A COST-BENEFIT ANALYSIS OF CONSUMER PROTECTION THROUGH UPHOLSTERED FURNITURE FIRE BARRIERS*

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Abstract

This paper describes a cost-benefit analysis that finds the net present value of the cost of a cloth fire-barrier standard for upholstered furniture sold in California is greater than the benefits of reduced fire related deaths, injuries, and property damage. It also offers the history of why California has considered such a barrier, the difficulties in getting the data needed to account for the benefits from the fire barrier and the uncertainty in the finding that this generates, and the solution of offering an alterable sensitivity analyses that rule out a different conclusion when using a range of realistic variable values.

(JEL Code D61: Allocative Efficiency Cost-Benefit Analysis)

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I. Introduction

California committed its Bureau of Electronic and Appliance Repair, Home Furnishings and Thermal Insulation (BEARHFTI, 2015) to an evaluation of a flammability standard for residential upholstered furniture in 2014. An important part of this evaluation is a cost-benefit analysis (CBA) of the adoption of a performance standard for residential upholstered furniture that would require a cloth barrier (not chemically treated with flame retardant) to improve the resistance of upholstered furniture to ignition from an open flame. Such a CBA accounts for both the costs to upholstered furniture manufactures of implementing it for home furniture sold in California, and the benefits of the adoption in the form of reduced loss of life, personal injury, and property damage that accrue to the State's residents. This paper draws from this specific analysis to describe in general the use of CBA to evaluate a proposed consumer protection regulation pertinent to the fire barrier performance standard. In the remainder of this introduction we offer further background on the concerns that led California to consider such a fire barrier. Section II of the paper frames this work in the previous academic literature related to the use of CBA in assessing the desirability of a regulation geared to reduce the incidence of fires. Section III continues with a description of the methodology behind the cost-benefit analysis. While the fourth section offers descriptions of the data used to complete the benefit-cost analysis and its results. We conclude with a description of how robust our conclusion is to changes in the values of variables necessary to yield it, and how we accomplished this through a spreadsheet simulation that others may want to adopt to ease the understanding and acceptance of a CBA finding.

Upholstered Furniture Regulation

In 1973 the National Commission on Fire Prevention and Control published *America Burning* that raised the consideration given to the costs of residential fires in the United States. Seventy percent of the nearly one million building fires that occurred nationwide in the early 1970s were residential. Called out was 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 building materials and standards regulated by codes – is best left to the consumer. But as the report points out, a resident is only able to fulfill this responsibility if aware of the combustion hazards of interior furnishings, and be willing and able to appropriately process this knowledge.[1] 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 that the newly formed federal Consumer Product Safety Commission (CPSC) develop regulatory standards to minimize the combustion propensity of interior furnishings. California adopted this suggested national regulatory standard in 1975 and became the first and only state to require flammability standards for residential upholstered furniture sold within its boundaries.

California adopted its restriction (Technical Bulletin 117) regarding a vertical open flame test from Federal Test Method Standard 191, Method 5903.2 (BEARHFTI, 2000). This required resilient filling materials (namely one-piece foam) used in home furniture to pass separate tests for cigarette smolder and a 12-second exposure to an open flame. In addition, shredded resilient filling materials needed a fabric encasement that passed both a three-second, and a 12-second open flame exposure. Absent federal CPSC action, and because a sizeable percentage of the

[1] Case in point, half of the deaths caused by residential fires in the United States from 1985 to 1994 were due to sleep or intoxication while smoking on upholstered furniture (USFA, 1997).

United States furniture sales occur in California, Technical Bulletin 117 became the *de facto* national standard for fire protection in upholstered furniture (CPSC, 2016).

California's Technical Bulletin 117 remained relatively unchanged until 2012, when Governor Brown asked BEARHFTI to review the bulletin considering growing concerns of the prevalent use of flame retardant (FR) chemicals in upholstered furniture (California Legislative Information, 2014). BEARHFTI (March and June 2013) 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) the predominant role of cigarettes as ignition sources.

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 international standard ASTM E1353-08a (BEARHFTI, 2013). The intent of this technical bulletin is a reduction in the smoldering ignition of upholstered furniture for residential use. However, industry input suggested that the absence of a standard to address the ignition from open flame sources underestimates this component of risk. California's Bureau of Electronic and Appliance Repair, Home Furnishings and Thermal Insulation recently set out to further evaluate whether the use of a cloth fire barrier improves open flame resistance in upholstered furniture; and if so, is it desirable to mandate their use.

Fire Barriers in Upholstered Furniture

It is economically desirable to mandate fire barriers in upholstered furniture for home if their cost is less than the benefit gained from imposing it. The benefit of a reduction in upholstered furniture fires through the inclusion of a fire barrier stems from the incremental reduction in losses (deaths, injuries, and property loss) attributed to upholstered furniture. A reduction in the number and/or severity of residential building fires occurs through the fire barrier stopping the ignition source from causing the residential building fire, and/or a piece of upholstered furniture being less likely to be a contributing cause for a residential fire not started directly by upholstered furniture (CPSC, 2016; and Lock, 2016)[2] The central question then becomes if the expected dollar value of these benefits exceeds the costs of achieving them?

Before offering the details of such a CBA, there are public policy factors to consider. First and foremost, is there a theoretical justification for government involvement in trying to prevent fires started and/or accelerated by upholstered furniture? A core tenant of the economic approach to deciding when it is appropriate for government to intervene in the market of a consumer buying a piece of furniture for residential use and a manufacture selling it, is whether the consumer possesses the data necessary to make an informed choice. If consumers do not know of differences in degree of flammability across furniture pieces, producers of less flammable furniture will be unable to sell it at the needed higher price to cover the additional costs to manufacture it. Such *imperfect* or *asymmetric information* opens a possible role for government intervention to overcome this *market failure*.

