2017$)	NPV (in 2017$)	Decision Criteria: NPV > 0	Input ΔNeeded for NPV > 0
1[a]	50 percent increase in Average number of Civilian Deaths	$27,981,585	$838,831,008	-$810,849,423	No	140 Deaths
2[a]	50 percent increase in Average number of Civilian Injuries	$23,480,960	$838,831,008	-$815,350,048	No	2241 Injuries
3[b]	100 percent increase in Average number of Civilian Deaths	$27,714,856	$646,184,415	-$618,469,559	No	132 Deaths
4[b]	100 percent increase in Average number of Civilian Injuries	$20,363,452	$646,184,415	-$625,820,962	No	2127 Injuries
5[b]	50 percent Increase in Worst Case Scenarios for All Upholstered Furniture Fire loss categories	$58,843,095	$646,184,415	-$587,341,320	No	Greater than 1000 percent increase to all fire loss categories
6[b]	100 percent Increase in Worst Case Scenarios for All Upholstered Furniture Fire loss categories	$75,216,099	$646,184,415	-$570,968,315	No	Greater than 1000 percent increase to all fire loss categories

Note. [a] calculations used a 3% discount rate and [b] calculations used a 7% discount rate

Changing the Risk Reduction Probability

Throughout this BCA, I assumed an average risk reduction probability of 19 percent based on the ranges provided by the CPSC. Yet this value is based on CPSC's judgement, and therefore it is reasonable to assume a degree of uncertainty with the risk reduction probability – the probability that an inclusion of a fire barrier in upholstered furniture prevents a residential fire. Accordingly, I examine the impacts of assuming a 51 percent risk reduction probability consistent with upholstered furniture deemed severely ignition prone to an open flame, and a 25 percent risk reduction probability for moderately ignition prone upholstered furniture (see CPCSC, 2008). In other words, a fire barrier assumed to have a risk reduction probability of 0.51 will reduce fire losses from upholstered furniture fires by 51 percent on average. Table 11 provides a range of sensitivity outcomes of both the risk reduction probabilities, and with worst case fire loss scenarios not held constant. Model assumptions are noted in model the Appendix. The net present value (NPV) outcomes for all sensitivity scenarios are negative with a range of -$444,288,569 to -$809,846,305 over a 16-year time horizon. To obtain a net present value outcome would require the impossible probability value of greater than one. These outcomes provide a lack of evidence that reasonable levels of uncertainty in risk reduction probability of fire barriers, or in combination with increases in fire losses has a decisive impact to net present value outcomes.

Table 11

Sensitivity of Assumed Fire Barrier Risk Reductions and Fire Losses

Outcome	Value(s) Used in Sensitivity	NPB (in 2017$)	NPC (in 2017$)	NPV (in 2017$)	Decision Criteria: NPV > 0	Input Needed for NPV > 0
1[a]	P(r) of .51 for Upholstered Furniture	$59,128,795	$838,831,008	-$779,702,213	No	P(r) exceeds 1
2[a]	P(r) of .25 for Upholstered Furniture	$28,984,703	$838,831,008	-$809,846,305	No	P(r) exceeds 1
3[b]	P(r) of .51 for Upholstered Furniture	$48,291,023	$646,184,415	-$597,893,392	No	P(r) exceeds 1
4[b]	P(r) of .25 for Upholstered Furniture	$23,672,070	$646,184,415	-$622,512,345	No	P(r) exceeds 1
5[b]	P(r) of .51 and 100 percent Increase in Worst Case Scenarios for all Upholstered Furniture Fire loss categories	$201,895,846	$646,184,415	-$444,288,569	No	P(r) exceeds 1
5[b]	P(r) of .25 and 100 percent Increase in Worst Case Scenarios for all Upholstered Furniture Fire loss categories	$98,968,552	$646,184,415	-$547,215,863	No	P(r) exceeds 1

Note. All results use a 16 year time horizon. [a] calculations used a 3% discount rate and [b] Calculations used a 7% discount rate

Changing the Discount Rate

The costs of a fire barrier in upholstered furniture occur at the time of the manufacture, but the realization of benefits in fire reduction due to barrier occur each year that the product exists. A consequence is the costs are more susceptive to increases in the discount rate than the benefits; a finding repeatedly demonstrated in the above sensitivity analyses. A review of the literature indicates some support for the use of as high a10 percent real discount rate (Dardis, 1980b; McNamee *et al.*, 2015). Justification for the use of a high real (adjusted for inflation) discount rate comes from the theory that citizens value the present more than they value possible future benefits.

In Table 12, I report upon a sensitivity analysis of both the discount rate, and with worst case fire loss scenarios not held constant. Further details on necessary model assumptions are in Appendix. The net present value (NPV) outcomes for all sensitivity scenarios are again negative and range from -$480,106,005 to -$530,084,045 over a 16-year time horizon. Furthermore, even after accounting for large fire losses the NPV remains significantly negative.

