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MBA PROFESSIONAL REPORT

**Predicting the Impact of Full Body Scanners on Air Travel
and Passenger Safety**

**By: Mary Elaine Kessler and
Brett R. Seeley
June 2010**

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**PREDICTING THE IMPACT OF FULL BODY SCANNERS
ON AIR TRAVEL AND PASSENGER SAFETY**

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Submitted in partial fulfillment of the requirements for the degree of

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from the

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PREDICTING THE IMPACT OF FULL BODY SCANNERS ON AIR TRAVEL AND PASSENGER SAFETY

ABSTRACT

Good decisions can be made only by looking at the full picture and accounting for what is seen and what is not seen. Air travel security measures aim to create more safety for the passenger; this is what is seen. What is not seen is the impact increased security measures create when passengers decide to substitute driving for flying. Traveling on a short-haul flight (under 500 miles) is significantly safer than driving that same distance in a vehicle. However, air travel security measures have led to more passengers choosing to substitute driving for flying due to longer wait times, greater inconvenience, and, in particular, the invasion of privacy.

This study forecasts the impact full body scanners will have on air travel and passenger safety. Full body scanners invade one's privacy and, as a result, will negatively affect those passengers who place a high value on securing and maintaining their privacy. Passengers who substitute driving for flying will increase their risk level and increase the number of highway driving fatalities. The findings are that full body scanner usage at airports will increase annual highway driving fatalities from as few as 11 additional deaths to as many as 275.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACLU	American Civil Liberties Union
APL	Hopkins University Applied Physics Laboratory
CAB	Civil Aeronautics Board
DOT: DB1B	U.S. Department of Transportation Data Bank 1B
EPIC	Electronic Privacy Information Center
FAA	Federal Aviation Administration
FDA	Food and Drug Administration
GAO	Government Accountability Office
NIST	National Institute of Standards and Technology
O&D	Origin and Destination
RITA	Research and Innovative Technology Administration
TSA	Transportation Security Administration

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I. INTRODUCTION

A. BACKGROUND

The assumed purpose of federal airline safety regulations is they exist to reduce security threats. More explicitly, recent airline safety regulations have been introduced primarily to deter the apparent “threat” of terrorism. Perhaps the true purpose of the regulations lies in the way they are intended to make the public feel. This research will focus on the assumed purpose.

Current technology is capable of detecting dangerous substances, firearms, and other weapons (EPIC, 2010, p. 11). However, new methods are continually being developed and proposed. The latest proposed addition to current airline safety regulations is full body scanners.

Unfortunately, full body scanners may pose an intrusion into personal privacy so invasive that air travelers will alter their behavior. Therefore, the costs associated with implementing the new regulations must be evaluated. Federal air travel safety regulations, as defined, are safety regulations designed to improve the safety of air travel for passengers. Making air travel safer for air passengers works only if those travelers continue to use air travel. Air travel continues to be the means of travel with the lowest fatality rate. Implementing air travel safety regulations that drive passengers to substitute other modes of transportation for flying can, ironically, cause increased fatalities.

Full body scanner use in the United States began during the early months of 2010. The federal government plans to roll out more machines throughout the year. “Plans to deploy them this year were given added urgency after the arrest of a Nigerian man, Umar Farouk AbdulMutallab, who has been accused of attempting to detonate an explosive sewn into his underwear on a December 25 flight” (CNN, 2010, p. 2). Secretary of Homeland Defense Janet Napolitano announced the plan to implement the new air travel

regulation by stating, “By accelerating the deployment of this technology, we are enhancing our capability to detect and disrupt threats of terrorism across the nation” (CNN, 2010, p. 1).

During the past decade, terrorist attacks, with respect to air travel in the United States, have occurred three times involving six aircraft. Four planes were hijacked on 9/11, the shoe bomber incident occurred in December 2001, and, most recently, the Christmas Day underwear bomber attempted an attack in 2009. In that same span of time, over 99 million planes took off and landed within the United States, carrying over 7 billion passengers. Therefore, the odds of being on a plane subject to a terrorist attack are the highly unlikely 1 in 10,408,947 (Silver, 2009, p. 2). Let us put those numbers into perspective. The odds of being hit by lightning in a given year are 1 in 500,000. Simply, an individual is twenty times more likely to be hit by lightning than to be involved in an airborne terrorist attack.

Examining just the numbers does not, by itself, provide the total implications of imposed air travel safety regulations. There is no way to compare a control group of flights with no security measures to Transportation Security Administration (TSA) controlled flights. Thus, there will be some unknowns. Are only six terrorist incidents in the past decade the result of the air travel safety regulations, the tendency of U.S. air travelers to fight back, or the natural state of U.S. society, meaning the lack of daily terrorist activities such as car bombs, suicide bombers, etc.?

What do we know? Terrorist incidents receive attention. Policy changes introduce new safety regulations that result in behavioral changes. After 9/11, air travelers were forced to undergo stricter personnel and baggage screenings. Following the shoe bomber, air passengers were required to remove their shoes to go through security. Following the alleged terrorist plot in Britain during the summer of 2005, all liquids had to be in containers no bigger than 3.4 ounces. All of these and previous safety regulations caused passenger inconvenience and invaded personal privacy. It follows that a percentage of air travel passengers choose to substitute driving for flying as a result of the air travel safety regulations. Presently, because of the Christmas Day bomber, air passengers will soon be subject to full body scanners.