Solutions to consumer harm from lack of information can take the form of a government-imposed performance standard meant to ensure a minimum level of product safety. Though such standard results in the additional costs of greater material, labor, and shipping costs that are

[2]Our CBA analysis, consistent with Hall's (2015) approach, considers residential building fires as reducable by a proposed fire barrier performance standard when upholstered furniture is the primary contributing fuel source.

either passed forward to consumers in higher prices, and/or backward to producers in lower profits. In addition, taxpayers must fund the additional costs of government testing and enforcement. Furthermore, regulation at its worst can result in a form of *government failure* where the standard of regulation is set so high that the social costs of government intervention exceeds the social benefits of rectifying a market failure. Critics of government intervention designed to enhance product safety argue that a producer in an unregulated private market faces sufficient reputation and legal incentives to ensure adequate safety in their products, and industry associations also exist that require safety assurances from its members (Shleifer, 2005). A relevant example is the Upholstered Furniture Action Council's long-standing development and adoption of fire-related test standards.[3]

Objective public policy analysis does not align with the politically driven views of Liberals or Conservatives regarding the need for government intervention to correct it. Instead, it takes the perspective that if there is indeed a possible role for government to rectify a clearly denoted market failure, there must also be an objective justification of its social desirability before it occurs. Here we have identified the legitimate public policy problem as the imperfect and/or asymmetric information that exists regarding the risk of deaths, injuries, and property losses associated with inadequate information on open flame ignition resistance in upholstered furniture. And even if the consumer possesses this information, the inability of the typical consumer to process and act upon it appropriately. In the case public policy makers adopt the regulatory approach, a CBA is a method to determine the level of consumer protection that is social desirability for upholstered furniture.

The Role of Upholstered Furniture in Residential Building Fires

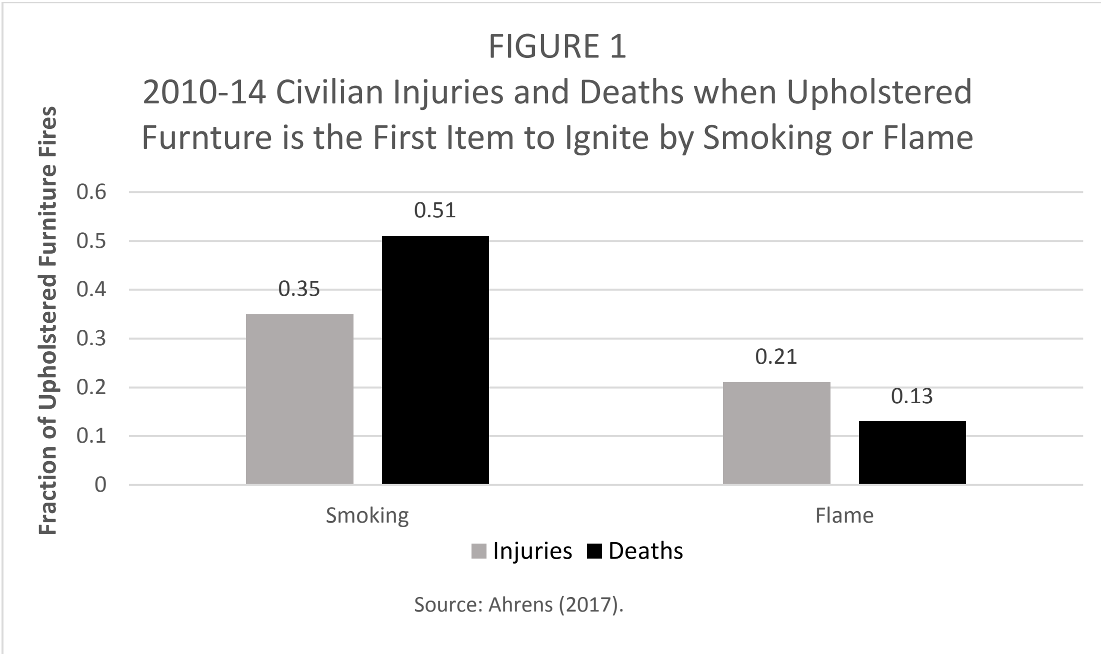
[3] See https://www.astm.org/BOOKSTORE/BOS/index.html .

The benefit side of this CBA requires the degree to which open flame ignition sources are the cause of residential building fires in California. Combining this with an inventory of the magnitude of the civilian deaths, injuries, and property losses due to residential building fires, allows an estimation of the previous social costs inflicted by residential building fires due to upholstered furniture. A reduction of these social costs represents the benefits that fire barrier performance standard offers.

Yearly data from the National Fire Incident Report System (NFIRS) offers one source of the needed information for the entire United States.[4] For the period of 2006 to 2015, using the NFIRS data, residential building fires throughout the United States accounted for an estimated annual average of 2,586 civilian deaths, 12,800 civilian injuries, and about 7.5 billion dollars (adjusted to 2015 dollars) in property losses annually (United States Fire Administration, May and July 2017). A more focused examination of national data sets from NFIRS and the National Fire Protection Association's (NFPA) fire department experience survey offers a further understanding of the underlying contribution of smoking and open flame ignition of furniture to fire in residential buildings occurs. Data from the 2010 to 2014 combined data sets of NFIRS and the NFPA fire department experience survey, shows upholstered furniture as the first item to ignite in residential building fires. As a result, upholstered furniture caused an average of 440 civilian deaths, 700 civilian injuries, and 269 million dollars (in 2015 dollars) in national property losses annually (Ahrens, 2017). Smoking ignition sources – defined as cigarettes and lighted tobacco products – are 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

[4] NFIRS is a database of United States fire departments reporting on a standardized range of fire related statistics. See https://www.nfirs.fema.gov .

first item to ignite.[5] Figure 1 shows the fraction of civilian deaths and injuries by ignition source when upholstered furniture is the first item to ignite.