Table 12

Sensitivity of Discount Rate and Fire Losses over a 16-year Time Horizon

Outcome	Value(s) Used in Sensitivity	NPB (in 2017$)	NPC (in 2017$)	NPV (in 2017$)	Decision Criteria: NPV > 0	Input Needed for NPV > 0
1	10% Discount Rate	$15,712,337	$545,796,381	-$530,084,045	No	Discount rate > 100%
2	10% Discount Rate and 100 percent Increase in Worst Case Scenarios for all Upholstered Furniture Fire loss categories	$65,690,377	$545,796,381	-$480,106,005	No	Discount rate > 100%

Changing the Time Horizon

An alternative method in evaluating the impacts of the timing of benefits and costs is to alter the assumed time horizon. In this BCA, the useful life of upholstered furniture determines the time horizon. A longer time horizon significantly increases the accrual of discounted benefits, by presuming households will hold onto upholstered furniture longer. Table 13 provides a sensitivity analysis of both the time horizon, and with worst case fire loss scenarios not held constant. The net present value (NPV) outcomes for all sensitivity scenarios are again negative and range between -$310,993,795 to -$709,441,651 million dollars over a 16-year time horizon. Here input changes beyond 32 years are not calculated, because likely policy or technology changes will occur, and invalidate the results of unrealistically long-time horizons. Subsequently, all four scenarios demonstrate the net present value outcome is robust to substantial changes in the time horizon, and in combination with large increases in fire losses.

Table 13

Sensitivity of the Time Horizon and Fire Losses

Outcome	Value(s) Used in Sensitivity	NPB (in 2017$)	NPC (in 2017$)	NPV (in 2017$)	Decision Criteria: NPV > 0
1[a]	24-year Time Horizon	$30,168,293	$739,609,944	-$709,441,651	No
2[a]	32-year Time Horizon	$37,188,748	$661,508,177	-$624,319,428	No
3[b]	24-year Time Horizon and 100 percent Increase in Worst Case Scenarios for all Upholstered Furniture Fire loss categories	$95,880,491	$514,199,312	-$418,318,822	No
4[b]	32-year Time Horizon and 100 percent Increase in Worst Case Scenarios for all Upholstered Furniture Fire loss categories	$111,064,594	$422,058,389	-$310,993,795	No

Note. [a] calculations used a 3% discount rate and [b] calculations used a 7% discount rate

Changing the Cost of Upholstered Furniture

When examining the findings of BCA conducted after a regulation put in place, it is important to note the estimation of future costs is often significantly greater when compared to the costs that occurred after the regulation in place. Kopits *et al.* (2014) note several factors that impact the accuracy of *ex ante* cost estimates. Of those described, two are particularly relevant to the BCA performed here. First, industry representatives generally have better information about the cost of complying with regulatory standards, and this asymmetric information incentivizes giving plausible, but unlikely his cost estimates to analysts. Second, regulatory agencies seeking to pass a standard may have the incentive to underestimate the true cost of the regulation to consumers in higher prices and/or firms in lower profits. A point often presented by industry representatives of increasingly burdensome regulations.

From the perspective of objective BCA, it is not unreasonable to suggest the initial range of cost estimates are subject to a degree of uncertainty. Thus I examine two alternative cost scenarios: (1) an underestimation of the average costs of upholstered furniture per household by 50 percent, and (2) an overestimation of the average costs of upholstered furniture by 50 percent. This provides a more complete examination of the impact of costs to the previously reported lowest negative net present value outcomes from either perspective of uncertainty. Table 14 below provides a sensitivity analysis of the changing costs of upholstered furniture per household, paired with the lowest negative NPV scenarios in the prior analyses. The net present value (NPV) outcomes for all sensitivity scenarios are negative values from negative $99,974,868 to negative $894,044,804 million dollars. To obtain net present value outcomes greater than zero, the cost of upholstered furniture per household would need to be as low as $9.08 under a 7% discount rate, risk reduction probability of 0.19, and a 16 year time horizon. If the risk reduction probability increases to 0.51 holding all else constant, then the cost of upholstered furniture per household would need to fall to $24.40. Changes to either the time horizon, or discount rate needed to obtain a NPV greater than zero requires the cost of upholstered furniture per household to fall to $20.55 and $9.39 respectively. These results offer the distinct conclusion that the combination of benefits and cost circumstances required to obtain net present values greater than zero are unlikely to occur. Regardless of the inherent uncertainty in the cost data, I demonstrate in Table 14 that any reasonable variation in model assumptions and costs fail to produce a positive net present value outcome.