The questions that must be asked are: What are the total costs of this new air travel safety regulation to air travel passengers? What is going to be the behavioral change associated with full body scanner usage with respect to substituting driving for flying? The full body scanner is being chosen to keep passengers safe. Safety is what everyone wants and the goal of air travel safety regulations should be to save lives, not cause more death. Will this new air travel safety regulation meet its goal of saving lives?

French economic journalist Frederic Bastiat made famous the notion that good decisions can be made only by looking at the full picture and accounting for what is “not seen” as well as what is seen (Bastiat, 1850, p. 2). Regulations dealing with air travel safety have both seen and unseen costs and benefits. When decisions are being made, more information is almost always better than less information. If it is known that there are unseen costs, and these costs can be foreseen to attain the full picture, the costs need to be recognized, highlighted, and included in the discussion before a decision is made. This insight has direct application to air travel safety regulations. The full picture needs to be addressed, including what is seen and not seen (but can be foreseen), before a decision is made to implement further air travel security measures.

Finally, one particular problem associated with air travel safety regulations is that short-haul air passengers are the ones most affected by implementing new air travel security measures. The greater the inconvenience created by new security measures, the greater the likelihood that potential air travel passengers will not fly. Short-haul passengers are able to substitute air travel with alternate modes of transportation in order to arrive at their destinations.

B. PURPOSE

The purpose of this research is to forecast the impact full body scanners will have on air travel and passenger safety. Specifically, how will the implementation of full body scanners in airports affect highway driving fatalities? This study is an examination of the correlation between air travel safety regulations and highway driving fatalities. One objective is to estimate the percentage of air passengers who will substitute driving for flying as a result of implementing full body scanners in airports. The primary research

question is the following: What effect will full body scanners have on air travel and passenger safety? The objective of this analysis is to help decision makers, specifically TSA, incorporate both seen and unseen costs into the discussion when making policy decisions.

Research Questions

Primary:

1. What will be the effect full body scanners will have on air travel and passenger safety?

Secondary:

1. What were the previous effects of increased air travel security measures on air travel and passenger safety?
2. Does evidence exist to support theory of more air travel security measures actually leads to less safety for passengers?

C. METHODOLOGY AND SCOPE

This study examines factors contributing to air travel safety regulations and how they affect air travel and passenger volume. This study uses a mathematical analysis in an effort to forecast the impact full body scanners will have on air travel and passenger safety. A mathematical model is used to determine a range of passengers who will substitute driving for flying, and, as a result, increase highway driving fatalities.

D. BENEFITS OF THE STUDY

The goal of this study is to highlight the impact air travel security measures have on air travel and passenger safety. Passengers choosing to substitute driving for flying are creating more risk for themselves by selecting a mode of transportation with a higher rate of fatalities. This study brings attention to the full picture when making decisions in the field of air travel security measures. However, the concepts contained in this research may be applied to any field for decision making. Decision makers must be aware of the full picture and this study provides insight into the total costs, seen and not seen, so the full picture may be realized. This study suggests an increase in fatalities as a result of

implementing a security measure. The Department of Defense may benefit from the concepts contained in this study, especially when making decisions where Sailors and Marines' lives are at stake.

E. ORGANIZATION OF THE THESIS

Four more chapters follow this chapter. Chapter II, "Literature Review," presents the findings from prior studies dealing with air travel safety regulations and passenger safety. "Literature Review" also discusses the evolution of air travel safety regulations in the airline industry since deregulation in the 1970s and how the regulations affected passenger safety. Chapter III, "Methodology," discusses the sources of data used to analyze and predict the impact full body scanners will have on air travel and passenger safety. Chapter IV, "Presentation of Results," presents the information learned and predicted in a concise, straightforward manner. Chapter V provides a summary, conclusion, and recommendations for further study.

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II. LITERATURE REVIEW

A. OVERVIEW

The increasing invasion of privacy for air travel passengers poses a serious problem for the safety of individuals who drive on the nation's highways. Air travel safety regulations have created an inconvenience, time delay, and invasion of one's privacy to such an extent that a percentage of air travel passengers have decided to substitute driving for flying in an attempt to avoid the above mentioned nuisances. The decrease in air travel passenger volume has resulted in an increase in highway vehicle volumes that have led to further congestion on the nation's highways and more vehicle accidents. The shift in modes of transportation has been mostly seen with the short-haul passenger segment in response to air travel safety regulations that not only create inconvenience, but also invade one's privacy. Although a percentage of passengers have already chosen to substitute driving for flying, the researchers feel there remain more passengers on the margin who may be affected by further air travel safety regulations.