In terms of civilian deaths caused from upholstered furniture as the first item to ignite in a residential building fire, smoking ignition sources accounted for an estimated average of 51 percent of the civilian deaths, and open flame ignition accounts for an estimated average of 13 percent of the civilian deaths. 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[6]. These estimates from the NFPA contrast with the limited estimates provided by the USFA on upholstered furniture as the first item to ignite in a residential building fire. Of all smoking ignitions, cigarettes caused about 86 percent of the residential building fires reported to NFIRS between 2008 and 2010 (United States Fire

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

Administration, June 2012). The initial item to ignite 13 percent of the time was upholstered chairs and sofas (United States Fire Administration, February 2012). Unfortunately, the USFA (2016) in its most recent offering of fire statistics does not include further upholstered furniture analysis.

NFRIS and NFPA's fire department experience survey data yield several conclusions relevant to the CBA offered here. The first being the overall importance of smoking ignition as a cause of civilian deaths in residential building fires, and civilian deaths attributed to a residential building fire when upholstered furniture is the first item to ignite. Second is the persistence in smoking ignition sources as a predominate cause of upholstered furniture fires. Third is the role of open flame ignition in causing civilian injuries from residential building fires involving upholstered furniture. While never the leading cause, it is sufficiently large to warrant inclusion in this CBA of upholstered furniture barrier regulation. Lastly, total property losses from residential building fires attributable to upholstered furniture as the first item to ignite, accounts for a much smaller subset of the total national property losses in residential building fires overall. However, if upholstered furniture as a principle contributor to flame spread in a residential building fire supplements the first item ignited, the estimates of average civilian deaths, injuries, and property losses respectively increase to 610 deaths, 1,120 injuries, and 615 million in inflated-adjusted 2015 dollars (National Fire Protection Association, 2013). Taking a more expansive view of property losses, civilian deaths, and injuries attributed to upholstered furniture as a contributing factor to a residential building fire is important, considering upholstered furniture total heat release potential and time to flashover (Lock, 2016). Given the California specific framework for this CBA, we use the most recent California data from the NFIRS and/or other sources. Regarding the NFIRS, this is possible because the office of the California State Fire Marshall currently reports to it.[7]

II. Literature Review

The use of cost-benefit analysis (CBA) to evaluate the efficiency of a regulatory fire safety standard for upholstery furniture is well established (Dardis, 1980a and 1980b; CPSC, 2008; Jaldell, 2013; McNamee & Anderson, 2015). The following review offers a concise understanding of the information and methodology needed to conduct a CBA on this topic.

Differentiation of Product

Jadell (2013) evaluated the required installation of ceiling fire sprinklers as a means of reducing fire related deaths, injuries, and property losses in buildings that house the elderly. He notes that the available information on apartments offered little evidence of structural differences in materials that suggests differences in flammability. In contrast, the Consumer Protection Safety Commission (2008) examines the establishment of an open flame fire performance standard in upholstered furniture as a means of reducing residential fire related deaths, injuries, and property losses. An important allowance in this study is differences in flammability characteristics across types of upholstered furniture. As Nazare and Davis (2012) note, such a categorization is important because the material used in a fabric cover determines its ignition characteristics. CPSC (2008) determines the total estimated benefits to society from an open flame ignition standard for severely ignition prone cellulosic material to range between $9 and $11 million. Alternatively, the same standard applied to upholstered furniture using thermoplastic cover materials results in zero benefits to society. The CBA application of the different cover fabric flammability characteristics used by CPSC, however, required their own funded surveys and

[7] See http://osfm.fire.ca.gov/cairs/pdf/cfirsresponseltr.pdf.

further information from the Upholstered Furniture Action Council. 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. This CBA, like Jadell (2013), assumes homogenous upholstered furniture flammability characteristics; however, compensates for this by using a wide range of possible values in a sensitivity analysis.

Fire Barriers and Risk Reduction

Fire barriers provide flame resistance in upholstered furniture by delaying flame propagation and limiting thermal penetration to the underlying resilient filling materials. A fire barrier is typically an individual fabric component, or a fabric composite that takes on the form of individual or laminated layers (Nazare & Davis, 2012). For this study, we only consider flame resistance. This is an important distinction given that fire barriers that resist cigarette ignition do not necessarily resist open flame ignition, and vice versa (Babrauskas & Krasny, 1985). Nazare *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. They subject all of this to an open flame for 20 seconds. Most nonwoven high-loft fire barriers demonstrated lower heat transfers during the test period of 90 seconds 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.

Alternatively, the Consumer Protection Safety Commission (2005) evaluated the efficacy of fire barriers using a measure of mass loss of the standard polyurethane foam and 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. The finding being less than five percent mass loss of the foam in a highly dense (18.3oz/yd^2) ceramic woven fire barrier paired with 100 percent cotton velvet cover fabric. 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 flame resistance (CPSC, 2005 and 2012; Damant, 1995; and Nazare & Davis, 2012).

Dardis (1980a) offers a CBA on the desirability of home smoke detector use and chose a risk reduction probability of 0.45 for deaths in a home equipped appropriately with smoke detector. In simple terms, 0.45 indicates that the appropriate use of smoke detectors reduces the number of deaths by fire in a home by 45 percent. While 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 calculates that 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. He notes similar impacts to reduced deaths in United States fire statistics calculated from 2003 through 2007. McNamee and Anderson (2015) also use incidence data to estimate the risk reduction probability from flame retardant use in television fires. However, CPSC (2008) notes their findings may be circumspect given that incidence data does not exist for upholstered furniture given no standard exists that requires upholstered furniture to comply with a fire barrier performance standard. CPSC instead made reasonable judgements when estimating risk reduction probabilities of 0.51 for severely ignition prone cellulosic cover-fabric material, 0.25

for moderately ignition prone cellulosic material, and zero for all other categories. If we assume that all upholstered furniture exhibits an average risk reduction probability based on the above distribution, an average risk reduction probability of around 0.19 is reasonable for all upholstered furniture.