Table 14

Sensitivity Analysis of Furniture Costs and Lowest Negative NPV Scenarios

Outcome	Value(s) Used in Sensitivity	NPB (in 2017$)	NPC (in 2017$)	NPV (in 2017$)	Decision Criteria: NPV > 0	Input Needed for NPV > 0
1[a]	50 percent increase in Upholstered Furniture Cost per Household	$75,216,099	$969,260,903	-$894,044,804	No	Per Household cost of $9.08
2[b]	50 percent decrease in Upholstered Furniture Cost per Household	$75,216,099	$323,107,926	-$247,891,827	No	Per Household cost of $9.08
3[c]	50 percent increase in Upholstered Furniture Cost per Household	$201,895,846	$969,260,903	-$767,365,057	No	Per Household cost of $24.40
4[d]	50 percent decrease in Upholstered Furniture Cost per Household	$201,895,846	$323,107,926	-$121,212,080	No	Per Household cost of $24.40
5[e]	50 percent increase in Upholstered Furniture Cost per Household	$65,690,377	$818,681,295	-$752,990,919	No	Per Household cost of $9.39
6[f]	50 percent decrease in Upholstered Furniture Cost per Household	$65,690,377	$272,911,468	-$207,221,091	No	Per Household cost of $9.39
7[g]	50 percent increase in Upholstered Furniture Cost per Household	$111,064,594	$633,077,317	-$522,012,723	No	Per Household cost of $20.55
8[h]	50 percent decrease in Upholstered Furniture Cost per Household	$111,064,594	$211,039,461	-$99,974,868	No	Per Household cost of $20.55

Note.
[a & b] Uses 100 percent increase in worst case scenarios for all upholstered furniture fire loss categories, 16 year time horizon, P(r) .19, and a 7% discount rate.
[c & d] Uses 100 percent increase in worst case scenarios for all upholstered furniture fire loss categories, 16 year time horizon, P(r) .51, and a 7% discount rate.
[e & f] Uses 100 percent increase in worst case scenarios for all upholstered furniture fire loss categories, 16 year time horizon, P(r) .19, and a 10% discount rate.
[g & h] Uses 100 percent increase in worst case scenarios for all upholstered furniture fire loss categories, 32 year time horizon, P(r) .19, and a 7% discount rate.

Qualitative Assessment of BCA Uncertainty

Benefit-Cost Analysis needs benefits and costs to be valued in monetary terms in order to determine if the benefits of a policy exceed the costs. This requirement can and often does restrict the range of included benefits, or necessitates indirect means of estimation when evaluating public policies that involve health, the environment, and human lives saved.[34] All of this imposes an inherent degree of uncertainty into the BCA findings. This BCA is no exception with the decision to exclude benefits from reduced health impacts from diminished flame retardant exposure. In a sensitivity analysis there is no means to address these hard to measure benefits to human health beyond inputting best guesses as to the values of these benefits. Instead I seek to provide a balanced perspective of the impacts of uncertainty to BCA by interviewing key stakeholders about their opinions of BCA's accuracy and value to the decision making process. This following section summarizes the interview procedure and the main themes across participants.

Interview Design

I utilized a semi-structured qualitative interview design with a telephonic format, consisting of 10 interview questions. The questions comprised of both closed and open-ended questions (see Appendix C for questions). Unstructured probing questions were asked throughout the interview when further information was needed. The design of the questions were intended to elicit a range of opinions about the BCA methodology and the value of BCA as an evidence based approach to evaluating regulation. Key stakeholders were then selected based on their connections to BEARHFTI, the furniture industry, or to a legislative oversight agency. Each participant was provided a one-page BCA research brief that summarized the contents of the proposed fire barrier regulation, the BCA methodology, data assumptions, and the primary results

[34] See http://www.ase.tufts.edu/gdae/Pubs/rp/Ack_UK_CBAcritique.pdf.

(see Appendix D). In total, I interviewed three participants, representing a state advisory council, the furniture industry, and a state analyst with experience in legislative oversight.[35]

IRB Consent Process

Participation in the interviews was voluntary with no financial compensation, reward, or other incentives offered. Each participant was given a consent letter that covered the purpose of the interview, participant rights, confidentiality, and timeline to retain and destroy data (see Appendix C). A copy of the signed consent form was secured prior to each interview.

Interview Results

Each of the three participants represented varying levels of knowledge about BCA as a method, the proposed fire barrier regulation, or the details of this BCA study. Consistent with the research ethics of self-determination, participants were given the opportunity to skip questions they were not fully confident in answering. Given the limited sample size and various questions skipped by participants, I present two common themes that emerged across interview responses.