The next round of air travel safety regulations deals with full body scanners and the further invasion of one's privacy. With privacy being such an important issue for air travel passengers, better predictions and review should go into the decision making process before choosing to implement the latest round of regulations. This chapter reviews prior air travel safety regulation studies, air travel demand elasticities, and the unintended consequences of passengers choosing to substitute driving for flying as a result of implementing air travel safety regulations. Additionally, this chapter outlines the mechanics of the new equipment to be implemented as an air travel safety regulation, the full body scanner, and how personal privacy is pushing passengers to substitute driving for flying and affecting the probability of being involved in a vehicle accident.

B. DEREGULATION OF AIRLINES

The history of deregulation of air travel plays a part in understanding the behavior of consumers when they encounter air travel regulation in the form of security measures. For the greater part of the past thirty-two years, deregulation in the United States has been part of a global airline liberalization trend throughout Asia, Latin America and the European Union. Domestically, in 1978, the Airline Deregulation Act moved control over air travel from a politically controlled economy closer to the market. It followed with the Civil Aeronautics Board (CAB) being phased out under the CAB Sunset Act on December 31, 1984. Originally, the CAB was the primary source of regulation over entry, exit, the pricing of airline services, intercarrier agreements, mergers, and consumer issues within the United States (Smith and Cox, p. 1).

The CAB had held the U.S. air travel industry in place by constraining investment and operating decisions through regulation. Therefore, airlines originally competed for consumers through service provisions: food, cabin space, crew quality, and frequency of flights. Thus, the prices for flights were high as well as the frequency, but the percentage of seats filled on each flight was low. Now, over time, the U.S. market has seen the prices of flights drop allowing for the common man to be a regular consumer. This has led to a higher percentage of seats routinely being filled on flights, but the level of service in regards to food, cabin space, crew quality, and frequency of flights has dropped significantly. If consumers are looking for a more luxurious flight experience with services as priority, they will have to pay for it by travelling business or first class.

With the falling prices of flights and the increase in smaller regional service providers, the competition for consumers is fierce. Loyalty programs exist for almost every service provider and bonuses such as a free piece of checked luggage are part of the current trend to maintain a consumer base. Therefore, security measures that might dissuade an air traveler are of significant interest to the air travel industry as a whole. Constraining personal freedoms restricts the open market. This is an unseen and not accounted for reality of implementing full body scanner security measures.

C. PRIOR AIR TRAVEL SAFETY REGULATION STUDIES

Numerous studies have been written on the impact airline regulations have on highway safety. One of the most significant air travel safety regulation studies ever done was by Blalock, Kadiyali, and Simon (2005). The study, titled *The Impact of Post 9/11 Airport Security Measures on the Demand for Air Travel*, looked, using five years of data, at the impact post-9/11 airport security measures had on air travel. Specifically, the study found a reduction in demand to be an unintended consequence of baggage screening (Blalock et al., 2005, p. 24). The passengers who chose to no longer fly did so either out of fear of flying or due to the inconvenience the new airport security measures created. Some of those passengers still needed a mode of transportation to travel to their destinations, and they selected either train, bus, or automobile.

A second study was completed looking at the specific effect the 9/11 airport security measures had on driving safety. The 2005 report was on the impact 9/11 had on driving fatalities; it estimated that an increase of 242 driving fatalities per month was the result of passengers substituting driving for flying following the terrorist attacks of 9/11 (Blalock et al., 2005, p. 10). The report identified baggage screening as the main catalyst for passengers substituting driving for flying. The report highlighted the sensitivity passengers have with regard to privacy as they chose to drive vice fly—a far riskier way to travel—in order to not have their personal bags screened. A separate study conducted in 1987 showed the effect of deregulation of the airline industry and the impact on highway driving fatalities. This study, *The Impact of Airline Deregulation on Highway Safety*, estimated that airline deregulation reduced vehicle congestion on the highways and saved 1,700 lives each year between 1979 and 1985 (McKenzie, 1987, p. 19). Deregulation of the airline industry led to lower price tickets and an increase in the number of flights, which resulted in an overall increase in air travel. More passengers flying in the air resulted in less passengers driving on the highways. Fewer vehicles on the highways made the highways safer. Deregulation reduced the number of vehicles on the highway, which, in turn, lowered the highway driving fatality rate.

The prior air travel safety regulation studies demonstrated a connection between air travel safety regulation and highway driving fatality rates. The prior studies highlight the fact that when regulations increased, the highway driving fatality rate increased and when regulations decreased, the highway driving fatality rate decreased.

D. OTHER STUDIES

Other studies related to air travel look at the elasticity of air travel demand for short- and long-haul flights based on air travel fares. The study prepared by InterVISTAS Consulting Inc., *Estimating Air Travel Demand Elasticities*, focused on fare elasticities for air travel. The study looked at fare elasticity data covering over 25 years and reviewed 23 papers to reach the conclusions of the report. The findings state that demand elasticities for North America short-haul travel range from -1.54 to -0.88 (InterVISTAS, 2007, p. 36). A separate study surveyed the 23 papers and reported their findings in Figure 1 (Gillen et al., 2002, p. 1). The researchers find this figure of significant value when selecting elasticities for this study. Short-haul fares are the focus of this research due to the ease of substituting driving for flying to a locale within the defined range of short-haul flights (500 miles or less one way, and 1,000 miles round trip).