Product Life Cycle

The costs of implementing a fire barrier standard for upholstered furniture largely occur in the manufacturing of the furniture. The benefits of a fire barrier only accrue after the furniture with fire barriers goes to new homes or replaces existing furniture not subject to the standard. As an example, McNamee and Anderson (2015) use the simplified assumption of a product life cycle of 10 years for furniture in which it takes 10 years for all furniture in use to exhibit the desired fire resistance. Alternatively, CPSC (2008) utilizes a product population model to calculate the likelihood the upholstered furniture item would remain in use in years after purchase. Unfortunately, CPSC reported no information on the detailed methodology underlying the derivation of their model. What CPSC does report is that the average life cycle of upholstered furniture is 16 years.

Value of a Statistical Life and Statistical Injury

A CBA does not put a value on a specific human life. Instead it assigns a value to a *statistical life* or *statistical injury* based on what people are willing to pay to reduce their chance of death or injury. Central to this CBA is the dollar value that individuals place on reducing mortality and injury risk from upholstered furniture fires. The two concepts widely used are *willingness to pay* (WTP) and *willingness to accept* (WTA). WTP is the maximum an individual is willing to pay for reducing fire related risks of death or injury. Whereas, WTA is the minimum amount of compensation an individual is willing to accept to bear fire related risks of death or injury

(Fuguitt & Wilcox, 1999). The purchase of injury reducing devices (smoke alarms and air bags) yields values of WTP. Values of WTA can come from increased compensation in a labor market for increased chance of injury. These methods then yield needed dollar value in benefit of a life saved and/or injury prevented. But as noted by Viscuis (1993), dependent upon the valuation concept and the characteristics of the population sampled, valuations of a statistical life and injury differ significantly. Furthermore, *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. It is contingent because of no requirement that the respondent puts any money toward her stated answer. 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 WTP a specific amount (Fuguitt & Wilcox, 1999).

The three methods of using WTP, WTA, or contingent valuation to derive a value for a statistical life yield a range of values from around one to nine million dollars, with an average of just under $4 million across many studies (CPSC 2008). This, however, differs from what suggested/required in 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 (United States Department of Transportation, 2016). In contrast, the Department of Transportation (2016) states the value of statistical life to use for a transportation-based CBA as $9.6 million in 2016. While the United States Environmental Protection Agency notes their default guidance for the value of a statistical life as $7.4 million.[8] Understanding these

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

differences between academically calculated and politically mandated values for a statistical life, we take a sensitivity approach that accounts for the range of possible values.

Previous research has shown the value of a statistical injury for an individual is highly correlated with the value she places on her statistical life (Viscusi & Aldy, 2003). The cost of a statistical injury reflects the value and individual lost from lower quality of life, pain and suffering, and reduced income potential after the injury. The United States Department of Transportation (2011) suggests the method of interpolation based on the value of a statistical life. The basis for interpolation using fixed proportional factors is the Abbreviated Injury Scale (AIS). 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.

We find that there are only a limited number of previous studies devoted to estimating the value of a statistical injury from fire risks, and even fewer are applicable to injuries consistent with residential building fires. Using contingent valuation, Viscusi and Magat (1987) report an average respondent's WTP to avoid a hand burn at about $1 million. Conversely, the damage cost approach employed by Consumer Product Safety commission 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 burn is then $1.48 million. Such a range, from $150 thousand to $1.5 million varies by a magnitude of ten. We note this but conclude that for this CBA, the AIS method allows for a better accounting of a broad range of fire related non-fatal injuries which we can best match with available incidence data specific to California.

<u>Discount Rate</u>

Inherent in any CBA is the requirement to discount future benefits and costs to obtain comparable values in present day terms (Burgess & Zerbe, 2011). A dollar today has a greater value to an individual than the same dollar received in the future. Thus, any future monetary value, be it a benefit or a cost, needs discounting to its present values to comparably aggregate dollar values over a time horizon. CPSC (2008) and McNamee and Anderson (2015) respectively determine the sensitivity of their findings to a range of three and seven percent discount rates, and three and 10 percent discount rates. Dardis (1980b) only considered a discount rate of 10 percent, whereas Jaldell (2013) restricted his analysis to only a three and four percent discount rate.

The guideline set forth by the United States Office of Management and Budget suggests a single discount rate of seven percent for CBA. The Environmental Protection Agency (2010) 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 the range of discount rates for the upper bound is between six and ten percent, with a consensus of seven percent; and second, the range of discount rates for the lower bound is between 2.6 and three percent, with a more consistent use of three percent.

III. Methodology

The challenge to operationalizing this CBA is bridging the preferred methodology to existing data sources that inherently limit the scope of some methods. We next describe the methods to do this by issues relevant to the benefit, and the cost side of the analysis.

Benefit Considerations

Consider the subset of residential building 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 (2017) data specific to California in years 2010 through 2016. We restrict the area of fire origin 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 (United States Fire Administration, 2015). 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. For (a) we use the category of upholstered furniture as the first item to ignite. This first item choice is different from non-upholstered chair, bench, wooden furniture, appliance housing, and other furniture categories. We 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. Of the cases identified as upholstered furniture as the first item to ignite, we then classify cases resulting from open flame ignition. Noteworthy is that the inclusion of other open flame heat sources has no impact on our calculation of civilian deaths or injuries.