Theme One – Accuracy of BCA

One factor that determines the accuracy of BCA is whether the main benefits and costs are accounted for in the model. Both the state advisory council and furniture industry participant noted the magnitude of fire losses, and the cost impacts to manufacturers as the two most important factors when considering the proposed fire barrier regulation for upholstered furniture. However, each of the three participants also aired various levels of concern regarding the accuracy of BCA in general, and in evaluating the proposed fire barrier regulation. The state advisory council participant indicated the main limitation to this BCA is the inability to assess health costs from exposure to flame retardant chemicals in upholstered furniture fires. The state advisory council participant noted this concern contributes to the opinion this BCA is not a

[35] For confidentiality reasons the names and direct professional affiliations of the participants are not disclosed.

precise representation of the benefits attributed to the fire barrier regulation. A similar opinion resonated from the state analyst participant, but from a general perspective of BCA. The state analyst indicated the research literature shows after the fact assessments of *ex ante* BCA tend to reveal overestimated benefits and underestimated costs. Whereas, the furniture industry participant indicated this BCA did not account for loss of comfort to the consumer, but felt the overall accuracy of this BCA was excellent.

Theme Two – The Value of BCA

While the state advisory council participant premised the response that this BCA attempted to be a fair and balanced analysis, BEARHFTI does not need to rely on BCA as a standard to determine the merits of regulation. Instead the state advisory council participant noted regulation is already required to meet the legal standard of *arbitrary and capricious* – the factual basis for imposed regulation. Therefore, the state advisory council participant concluded the value of BCA is limited, not only because it is prone to imprecision, but also because the standard of *arbitrary and capricious* is an established alternative to evaluating regulation. The state analyst participant provided a different perspective in that BCA conceptually provides significant value in the decision making process by determining which policies maximize social welfare. However, the state analyst commented in practice most benefit-cost analyses fall short of that ideal due to limited data, and the circuitous estimation techniques necessary to evaluate most benefits in BCA. Of the three participants, the furniture industry representative was the strongest endorser of BCA, suggesting this BCA provides tremendous value by providing an unbiased assessment to BEARHFTI on the actual costs and benefits of the proposed fire barrier regulation.

Qualitative Interview Conclusion

The majority opinion (two out of three) from the stakeholders is that while this BCA accounted for the major benefit and cost factors, both had inherent reservations about BCA providing a matter of fact conclusion of the costs exceeding the benefits. Each noted different aspects of uncertainty in BCA as a tool that undermined the confidence and usefulness of the findings. One of the main insights to the interviews was the concern over why the reduction to fire retardants was not included as a benefit in this BCA. This highlights an important reminder that these stakeholders came from various backgrounds, interests, and knowledge that impacted the lens through which the weaknesses and uncertainty of BCA are viewed. How this feedback affects the confidence of the BCA findings depends largely upon why the reduction to fire retardants was not included in this BCA. The omission of the possible health impacts from flame retardants stemmed not from the inability to quantity the benefits, but that the benefits most likely are attributed to a previous regulatory change outside the scope of this BCA. In 2013, BEARHFTI updated its upholstered furniture smoldering standards under Technical bulletin 117-2013 with the specific intent to reduce the prevalence of flame retardants needed to pass it smoldering standards (BEARHFTI, n.d.a). Moreover, BEARHFTI cited industry input that the removal of the open flame foam standard in TB 117-2013 would no longer necessitate the use of flame retardants (BEARHFTI, n.d.a). If future fire barriers without flame retardants are utilized by manufactures to meet the proposed fire barrier standard, then there would be no reasonable expectation an incremental change would occur to flame retardant use in upholstered furniture.[36] Therefore, what current or future reductions that might occur in flame retardant uses would be benefits attributed to TB 117-2013, not the proposed fire barrier standard.

[36] The reverse could also be argued that the proposed regulation could actually cause an increase use of fire barriers that achieve flame suppression with flame retardants. This in fact would be a cost imposed by the regulation and not a benefit.

CHAPTER SIX: CONCLUSION AND POLICY IMPLICATIONS

This final chapter provides the overall conclusion of the findings, and answers the primary policy question regarding the efficiency of a fire barrier performance standard. I conclude with a discussion on the relevant policy implications by reviewing policy alternatives in the existing literature on consumer protection.

BCA Conclusion of Fire Barrier Standard

The role of government regulation in consumer product markets is a reaction to consumer harm from products that arise in part from market failure. In terms of upholstered furniture products, the economic argument I outlined for government regulation concerned *asymmetric* and *imperfect information*. However, even if there is an argument for government regulation, the overriding research question becomes whether regulation achieves an optimal level of consumer protection.

The scope of this BCA addressed whether the benefits from a proposed fire barrier performance standard for upholstered furniture, likely exceeds the costs to furniture manufactures responsible for its implementation. The primary results demonstrated the likely costs of regulation far outweigh the likely benefits to California consumers. Additionally, these findings are robust to reasonable variations in model assumptions, and changes in the magnitude of cost/benefit inputs. Moreover, some of the concerns expressed about BCA in qualitative interviews seemed to reflect a misunderstanding about whether the proposed standard would lead to benefits from reducing health hazards from flame retardants. I argue that any benefits attributed to a reduction in flame retardant exposure is most likely due to Technical Bulletin 117-2013, and not the proposed fire barrier standard. Therefore, I can conclude with a high degree of certainty that directly imposing a fire barrier performance standard is not an optimal (i.e.

efficient) approach to protecting California consumers against upholstered furniture fire losses caused by an open flame.