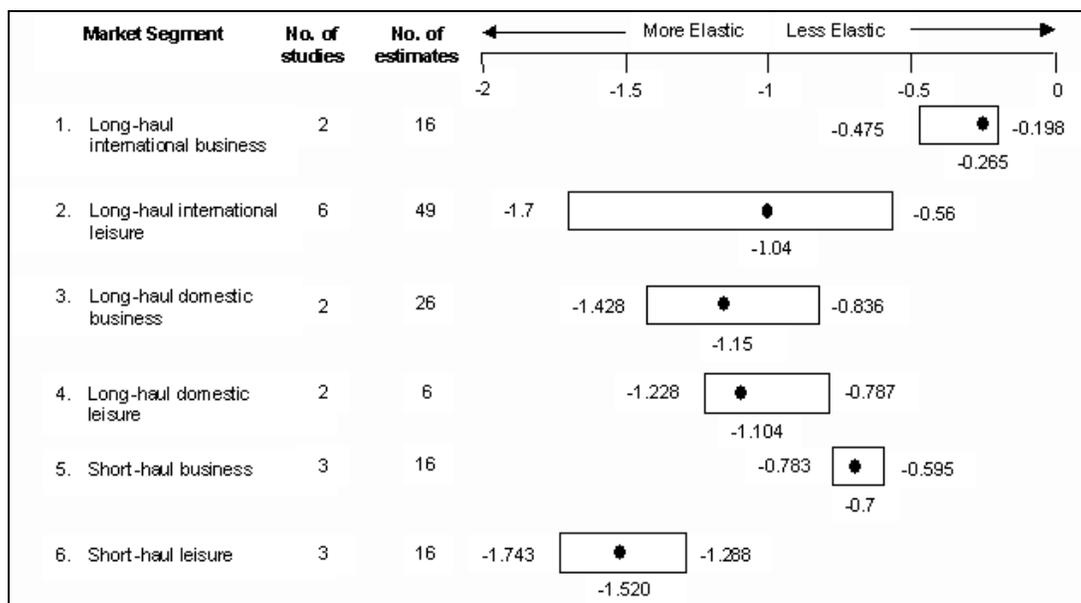


Figure 1. Air-travel demand elasticities (From Gillen et al., 2002)

E. DEFINING THE PROBLEM

Air travel safety regulations that infringe on passenger privacy have historically resulted in a decrease in air travel passenger volume for short-haul travelers. The latest round of air travel safety regulations to be implemented, full body scanners, infringes on passenger privacy. Understanding the capabilities and specifications of the new machine being implemented will help gauge to what degree the new machines will increase the level of the privacy invasion. This, in turn, will help better predict the impact full body scanners will have on passenger volume and passenger safety.

1. What Is a Full Body Scanner?

The TSA has been using two different scanning machines at airports. The first machine is a Millimeter Wave scanner, and it looks like a spacious phone booth. A passenger stands inside the machine and panels slide around, scanning the passenger. The machine emits radio waves that bounce off the passenger inside and create an image of the passenger's body without clothes on. Showing an image of a passenger minus clothes makes it easier for a TSA employee to discover any hidden items attached to the passenger's body. The whole scanning process can take up to 40 seconds to complete. Of the two scanning machines, this one creates the most detailed body images, and critics have called the process a virtual strip search (Jaunted, 2010, p. 2).

The second machine in use is a Backscatter scanner, and it looks like two boxes that a passenger stands between to be scanned. The machine works by taking low-level X-rays of a passenger, and if a passenger is not concealing any foreign objects, the X-rays will be absorbed into the body, but if a passenger is hiding any items, the X-rays will bounce back and display the hidden object on the scan. The scanning process takes only 20 seconds to complete (Jaunted, 2010, p. 2). Images of both types of scanning machines are displayed in Figures 2 and 3.

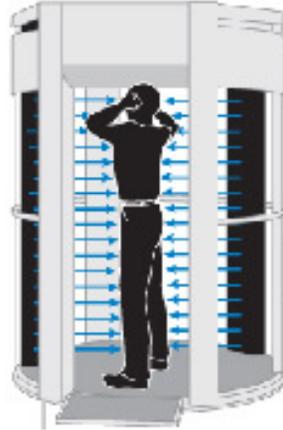


Figure 2. Millimeter Wave scanner (From InterVISTAS, 2007)



Figure 3. Backscatter scanner (From InterVISTAS, 2007)

For both scanners, it does not matter what type of clothing a passenger wears; the scanners will see through whatever article of clothing worn and reveal all the details of the passenger to the TSA employee viewing the scanned images. Although the scanners are great at picking up items on a passenger's skin, the one main weakness with both types is the fact they are not strong enough to detect if items have been placed inside body cavities. This major weakness of the technology presents a difficult choice for TSA leadership to make. The machines take virtual nude scanned images of passengers to ensure safe air travel, but the machines are useless in detecting if foreign objects are located inside a body cavity. With the cost of each machine hovering around \$150,000, and the machine being incapable to detect items inside cavities, concerns over who would

spend so much on results that cannot be guaranteed have begun to circulate within privacy advocate groups, such as the Electronic Privacy Information Center (EPIC) and the American Civil Liberties Union (ACLU).