Fire scenario (b) carries over the same methodology with three exceptions. First, is the need to identify which residential building fires exhibited significant flame or fire spread. Adopting Hall's (2015) method, we use fire spread categories listed as confined to room, floor, building, and beyond building of origin. Second, we classify these residential building fire cases by upholstered furniture items contributing most to flame or fire spread. To avoid double counting, we 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. We 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 (Lock, 2016). The third exception is the use of ignition sources. Given that upholstered furniture may not be the first item to ignite, we 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. We 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, we then derive monetary valuations that represent the total societal costs from residential upholstered furniture fires. The most straightforward valuation is property loss in nominal 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 to be 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, we 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. We then multiply this range of values for a statistical life by the expected number of civilian deaths saved after a proposed fire barrier standard in place.

To estimate the monetary value for civilian injuries, we accept the United States 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. 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 (United States Department of Transportation, 2009). For this CBA, we 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, we use the NFIRS 2013-2015 report on civilian fire injuries in residential buildings as a proxy for upholstered furniture fires in California.[9]

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.[10] Based on this, we assign smoke inhalation injuries an AIS score of two. We 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[11]. We assume, furthermore, that breathing difficulty is a subset of smoke inhalation, and associated with significant direct damage to the respiratory tract. This form of injury can

[9]USFA (May 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 is 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. To make reasonable judgements about assigning fire injuries to an AIS score, we combine AIS trauma scores for listed injuries, NFIRS body part data, burn body surface area percentages, and basic medical knowledge.

[10] See https://www.webmd.com/lung/smoke_inhalation_treatment_firstaid.htm#1 .

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

require immediate intubation and predispose individuals to complications.[12] This subset condition of smoke inhalation receives an AIS Score of a 3, which reflects an assumed more serious nature of this condition. Thermal burns AIS scores are heavily dependent on the percent of body 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 2; second and third degree burns between 20-30 percent BSA receive an AIS score of 3; and second and third degree burns between 30-50 percent BSA receive an AIS score of 4.[13]

To relate the reported body parts affected to BSAs, we use the medical rule of nines – the percent BSA assigned to burns of major extremity parts for anterior and posterior orientations.[14] To simplify the possibilities, we assume both anterior and posterior orientations to a body extremity affected. We 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, we allocate a corresponding BSA of 36 percent and 18 percent. For all other body parts, the BSAs range from 9-18 percent. We understand the non-attribution of body parts reported in the NFIRS data to any one injury.

We use the preceding information to develop a weighted factor and the corresponding value of a statistical injury for each fire related injury. We believe that these factors alone cannot account for the frequency of sustaining these specific injuries, which impacts consumer valuations of avoiding/preventing an injury. Accordingly, we then weigh each of these factors by the injury occurrence.

<u>Cost Considerations</u>

[12] See https://www.webmd.com/lung/smoke_inhalation_treatment_firstaid.htm#4 .
[13] See http://www.traumascores.com/index.php/scores2/16-allgemein/105-104 .
[14] See https://www.emedicinehealth.com/burn_percentage_in_adults_rule_of_nines/article_em.htm .

Cost of a cloth barrier in upholstered furniture involve the incremental increase in state enforcement, testing, compliance, financing, fire barrier material, and labor costs. We next present the physical dimensions used in our upholstered furniture scenario and follow that with the cost methodology for each cost component.

Upholstered furniture dimensions. For chairs and sofas, a fire barrier is located between the cover fabric and the resilient filling material. A reasonable assumption is the fire barrier encompasses an upholstered furniture's seats, back, and sides. We adopt the CPSC (2008) estimates that the total length of fire barrier material needed is three (six) linear yards for an upholstered sofa (chair).

Fire barrier material and labor costs. BEARHFTI provided us with a list of 19 non-chemically treated fire barriers available in the commercial market, and there lower and upper cost estimates. We use the midpoint value between the average of the lower and upper bound estimates as the expected material cost of a fire barrier per linear yard. 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. Accordingly, we 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.

There is an expected increase in labor time to incorporate the fire barrier material in the upholstered furniture manufacturing process. We 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.[15] Additionally, we assume an upholstered

[15] The California Employment Development Department estimates furniture finisher's statewide average hourly wages at $16.14 for the first quarter of 2017 (http://www.labormarketinfo.edd.ca.gov/cgi/dataanalysis/areaselection.asp?tablename=oeswage).

sofa will require more time to install the fire barrier. Interviews conducted with multiple representatives of furniture manufactures confirm that on average an upholstered chair (sofa) will require an additional 15 (30) minutes of time to install the fire barrier in an additional fire barrier.[16]

Testing and compliance costs. Currently, upholstered furniture manufacturers must test and keep compliance records for upholstered furniture meeting the TB 117-2013 smoldering ignition standard. Under the proposed open flame fire barrier standard, upholstered furniture manufacturers would need to perform an additional test and keep separate compliance records. To account for the current cost of these additional tests, we inflation adjust the CPSC (2008) estimates to 2017 dollars and assume these estimates are constant across furniture types.

Financing costs. CPSC (2008) assumes that sellers of furniture use inventory financing as a form of asset-based lending that allows 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, we incorporate this cost input into the CBA model. We calculate financing costs as the interest rate multiplied by the total incremental increase in cost to upholstered furniture. We use the average between the CPSC (2008) estimate of 10 percent, and our interview estimates of 3.5 and 7.0 percent.

State enforcement costs. A task designated to BEARHFTI is the testing of upholstered furniture to ensure regulatory compliance.[17] For budget years 2016-2018, BEARHFIT reports that the program expenditure for Home Furnishings and Thermal Insulation at about $4.8 million (BEARHFIT, 2017). Without further information on testing and related enforcement expenses,

[16] We 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.