It is important to remember this BCA limited the comparison of the fire barrier performance standard to the status quo. In other words, the scope of the analysis did not directly compare the fire barrier performance standard to other alternative safety standards or policies. While this limits the conclusions drawn directly from this BCA, the existing literature can inform the relevant policy implications as to what alternative means exist for government to address the likely *asymmetric* and *imperfect* information in the upholstered furniture market. The remaining of this final chapter provides the following: (1) an overview of policy alternatives for consumer protection, (2) contrasting current upholstered furniture labeling law with policy recommendation, and (3) concluding remarks.

Policy Alternatives for Consumer Protection

The range of alternative government approaches in the economic literature to address consumer protection from *asymmetric* and *imperfect* information is consumer education and product banning (Dardis 1980; Marette *et al.*, 2000; Oi, 1977). For obvious reasons the risk to life and injury from upholstered furniture does not merit a ban on upholstered furniture. The civilian lives, injuries, property, and content losses saved would not outweigh the substantial economic costs in the form of a complete loss in consumer welfare, and lower profits to the producer. Even if the alternative only involves selectively banning upholstered furniture with the highest risk to ignite from open flame sources, this process assumes the level of risk is known. As previously discussed, the myriad of upholstered furniture characteristics that contribute to flammability, and the needed testing for each combination would likely prove impracticable to implement. Alternatively, consumer education is a well-established policy alternative to minimum safety standards (Darids, 1980; Damania and Round, 2000). And in the context of upholstered furniture, a better informed consumer can benefit (at least in theory) by selecting a level of flammability risk at a price that best matches their behaviors (e.g. a smoker vs. non-smoker) and tolerance for risk (Dardis, 1980).

Within the broad category of consumer education, the method of informing the consumer of risks associated with the use of a product generally fall under product labeling, education programs, and public marketing campaigns (Stoltman and Morgan, 1995). Marette *et al.* (2000) note product labeling is preferable when the *search cost* – the time and energy spent on researching product or service information – for risk is substantial; the risk is not salient or experienced by the consumer after consumption; and when consumers view the actual risk of injury or death small. In terms of upholstered furniture, the likely occurrence of asymmetric or imperfect information makes the cost of searching flammability risk to the consumer extremely high. The risk of ignition is also not directly experienced or noticed by the consumer until an ignition event occurs. Further, California fire data from 2010 through 2016 demonstrates on average, insignificant magnitudes of civilian injury and death from upholstered furniture fires caused by an open flame; suggesting the overall risk to the consumer is small. Under these circumstances consumer protection that relies on an informed consumers through product labeling can be efficient (Marette *et al.*, 2000).

In its application however, the efficacy of product labeling in reducing consumer harm from products is determinant on a large number of factors (Stoltman and Morgan, 1995). First among them is the underlying consumer behavior that is at cause for product misuse or harm. Product labels are meant to address the unintentional or incorrect use of products. What are not addressable include consumer behaviors of carelessness, intentional misuse, or the disregard of labels from the general perception they are not important (Stoltman and Morgan, 1995). To what extent these underlying behaviors contribute to upholstered furniture fires is not within the scope of this BCA, but it is worth noting the types of consumer behaviors that product labels cannot address.

The choice of information accessibility in the form of point of purchase displays, package inserts, or product labels also impact the efficacy of product labeling (Stoltman and Morgan, 1995). Point of purchase displays are designed to inform the consumer of the risks before purchase, but it loses effectiveness after the hazard information becomes separated from the product (Stoltman and Morgan, 1995). Likewise, package inserts as a standalone approach is considered the least effective in reducing consumer harm, because inserts are often discarded or misplaced. In addition, the actual product label itself is only as effective as its design (Stoltman and Morgan, 1995). To combat the limitations inherent in each approach, Bettman *et al.* (1986) recommend a labeling system that incorporates all three approaches.

In terms of the actual label design, a plethora of design considerations is noted in the body of literature (Stoltman and Morgan, 1995). Here I only provide the most relevant considerations for upholstered furniture by providing a summary of Bettman *et al.* (1986) review of the subject. Chief among them are human processing limitations. When consumers are faced with a decision making problem that concerns complex information, the increase in *heuristic thinking* – mental shortcuts or rules of thumb used in information processing – limits the amount of information used (Bettman *et al.*, 1986). Similarly, providing too much information can cause the consumer to also selectively process the information. Both of these processing limitations are a concern when it leads the consumer to mistakenly judge the riskiness of a product; especially among commonly used products where consumers often assess the risk to be small (Bettman *et al.*, 1986). Therefore, to minimize errors related to processing of information, product labels need to consider the ease of which information can be processed and used. Design considerations that increase the processability of product information include the following: (1) use of symbols to designate the type and degree of hazards or risks, (2) information should be designed for low levels of reading comprehension, (3) information should be salient through the use of font size or color changes, and (4) organize the information such that the risks are all presented in one place on the label (Bettman *et al.*, 1986).