Images of scanned passengers are illustrated in Figure 4.

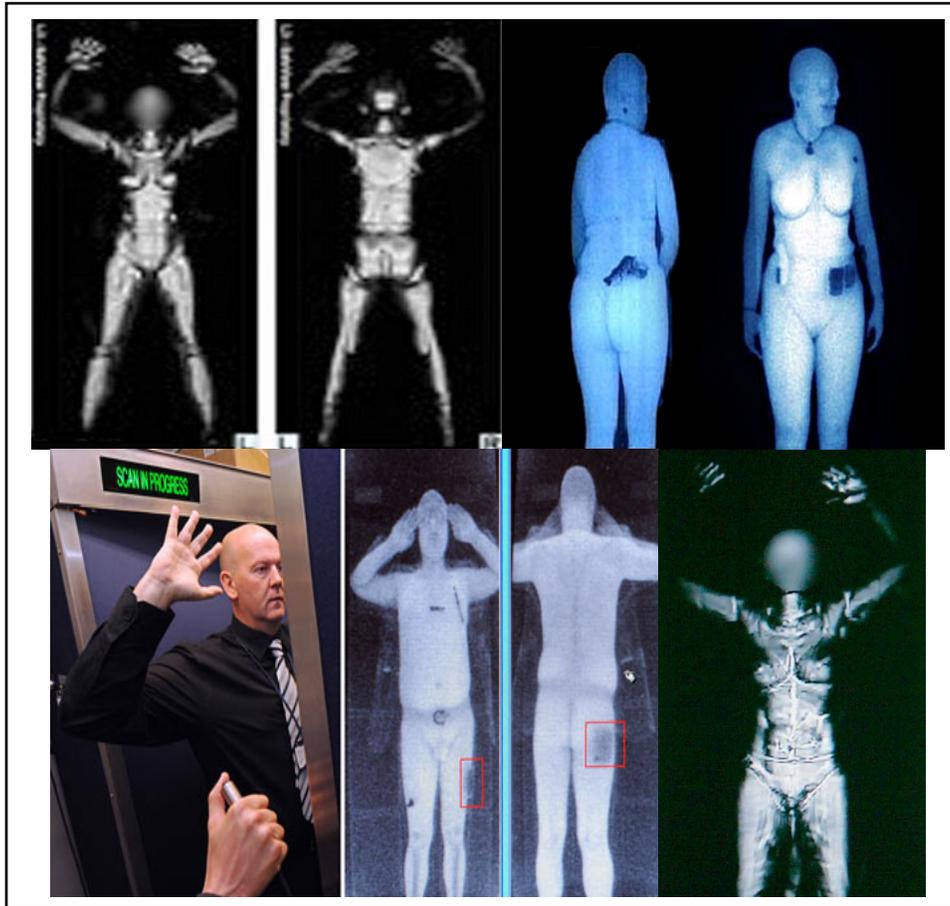


Figure 4. Scanned body images (From Travis, 2010)

2. Transportation Security Administration's (TSA) Full Body Scanner Policy

Since the implementation of full body scanners, the TSA has stated that full body scanners are optional for passenger screening, and that it has no plans to make the scanners mandatory. Passengers who do not wish to be scanned may instead opt to be patted down by a TSA employee. This opt-out policy is not widely disseminated at the

security lines, so a passenger must know his/her rights and options beforehand, and when directed to be scanned must make known that he/she wishes to be patted down instead. The TSA has acknowledged concerns passengers may have regarding health concerns and privacy concerns and issued statements in an attempt to justify and calm those who are concerned. Regarding privacy concerns, TSA states the body scanners blur facial areas, so no facial identification is available to the employee conducting the screening of the scanned images (TSA.gov, 2010, Imaging Technology). The scanning machines are also stated to have no storage, printing, or transmitting capacity for scanned passenger data (TSA.gov, 2010, Imaging Technology). Regarding health concerns over the levels of radiation the scanners expose to a passenger, the TSA has had the Food and Drug Administration (FDA), the National Institute of Standards and Technology (NIST), and the Hopkins University Applied Physics Laboratory (APL) specialists review and discover the amount of radiation the scanners emit to be so low it is almost negligible (TSA.gov, 2010, Imaging Technology).

3. Current Full Body Scanner Usage

To date, full body scanners have been implemented at the following airports. Plans to further disseminate machines are scheduled for the remainder of 2010 and into 2011.