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

we assume the incremental increase in state enforcement costs fall within the range of an additional 0.5 to 1.5 percent.

<u>CBA Specification</u>

Once we calculate the benefit and costs as described above, CBA requires the aggregation of them to a net-present value (NPV) in period zero that equals the discounted stream of benefits, less the discounted stream of costs. Before this can occur, we must decide whether to conduct the analysis in nominal or real (inflation adjusted) dollars. Since we have no reliable way of predicting the future inflation rate, we present the CBA in constant 2017 dollars using the national CPI index.[18] A second consideration is the timing of benefits and costs. The first incursion of a cost determines the starting date (period zero) of a CBA. 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. Accordingly, we expect that manufactures intending to sell upholstered furniture for residential use in California will quickly comply to develop a supply of furniture that meets the regulatory standard at the end of the grace period. Alternatively, we assume that most consumers are more likely to acquire furniture with fire barriers at the end of the grace period. Consequently, we assume the initial compliance costs occur in period zero (starting year 2017), followed by the initial benefits incurred in period one (the first year that consumer purchase upholstered furniture with required liner).

A third consideration for a CBA 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, these have

[18] If using inflation-adjusted values throughout the CBA, it is then appropriate to use an inflation-adjusted (real) discount rate. This takes the inflation component out of an equivalent interest rate and suggests a lower discount rate.

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 that the future reflect a past trend line – an assumption that is often tenuous. Instead, we chose the more conservative approach and project constant benefit and cost values over the CBA's time horizon.

Finally, a CBA 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 if the fire barrier regulation adopted. Costs of the fire barrier regulation relate to upholstered furniture, so we need an assumption regarding the number of upholstered sofas and chairs in a typical California household. We start with a baseline where the typical California household contains two upholstered chairs and one upholstered sofa (we later alter this in a sensitivity analysis). One sixteenth of the total number of households in California will be buying a new sofa and two chairs for 16 years (assuming a product life cycle of 16 years) until all CA households have furniture that meets the new fire protection standard for upholstered furniture.[19] Thus the need to only sum yearly NPVs over 16 years.

A formula representation of the NPV for this CBA is:

$$\text{NPV} = \sum_{t=0}^{T=16} \frac{\left[\left(\frac{t}{16} * N\right) * B_t\right]}{(1+d)^t} - \sum_{t=0}^{T=16} \frac{(C_t)}{(1+d)^t}, \qquad (1)$$

where;

B_t is the real (inflation adjusted) dollar benefit to a typical CA household in the form of reduced chance of death, injury, and property damage due to adoption of fire barrier standard for upholstered furniture in period "t",

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

C_t is the real (inflation adjusted) dollar 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 1/16 of all California households (assuming a product life cycle of 16 years) in period "t";

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

d is the real (inflation adjusted) discount rate,

t is the period that runs from 0 to 16 (assuming a product life cycle of 16 years).

Based on the distribution of CPSC (2008) reported open flame ignition risk reduction probabilities, we initially assume that the average risk reduction probability achieved by a fire barrier is 0.19. In other words, we expect upholstered furniture with a fire barrier to be 19 percent less likely to ignite from open flame sources, and of the 19 percent of furniture that does not ignite, we assume that no injuries, deaths, or property loss occurs. Accordingly, the percent of households who replace existing furniture not subject to the fire barrier standard is determined by the inverse of the product life cycle. This method, outlined in McNamee and Anderson (2015), assumes households will turnover existing upholstered furniture at the rate equal to the inverse of the product's life cycle. If upholstered furniture chairs and sofas exhibit a product life cycle of 16 years, in any given year one sixteenth (6.25 percent) of all California households will replace their existing upholstered furniture with new upholstered furniture.

IV. Data Used and Results of the CBA

Central to this CBA is the magnitude of civilian deaths and injuries resulting from upholstered furniture fires. The CAL FIRE Incident Reporting System data set, from 2010 through 2016, provides a large sample of 23,506 residential building fires (National Fire Incidence Reporting System, 2017). By year, Table 1 provides the total annual fire losses for civilian deaths, injuries, property and content losses. Contrary to what observed in the national level data for upholstered furniture fires (NFPA, 2013; and Ahrens, 2017), reported fire losses for California appear substantially lower. Since upholstered furniture caused fire losses are the driver of benefits derived from a barrier regulation, the potential magnitude of them calculated from the California specific data are relatively small. Tables 2 and 3 offers the data that serves as the basis for our baseline CBA. At the bottom of Table 2 we list the range of expected benefits, in present value terms, from the fire barrier regulation. At the bottom of Table 3 we list the range of expected benefits, in present value terms, from the fire barrier regulation. Subtracting the present value of costs from the present value of benefits yields the net present value.

In the first row of Table 4 we offer the range of net present value outcomes calculated from the baseline CBA using average value. In the rows that follow, we 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 exceeds the costs (greater than zero). The range of net present benefits for all outcomes presented is \$1,721,712 – \$2,534,975 million dollars over the 16-year time horizon used. These relatively low values are due to minimal loss of life, injuries, and property damage recorded in Table 1. Furthermore, the range of net present costs for all outcomes presented resulted in \$620,693,130 – \$871,921,994 million dollars over the same 16-year time horizon. For all values used in Table 7, the benefits of a proposed fire barrier performance standard for upholstered furniture failed to exceed the costs. We next offer the results of a sensitivity analysis that indicate the degree of change necessary in these variables to yield a CBA that would yield a positive NPV and hence support the fire barrier performance standard for upholstered furniture in California.

TABLE 1 **Combined Upholstered Furniture Fire Scenarios for Residential Buildings in California**					
Year	Incident Count	Property Loss[1]	Content Loss[1]	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**
[1]All values are in constant 2017 dollars.					