Current Upholstered Furniture Labeling and Policy Recommendation

Under the Bureau of Home Furnishings Article 2 C.C.R. § 1126 (2014), businesses selling home furniture in California are responsible for providing a product tag that is at minimum a 2 x 3 inches, and includes in part the percentage of filling materials, its type, if its new or used materials, and must contain two all capitalized statements: (1) "… materials in this article are described in accordance with law," (2) "this product meets the requirements of Bureau of Electronic and Appliance Repair, Home Furnishing and Thermal Insulation Technical Bulletin 117." Based on the labeling requirements it is clear there are no design intentions consistent with a product warning label. As a consequence, no information is provided to the consumer regarding the specific risks concerning upholstered furniture flammability. To better achieve an informed consumer of the risks associated with upholstered furniture use, I recommend BEARHFTI require a labeling system.

Consistent with Bettman *et al.* (1986) approach, a labeling system should at minimum require a product warning label and a product insert. Product warning labels have two primary objectives: (1) inform consumer of risks associated with use of the product, and (2) indicate safe and unsafe uses of the product (Bettman *et al.*, 1986). Both objectives should be conveyed in a salient manner while keeping statements brief. According to Bettman *et al.* (1986), a symbolic visual display is optimal to convey the type and level of risk. This is followed by a hierarchical organization of product use information delineated by its risks, and behaviors or uses of the product that avoids those risks. This format ensures both risk and product use information are presented in one place (Bettman *et al.*, 1986). Package inserts then allow for more detailed information about the risks associated with the product. Since size of the package insert is not an issue, there is an opportunity to also provide details of the Technical Bulletin 117-2013 requirement for upholstered furniture sold in California. Point of purchase displays are not recommended, because the main purpose is to provide comparative information about product risks (Bettman *et al.*, 1986). The sizeable variance in upholstered furniture characteristics, and their corresponding risk to ignition from an open flame makes comparing risks across upholstered furniture untenable. Consequently, any labeling system will be unable to convey different smoldering, or open flame ignition risks across upholstered furniture types; a major limiting factor to the informed consumer approach. Instead any product labeling system will only be able to convey the same general risk of flammability for all upholstered furniture.

To demonstrate the above principles of effective product label design based upon Bettman *et al.* (1986) work, an example of upholstered furniture warning label for illustrative purposes is offered in Figure 2 below. The warning label uses color, font size, and a universal recognized symbol to alert the consumer upholstered furniture is highly flammable. This is followed by a hierarchical organization of potential hazards, and a clear link to the possible behaviors or uses that cause upholstered furniture ignition. Potential hazards are separated by a yellow and red color scheme to denote different ignition risks. The reasoning is upholstered furniture currently has no minimum performance standards for ignition by an open flame. To increase salience of statements on unsafe behaviors and their hazard sources, I use bold letters, capital letters, and color. Given the role of children in upholstered furniture fires, (see Ahrens, 2017) hazards emanating from children are further emphasized with a red color scheme. This labeling system described and illustrated, is but one example for increasing processability and use of information, while minimizing human processing errors.

Figure 2. A Potential Upholstered Furniture Product Warning Label

Upholstered Furniture

WARNING

Potential Hazards	How to Avoid Hazards
CAUTION **Cigarettes** **Hot Embers** **Smoldering Objects**	**NEVER** smoke on furniture Keep cigarettes and smoldering objects away from furniture Keep cigarettes and hot embers away from discarded material Keep **cigarettes** OUT OF REACH OF CHILDREN
DANGER **Matches** **Lighters** **Candles** **Open flame**	**NEVER** expose furniture directly to an open flame **NEVER** leave burning candles unattended Keep lit candles, matches, lighters, or an open flame away from furniture Keep **matches, lighters, and candles** OUT OF REACH OF CHILDREN

Concluding Remarks

As consumer products continue to expand and evolve in the market place, there will always be a need to balance consumer protection from product risk against the costs to society from imposing regulation. This thesis addressed the question of whether the proposed fire barrier regulation in California achieves an efficient level of consumer protection. By employing BCA, I offer considerable evidence that the cost to upholstered furniture manufacturers will far outweigh the estimated benefits to California consumers. These findings support competing policy alternatives that address the likely *asymmetric* and *imperfect* information in the upholstered furniture market. Given the lack of consumer information requirements under the Bureau of Home Furnishings Article 2 C.C.R. § 1126 (2014), I recommended BEARHFTI adopt a product labeling law. My recommendation includes both product warning labels and package label inserts for all upholstered furniture sold for residential use in California. The advantage of the informed consumer approach is twofold: product warning labels are a cost effective means of increasing consumer knowledge about the risk (Marette *et al.*, 2000), and product warning labels avoid the substantial costs of market interference. Should interest in upholstered furniture regulation continue, my BCA findings suggest examination of upholstered furniture regulation at the federal level is warranted.