Airport Code	Location	Airport Code	Location
ABQ	Albuquerque	LAS	Las Vegas
ATL	Atlanta	LAX	Los Angeles
BWI	Baltimore	MCI	Kansas City**
BOS	Boston**	MIA	Miami
CLT	Charlotte**	OAK	Oakland**
CMH	Port Columbus**	PHX	Phoenix
CVG	Cincinnati**	RDU	Raleigh-Durham
ORD	Chicago**	RIC	Richmond
DCA	Washington DC	SAN	San Diego**
DEN	Denver	SFO	San Francisco
DFW	Dallas-Ft. Worth	SJC	San Jose**
DTW	Detroit	SLC	Salt Lake City
FLL	Ft. Lauderdale**	TPA	Tampa
IND	Indianapolis	TUL	Tulsa
JAX	Jacksonville	**Denotes scanners by summer 2010	

Table 1. List of airports with scanners (From EPIC, 2010)



Figure 5. Map of current scanner locations (After EPIC, 2010)

F. THE RIGHT TO PRIVACY ISSUE

The researchers acknowledge the study is not designed to answer or suggest solutions for the following possible problems related to the implementation of backscatter X-ray security measures. Properly addressing the issues attached to the implementation of backscatter X-rays would require a different model. However, this study presents these topics in order to provide a total picture of the controversial backdrop behind this particular airline security measure.

The implementation of body scanners as a security measure throughout airports in the United States, Australia, England, and Europe appears to have generated more issues than security solutions. Questions still remaining are the manner in which they are used, the material the machine has the power to collect and store, and the fact the machine has a broad flaw (body cavities may still be used to hide contraband). All of these issues bring the individual's right to privacy to the forefront. The body scanner machines appear to have breached the public's sense of personal privacy enough to cause internal arguments within and between federal agencies, states and the federal government, the European Union, and individual citizens. The following discussions touch on some of the issues being brought to light by the full body scanner machines.

1. Child Pornography and Health

A disturbing issue brought to light by the use of full body scanners is that of child pornography. Due to the graphic nature of the images produced by the full body scanner, Great Britain has exempted those passengers under the age of 18 from going through the scanners. Under the Protection of Children Act of 1978, it is illegal to create an indecent image or "pseudo-image" of a child. As the pictures created by these machines are considered a virtual strip search and display genitalia and breast enlargements, the United Kingdom's Department of Transport agreed that the possibility of child porn is among the legal and operational issues under discussion. Simon Davies of Privacy International voiced his concern over the current privacy safeguards said to be in place here in the United States. The United States has announced that all images will be deleted, but Mr. Davies believes the scans of unusual body profiles and celebrities will be too much of a

temptation for some scanner operators, leading to these images being used for personal gain and public publication. All machines maintain the ability to take, transmit and store images when in “test” mode (Travis, 2010, pp. 1–2). In addition, the Inter-Agency Committee on Radiation Safety, which includes the European Commission, the International Atomic Energy Agency, and World Health Organization, suggests that though the radiation dose is extremely small, pregnant women and children should not undergo scanning (Hsu, 2010, p. 2).

2. Government’s Decisions

Bruce Schneier, internationally renowned security technologist, probably put it best when he said:

Unfortunately for politicians, the security measures that work are largely invisible. Such measures include enhancing the intelligence-gathering abilities of the secret services, hiring cultural experts and Arabic translators...investigative arms to prevent terrorist attacks, and emergency communications systems for after attacks occur — and arresting terrorist plotters without media fanfare. (Privacy International, 2009, p. 2)

Mr. Schneier has referred to the use of these full body scanners as nothing more than “security theater.”

The machines cannot detect the low density materials, such as liquid, powder, or thin plastics it needs to see to be an improved security measure. Basically, the sacrifice of personal privacy for no enhanced or improved capability is utterly pointless and destructive. Moreover, it is possible to design and use the body scanners in such a manner that privacy is protected without diminishing the remaining security capability of the machine. However, the U.S. government chose not to do this. The researchers who developed the machines at the Pacific Northwest National Laboratory offered a design projecting concealed contraband onto a neutral nondescript “blob” shaped figure. However, the federal government selected the naked, graphic, descriptive figure. And, as previously mentioned, the TSA assured the public it was not holding the images it collected through the full body scanners. However, EPIC found that in 2008, the TSA told vendors that the machines it receives must have the ability to send or store images

when in “test” mode (Rosen, 2010, pp. 8–10). As all machines come with a “test” mode, the problem could become who has the control over the mode of the machine.

3. Disagreement Within the Federal Government

After the Christmas bombing in December 2009, former department of Homeland Security director, Michael Chertoff said this was a lesson in the value of the full body scanner machinery. (Rosen, 2010, pp. 8–10) At the same time, the Government Accountability Office (GAO) has said it’s unclear whether or not the machines would have detected the weapon used in the shoe bomber incident. The use of these machines would cost U.S. taxpayers roughly \$3 billion over eight years: each unit costs approximately \$170,000, each unit requires 3 people to run it, and 1,800 units will be required to cover about 60 percent of checkpoint lanes. For that reason, GAO official Steve Lord told the House Homeland Security Committee that the TSA should conduct a new cost-benefit study before deploying the scanners (Hsu, 2010, pp. 1–2).

Ironically, but not widely disseminated, the House (but not the Senate) voted in 2009 to ban the use of full body scanning machines for primary screening and prohibit the images from being stored. Additionally, the Supreme Court found, 8–1, that strip searches in schools without some suspicion of danger or wrongdoing are unreasonable. However, virtual strip searches will soon be commonplace for air travelers rather than reserved for secondary screenings (Rosen, 2010, pp. 8–10). Therefore, on one hand, a federal organization pushes the implementation of the full body scanners as a security measure while others appear to be saying restraint and possibly something else should be used.