TABLE 2 **Summary of Benefit Data and Calculations used in CBA**					
Data Input	Average Whole # Frequency	Average Dollar Value[1]	Lower Bound Dollar Estimate	Upper Bound Dollar Estimate	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); United States 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	
Benefit of Upholstered Furniture Regulation to CA		**$319,793**	**$294,249**	**$353,831**	
[1] All dollar values are in constant (inflation adjusted) 2017 dollars. [2] All residential building fires involving upholstered furniture as the first item to ignite, and as a contributing source. This excludes the category of "other furniture."					

TABLE 3 **Summary of Cost Data and Calculations used in CBA**					
Data Input	Average Frequency	Average Dollar Value[1]	Lower Bound Dollar Estimate	Upper Bound Dollar Estimate	Source(s)
Fire Barrier Linear Yard (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[2]	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[3]		$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**	

[1] All dollar values are in constant 2017 dollars.
[2] Assumes $16.14 hourly wage.
[3] Assumes a 0.07 interest rate.

TABLE 4 **Summary of Net Present Value Outcomes over a 16-year Time Horizon**					
Outcome	Values Used	PV Benefits (in 2017$)	PV Costs (in 2017$)	NPV (in 2017$)	Decision Criteria: NPV > 0
1[a]	Average Values in Tables 2 & 3	$2,291,118	$838,831,008	- $836,539,890	No
2[a]	Lower Bound Values in Tables 2 & 3	$2,108,109	$805,740,021	- $803,631,912	No
3[a]	Upper Bound Values in Tables 2 & 3	$2,534,975	$871,921,994	- $869,387,020	No
4[b]	Average Values in Tables 2 & 3	$1,871,177	$646,184,415	- $644,313,238	No
5[b]	Lower Bound Values in Tables 2 & 3	$1,721,712	$620,693,130	- $618,971,419	No
6[b]	Upper Bound Values in Tables 2 & 3	$2,070,337	$671,675,699	- $669,605,362	No
[a] Calculation based on a 3% discount rate [b] Calculation based on a 7% discount rate					

V. Robustness of CBA to Assumptions and a Tool for Demonstrating it to Stakeholders

An objective CBA of the efficiency of a regulation investigates the impacts of uncertainty, potential bias in the data, and assumptions used. In terms of our analysis, the most practical method to assess the impacts of uncertainty, and the timing of benefits/costs, is the use of sensitivity analysis. A sensitivity analysis for CBA changes the value of one or more variables used 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 CBA model result is robust for a realistic degree of uncertainty.

<u>Changing the Number of Residential Fires Caused by Upholstered Furniture</u>

Fire statistics exhibit a fair degree of uncertainty due to unknown fire characteristics, measurement, and sampling error (USFA, August 2012; NFPA, 2013, McNamee & Anderson, 2015; NFPA; 2016). Lack of data also represents a sizeable portion of the uncertainty in fire statistics (Hall & Harwood, 1989; and Thomas & Butry, 2016). NPFA (2013) has also raised the issue of whether fire departments treat the category of other furniture, as either well-defined furniture items that do not fit the other listed categories, or as an unknown category. In the latter case, the relevant impact to the CBA is the potential underestimation of reported fire statistics. A statistical approach used to account for these data unknowns is to allocate proportionally fire characteristics of unknown fires across known fire cases (USFA, 2012b; and Thomas & Butry, 2016). This approach 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; and USFA, 2012b). Our baseline CBA adopted the 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, we treated other furniture at face value.

Under an alternative scenario, we 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. There are two reasons for this approach. The first 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 5, this approach significantly increases the upholstered furniture caused fire losses considered addressable by the fire standard. Table 6 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 to -$835,093,049 million dollars over the 16-year time horizon.

TABLE 5 **Combined Upholstered Furniture Fire Scenarios for Residential Buildings in California using Other Furniture Category**					
Year	Incident Count	Property Loss[1]	Content Loss[1]	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**
[1] All valuations reported are in constant 2017 dollars					

TABLE 6 **Summary of Net Present Value Outcomes of Alternative Fire Loss Baseline over a 16-year Time Horizon**					
Outcome	Values Used	PV Benefits (in 2017$)	PV Costs (in 2017$)	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
[a] Calculations used a 3% discount rate [b] Calculations used a 7% discount rate					

Changing the Civilian Death and Injury Occurrences

Two crucial factors that determine the overall benefits is the number of annual civilian deaths and injuries. Given the level of uncertainty in the fire data, we believe it reasonable to consider significant shocks to the number of civilian deaths and injuries to evaluate its relative impact on net present value outcomes. As important points of reference, holding all other variables constant, only at 132 to 140 residential home deaths, or 2,110 to 2,241 residential home injuries, does the CBA 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.

Changing the Risk Reduction Probability

Throughout this CBA we assumed an average risk reduction probability of 19 percent based on the ranges provided by the CPSC. Given that we based this value on CPSC's judgement, it is reasonable to assume a degree of uncertainty with the risk reduction probability. Accordingly, we 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 (CPCSC, 2008). The resulting net present value (NPV) outcomes for all sensitivity scenarios are negative with a range of -$444,288,569 to -$809,846,305. To obtain a net present value outcome would require the impossible probability value of greater than one.

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. Justification for the use of a high real (adjusted for inflation) discount rate comes from the belief that Californians are very present orientated and are willing to trade off a good occurrence in the future, for far less of the same good occurrence immediately. A review of the literature indicates some support for the use of a 10 percent real discount rate (Dardis, 1980b; and McNamee *et al*., 2015). With this high discount rate, 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.