Appendix A: Alternative Fire Loss Baseline Calculations

Summary of Alternative Fire Losses and Calculations used in Sensitivity Analyses				
Data Input	Average Frequency	Average Value	Worst Case Scenario Frequency	Valuations for Worst Case Scenario
Value of a Statistical Life		$4,373,404		$4,373,404
Value of a Statistical Injury		$266,778		$266,778
Upholstered Furniture Fire Civilian Deaths	2	$8,746,808	5	$21,867,020
Upholstered Furniture Fire Civilian Injuries	8	$2,134,224	14	$3,734,892
Upholstered Furniture Fire Property Loss		$4,042,576		$5,682,574
Upholstered Furniture Fire Content Loss		$1,259,085		$2,543,939
Risk Reduction Probability		0.19		
Note. All valuations reported are in constant 2017 dollars				

Appendix B: Cost Data Calculations used in Sensitivity Analysis

Summary of Baseline Cost Data and Calculations used in the Sensitivity Analyses		
Data Input	Average Frequency	Average Value
Fire Barrier (LY) Cost		$4.92
Fire Barrier (LY) Cost less Polyester Batting		$4.27
Number Seating Cushions per Chair	1	$4.27
LY other Chair parts	2	$9.84
Number Seating Cushions per Sofa	2	$8.54
LY other Sofa parts	4	$19.68
Chair Material Costs		$14.11
Sofa Material Costs		$28.22
Labor Cost per Chair	15min	$4.04
Labor Cost per Sofa	30min	$8.07
Testing Cost per Chair or Sofa		$0.01
Compliance Cost per Chair or Sofa		$0.13
Inventory Financing Cost per chair		$1.28
Inventory Financing Cost per Sofa		$2.55
Total Manufacturing Cost per Chair		$19.57
Total Manufacturing Cost per Sofa		$38.98
Chairs per Household	2	
Sofas per Household	1	
Upholstered Furniture Cost per Household		$78.12
State Enforcement Estimated Costs		$48,150
California Households	12,668,235	

Note. Note. All valuations reported are in constant 2017 dollars. Labor assumes $16.14 hourly wage. Financing assumes 0.07 interest rate.

Appendix C: Qualitative Interview Questions

1. Overall, what is your immediate impressions of this Benefit-Cost Study regarding the proposed fire barrier regulation?
2. What would you say are the three most important factors in deciding whether a proposed fire barrier regulation is needed for upholstered furniture in California?
   A. 1st Factor:
   B. 2nd Factor:
   C. 3rd Factor:
3. Do you agree or disagree this Benefit-Cost Study considered all relevant <u>benefit</u> factors? Would you say strongly agree, agree, neither agree or disagree, disagree, or strongly disagree.
   A. Strongly Agree
   B. Agree
   C. Neither Agree or Disagree
   D. Disagree
   E. Strongly Disagree
4. If you indicated disagree or strongly disagree, please indicate one or more benefit factors this study failed to consider, or did not consider appropriately?
5. Do you agree or disagree this Benefit-Cost Study considered all relevant <u>cost</u> factors? Would you say strongly agree, agree, neither agree or disagree, disagree, or strongly disagree.
   A. Strongly Agree
   B. Agree
   C. Neither Agree or Disagree
   D. Disagree
   E. Strongly Disagree
6. If you indicated disagree or strongly disagree, please indicate one or more cost factors this study failed to consider, or did not consider appropriately?
7. Overall, do you agree or disagree this Benefit-Cost Study is an accurate method in determining if the benefits of the proposed fire barrier regulation exceed its costs? Would you say strongly agree, agree, neither agree or disagree, disagree, or strongly disagree.
   A. Strongly Agree
   B. Agree
   C. Neither Agree or Disagree
   D. Disagree
   E. Strongly Disagree
8. Did this Benefit-Cost Study change your opinion of the proposed fire barrier regulation, or just reinforce what you already knew? (If change) What was the most convincing factor?
9. How likely or unlikely are you to use this Benefit-Cost Study as supporting evidence in a formal process to evaluate whether the proposed fire barrier regulation should be implemented? Would you say very likely, likely, neither likely or unlikely, unlikely, or very unlikely?
   A. Very Unlikely
   B. Likely
   C. Neither Likely nor Unlikely
   D. Unlikely
   E. Very Unlikely
10. Do you think BCA can be used as an effective tool in the political process that decides whether to regulate something in CA? If not, explain why.