4. State Government Disputes

The House of Representatives in Idaho voted to limit the use of full body scanners. The bill is now being sent to the Idaho Senate. In Idaho airports, this bill would bar body scanners as the primary screening, require security officers to offer an alternative search, and mandate an independent investigation into the possible health risk associated with the use of these scanners (EPIC, 2010, p. 2). This issue reveals disparity

at the foundation of our state and federal governments. Because each airport is located within a particular state, if every state in the union takes a different stance on the implementation of these full body scanners, this security measure could possibly take years, if ever, to enact across the country. The very fact that this disagreement is happening leads one to the idea that a more effective and widely acceptable security measure must be plausible. There must be another way to achieve the same goal.

5. Traveler Complaints

The EPIC filed a Freedom of Information Act lawsuit to obtain further information about the full body scanners. Therefore, the Department of Homeland Security and the TSA released documents including complaints from travelers who had to go through the full body scanners. Some of the complaints included the previously mentioned issues with regard to children going through the scanner and health concerns regarding radiation exposure. Other complaints included not being told about the option to not go through the full body scanner and alternatively receive the pat down, not being told what they were being subjected to, and officials not being able to tell individuals what was being done with the image they had collected (EPIC, 2010, p. 3). When a TSA screener was asked whether the face of an individual was blurred while they examined the “naked” picture, he replied he was unable to say. However, as the person walked away, the TSA official blurted out, “Someone ought to do something about those machines—it’s like we don’t have any privacy in this country anymore!” This willing declaration or, rather, a seeming cry for help, is disturbing confirmation of the perilous state of our personal privacy from the actual operator of a full body scanner (Rosen, 2010, p. 8).

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III. METHODOLOGY

A. ANSWERING THE RESEARCH QUESTION

Predicting the impact of airport full body scanner security measures on air travel and passenger safety consisted of several steps. First, research was done to identify previous work examining the impact of airport security measures upon air travel and passenger safety. The most recent studies were in relation to security measures imposed after the 9/11 terrorist attacks. These included physical checked baggage searches, X-ray machines and physical searches for carry on items, metal detectors, and physical pat downs of individuals.

Using simple and standard research methods found in previous studies, the researchers first gathered data from a reliable source. The second step was organizing the data into a useful format. Finally, the data were used to predict the impact of airport full body scanner security measures on air travel and passenger safety.

1. Sources of Data

The selection of data for air travel statistics was made from a reliable and consistent source. The U.S. Department of Transportation's (DOT) Data Bank 1B (DB1B) of the Origin and Destination (O&D) survey provides a 10 percent random sample of tickets sold by airlines for flights origination and terminating in the U.S. This includes the full itinerary for each trip, the price of the ticket and the carrier.

The time period selected is calendar year 2007. This year was selected as our base, as 2007 was before the current period of economic turmoil while being the most removed from the ripple effects of 9/11. Essentially, the researchers think 2007 best reflects what may be considered standard trends in travel.

The data from DB1B were further broken down to represent only those domestic flights considered to be short-haul one-way, less than 500 miles, and short-haul round trip, less than 1000 miles. This selection of flights is most representative of the traveler

who would possibly be diverted to highway transportation due to the implementation of full body scanner security measures. This group of travelers has the greatest flexibility in selecting whether to fly or drive to their destination.

The Research and Innovative Technology Administration (RITA) holds an abundance of data from the Bureau of Transportation Statistics. This is the source the researchers used to gather the fatality rate for motor vehicles for the year 2007. The rate was figured per 100 million vehicle miles. “Urban, total” is the category used as most representative of the type of travel individuals would be making if diverted from air travel due to the effect of applied full body scanner security measures. Furthermore, the Urban, total fatality rate for 2007 is the lowest, which biases the study’s results towards finding the smallest number of probable fatalities.

Again, the source for airline fatality rates for 2007 was the Bureau of Transportation Statistics using the Research and Innovative Technology Administration (RITA) Web site. The average fare for short-haul one-way and round trip flights was also pulled from the Data Bank 1B (DB1B) for the year 2007.

2. Organization of Data

Data were clearly presented by the Bureau of Transportation. The year 2007 was available by each quarter of a calendar year. Every quarter of 2007 was downloaded into ACCESS. From this point, it was easily manipulated to retrieve the required information.

The data collected in this manner included short-haul one-way flights, short-haul round trip flights, and fare paid.

The information regarding fatality rates for both highway and air travel for 2007 was available in table format based upon calendar year.

3. Presentation of Data

A consistent format, presenting the results of this research, is used by the study. To facilitate ease of understanding and comparison, the researchers’ standard format presents the question, data manipulation, provides the results in a table format, and simply describes the findings.

IV. PRESENTATION OF RESULTS

A. FORECASTING THE IMPACT FULL BODY SCANNERS WILL HAVE ON AIR TRAVEL AND PASSENGER SAFETY

Before diving into the data and the presentation of results, let us step back and understand exactly what data are being analyzed and what the background of the information being forecasted contains. Predicting the impact full body scanners will have on air travel and passenger safety is similar to estimating the impact previous safety regulations have had on air travel and passenger safety. By understanding that past air travel safety regulations have led to unintended consequences, specifically short-haul passengers substituting driving for flying, one can estimate the magnitude of unintended consequences that are likely to arise from other safety regulations such as usage of full body scanners in airports.