Changing the Cost of Upholstered Furniture

When examining *ex post* the findings of CBA after a regulation put in place, it is often observed that 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 analysis performed her.   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. Likewise, it is also important to consider that regulatory agencies seeking to pass a standard may have the incentive to underestimate the actual cost of the regulation to consumers in higher prices and/or firms in lower profits.

From our perspective of independent analysts, it is not unreasonable to suggest that our initial range of cost estimates is subject to a degree of uncertainty. Consistent with our desire to generate as objective an analysis as possible, we try underestimating the average costs of upholstered furniture by 50 percent over a 32-year time horizon. The net present value (NPV) outcomes for all sensitivity scenarios is still negative value of -$99,974,868. To obtain a NPV outcome greater than zero, the furniture barrier installation costs per household for one sofa and two chairs would need to be less than $9.08.[20]

These sensitivity results offer the distinct conclusion that the combination of benefits and cost circumstances required to obtain net present values greater than zero are very unlikely to occur. Regardless of the inherent uncertainty in either benefit or cost data, we demonstrate any reasonable variation in benefits and costs fail to produce a positive net present value outcome. Though even with this rather decisive CBA finding regarding the non-desirability of adopting a fire barrier mandate for California upholstered furniture, we still expect that there will doubters on the advocacy side of consumer protection. Thus, we finish with the suggestion of making the CBA sensitivity analysis available for all to try.

A Simple Excel Simulation to Convince Stakeholders of CBA's Robustness

[20] This being based upon a 100 percent increase in worst case scenarios for all upholstered furniture fire loss categories, the 16-year time horizon, a 0.19 risk reduction, and a 7 percent discount rate.

We accomplished all the just described sensitivity analyses using a spreadsheet simulation reproduced in Figure 2 and available online.[21] Since the use of fire barriers in upholstered furniture is a contentious issue with consumer protection advocates knowing that human lives and injuries are at stake, and furniture manufactures trying to preserve profits, these stakeholders have strong preconceived notions on their desirability. Thus, it is extremely helpful to make publicly available a simulation that anyone can access and enter their own beliefs on what reasonable values are for the values necessary to complete the CBA. We reproduce this simulation in Figure 2. In this figure, gray cells represent alterable variables. The resulting discounted benefit stream over the 16 years to full use of cloth fire barriers, cost stream, and net present value are in black cells. The value of making this simulation available to all is that it should elicit greater trust in our strong finding that given a reasonable expectation of the cost of a fire barrier regulation, that the benefits are not greater. We suggest such an offering become a more standard practice in the offering of CBA results for public consumption.

[21] See https://www.bearhfti.ca.gov/forms_pubs/barrierstudy_cba.xlsx

FIGURE 2

A Cost-Benefit Analysis Worksheet on the Use of Fire Barriers in Upholstered Furniture

(All Items in Light Gray Boxes Require Completion by User)

Period	Year	Total Cost to California	Total Benefits to California	Percent Households Purchasing Furniture		Present Value Costs to California	Present Value Benefits to California
0	2017	61,855,667	192,169	0.0625		61,855,667	0
1	2018	61,855,667	192,169	0.0625		60,054,045	186,572
2	2019	61,855,667	192,169	0.0625		58,304,898	367,710
3	2020	61,855,667	192,169	0.0625		56,606,698	543,573
4	2021	61,855,667	192,169	0.0625		54,957,959	714,313
5	2022	61,855,667	192,169	0.0625		53,357,242	880,080
6	2023	61,855,667	192,169	0.0625		51,803,147	1,041,019
7	2024	61,855,667	192,169	0.0625		50,294,318	1,197,270
8	2025	61,855,667	192,169	0.0625		48,829,435	1,348,971
9	2026	61,855,667	192,169	0.0625		47,407,218	1,496,252
10	2027	61,855,667	192,169	0.0625		46,026,425	1,639,245
11	2028	61,855,667	192,169	0.0625		44,685,850	1,778,072
12	2029	61,855,667	192,169	0.0625		43,384,320	1,912,856
13	2030	61,855,667	192,169	0.0625		42,120,699	2,043,714
14	2031	61,855,667	192,169	0.0625		40,893,883	2,170,760
15	2032	61,855,667	192,169	0.0625		39,702,799	2,294,107
16	2033	61,855,667	192,169	0.0625		38,546,407	2,413,860
					sum	838,831,008	22,028,374

Benefit Side of Upholstered Furniture Regulation	*Values Per Year and in 2017 $s*
Civilian Deaths by Upholstered Furniture Fire	2
Value of a Statistical Life	4,373,404
Total Value of Civilian Deaths	8,746,808
Civilian Injuries by Upholstered Furniture Fire	8
Value of a Statistical Injury	266,778
Total Value of Civilian Injuries	2,134,224
Property Losses by Upholstered Furniture Fire	4,042,576
House Content Losses by Upholstered Furniture Fire	1,259,085
Total Cost of Upholstered Furniture Fire	16,182,693
Risk Reduction if Upholstered Furniture Fire Regulation	0.190
Benefit of Upholstered Furniture Regulation to CA	**3,074,712**

Cost Side of Upholstered Furniture Regulation	*Values Per Year and in 2017 $s*
Per Chair Manufacturing Cost for Furniture Liner	19.57
Per Sofa Manufacturing Cost for Furniture Liner	38.98
Chairs Per Household	2
Sofas Per Household	1
Chair & Sofa Manuf Costs for Furniture Liner Per Household	78.12
Number of California Households	12,668,235
State Enforcement Estimated Costs	48,150
Cost of Upholstered Furniture Regulation to CA	**989,690,668**

Real Discount Rate	0.03
Number of Years that Chair/Sofa Used (Product Life Cycle)	16

Net Present Value	**816,802,633**
Fire Barrier Benefits Exceed Costs?	**No**

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