Appendix D: Interview Consent Letter

INFORMED CONSENT: *Perceived Relevance of Benefit-Cost Analysis in the Upholstered Furniture Policy Making Process*

You are invited to participate in a research study which will involve telephonic interviews. My name is Nathan Fesler, and I am a graduate student at Sacramento State University, Department of Public Policy and Administration. The purpose of this qualitative research study is to investigate stakeholder opinion on the use of Benefit-Cost Analysis as the principle method for deciding whether to implement a proposed fire barrier regulatory standard for upholstered furniture. If you decide to participate, you will be asked to answer approximately 10 interview questions. The duration of the interview session is approximately 30 minutes.

Your participation in this project is voluntary. You have the right to not participate or to leave the study at any time. Please email Nathan Fesler at [redacted], or [redacted] if you choose to withdraw your participation. You can also contact Nathan Fesler by calling [redacted], and give verbal notification of your withdrawal from this study.

Personal information obtained from you for this study will remain confidential and will be disclosed only with your permission. Study results will only describe the participant's broad professional affiliations and aggregate opinions. Measures to insure your confidentiality are that written notes of interviews will be stored in a locked file cabinet. Signed consent forms will also be kept in a locked file cabinet. Additionally, the aggregated data notated into excel will be kept in a safe, locked locations for a period of three years after the study is completed.

If you have any questions about the research at any time, please contact Nathan Fesler at [redacted] or [redacted], or contact research advisor Dr. Robert Wassmer at [redacted] or rwassme@csus.edu. If you have any questions about your rights as a participant in a research project feel free to please call the Office of Research Affairs, California State University, Sacramento, (916) 278-5674, or email irb@csus.edu.

Your signature below indicates that you have read and understand the information provided above.

Signature　　　　　　　　　　　　　　　　　　　Date

Appendix E: BCA Research Brief

The State of California's Bureau of Electronic and Appliance Repair, Home Furnishing and Thermal Insulation (BEARHFTI) is the only regulatory agency that has imposed smoldering safety standards for upholstered furniture. This does not however, address upholstered furniture ignition from an open flame. In response to industry input, BEARHFTI is evaluating a fire barrier performance standard that requires a flame-resistant fire barrier to improve the resistance of upholstered furniture to an open flame. The desirability of mandating fire barriers in upholstered furniture for residential use depends upon whether the benefits from pursuing a regulatory requirement, exceeds the cost of imposing it.

An evidence based method for evaluating the benefits and costs of regulation is Benefit-Cost Analysis (see Federal Executive Order 12866). Benefit-Cost Analysis accounts for the likely future benefits of the adoption of a fire barrier performance standard to the residents of California, and the future likely costs to furniture manufactures of implementing it for home furniture sold in the state. Formerly stated, this analysis measures benefits as the annual incremental reduction in residential fire caused civilian deaths, injuries, and property loss from the imposition of a fire barrier performance standard. Notably civilian deaths and injuries are converted to monetary valuations using a value of a statistical life and injury. Whereas costs are measured as the incremental increase in testing, compliance, financing, manufacturing costs, and state enforcement costs from implementation of the standard. Once benefits and costs are calculated annually, Benefit Cost-Analysis then discounts these future benefits over a defined time horizon, and subtracts that from the discounted future costs over that same period. If the net present value is greater than zero, Benefit-Cost Analysis indicates regulatory action produces an optimal level of consumer protection.

To objectively assess any Benefit-Cost results, it is necessary to present data used in this analysis. From 2010 through 2016, CALFIRE reports an average of zero civilian deaths, two civilian injuries, $874,427 in property, and $275,140 in content losses occurred from upholstered furniture igniting by an open flame. The total estimated cost to the manufacture for an upholstered chair is $19.57, and $38.98 for a sofa. Annual estimated state enforcement costs are $48,150. From these benefit and cost inputs, the net present value over a 16 year time horizon is -$836,539,890; suggesting the costs will far outweigh the benefits of fire barrier performance standard. Recognizing there is a level of uncertainty in the model assumptions and data used, a sensitivity analysis is provided. The sensitivity analysis uses an alternative fire loss baseline, where the maximum or worst case value is used across all four fire loss categories, and then increased by 100%. Accordingly, this alternative fire loss baseline assumes 10 civilian deaths, 28 civilian injuries, 11,365,148 in property, and 5,087,878 in content losses occur annually. If the time horizon increases to 32 years, the net present value is -$310,993,795. Even when the total cost of upholstered furniture is further decreased by 50%, the net present value over a 32 year time horizon remains -$99,974,868. In order to achieve net present value of zero under these conditions would require the total combined cost of upholstered furniture to fall to $20.55. These results offer the distinct conclusion that the combination of benefits and cost circumstances required to obtain net present values greater than zero is unlikely.

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