The basis for forecasting what will happen when new safety regulations are implemented is derived from looking back on what did happen when prior safety regulation decisions were made and the behavioral changes that occurred. De-regulation of the airline industry originally led to price wars and service wars between airlines, which benefited the passengers with better service and lower prices, along with a safer mode of transportation over highway driving. However, when safety regulations were implemented to improve passenger safety, they caused behavioral changes that were unintended or not seen by the decision makers.

Post-9/11 air safety regulations provide an example of air “safety” regulations contributing to making travelers less safe. When 100 percent baggage screening was implemented for all air passengers, the intent was to improve safety and deter the threat of another 9/11-type incident. The behavioral change not seen was the inconvenience of baggage screening leading to more short-haul passengers substituting driving for flying and, as a result, decreasing their own safety. Again, this was not the original intent of the air travel safety regulation. Looking back and understanding there are behavioral changes not seen when new air travel safety regulations are implemented, this study

focused on forecasting the unintended behavioral changes caused by the next air travel safety regulation to be implemented, the use of full body scanners.

The aspect of air travel being examined is short-haul flight data from 2007. Predicting the impact full body scanners will have on air travel and passenger safety is accomplished by estimating, based on elasticity of demand, the behavioral changes the new safety regulation will create. Full body scanners are likely to result in a certain percentage of passengers making the decision to substitute driving for flying. This study acknowledges that there are multiple substitutes for flying such as automobile, bus, or train, but for the purpose of this study the focus is only on automobile substitution for flying. This study forecasts a range of percentages of those passengers who will choose to drive instead of fly and the potentially fatal consequence of that decision.

The researchers gathered data to predict the impact of the next round of air travel safety regulations. The data collection consisted of finding the number of passengers who flew short-haul flights during the year of 2007. The researchers also collected data to compute the average price for short-haul fares, a crucial number to use in the elasticity formula. Next, data were collected on the highway driving fatality rate for 2007. Short-haul travelers who choose to substitute driving for flying will travel on both rural intrastate and urban roads to reach their destinations. Although the majority of the driving would occur on rural interstate roads, the researchers decided to use the fatality rate for urban roads. The reason is that this latter rate is the lowest rate for any kind of driving and using it, therefore, biases the study in favor of displaying the smallest probable impact of new airline safety regulations. All data collected are in Table 2.

Short-haul trip distance	< 1000 miles
Short-haul passenger volume	135.8 million
Avg ticket fare	\$325.14
Highway fatality rate (per 100 million vehicle miles)	0.88
Cost of passenger time (1 hr)	\$40.00

Table 2. Base year data 2007

The formula used in the study to obtain results is the elasticity formula, the percentage change in quantity divided by the percentage change in price. For short-haul travel the study reviewed extensive research that found the elasticity of demand for short-haul domestic travel to be fairly high, at -1.5. The researchers then did a sensitivity analysis, using progressively lower elasticities. The lower the elasticity, the less will be the impact of the safety regulations. With the three elasticities, -1.5, -1.0, and -0.5, decided upon, the next step was to plug into the formula the change in quantity (air passenger volume) and the change in price (value of body scanners to a passenger). To acquire a change in price labeled ‘ ΔP equivalent,’ the study looked at how much value a typical passenger might place on his/her time and privacy versus the benefit of feeling safe.

The privacy value is included due to the full body scanners’ ability to take near pornographic images of an individual. This invades passengers’ privacy. Moreover, the machines are able to capture this image for posterity. The value of privacy is subjective; it varies greatly from person to person. To create a range of possibilities, estimated values were used from \$0 to \$80, meaning some individuals may place no value on their privacy in regards to being subjected to the full body scanners while some individuals will place a value of \$80. The subjective values may have far greater or lesser values, but for this study a limit was drawn and only values from \$0 to \$80 were utilized. After creating a value range for an individual’s privacy, the cost of an air traveler’s time needed to be addressed.

The inconvenience of having to arrive at the airport early and wait in line has an impact on an air traveler's time. This study valued time at \$40/hr. The researchers came up with this time value as follows. First, a Federal Aviation Administration (FAA) study in 1995 claimed the average value of time per air traveler to be \$45/hr. Adjusting for inflation to 2007 would yield an average of \$61 an hour. In order to once again bias the data against the study, the researchers understated the value to be \$40/hr. The study substantiates this valuation of time at one hour by the documented recommendation from the TSA to arrive at the airport 90 minutes early and to expect to allow 60 minutes for security screenings (TPA, Security Questions, 2010). To predict the incremental time lost due to the full body scanners being implemented the researchers assumed two different amounts of time. The first amount of time lost is one hour due to the full body scanners taking more time to pass through than a standard metal detector, the fact that the machines are new and will take some time for the TSA employees to become familiar with the screening process, and the assimilation time for passengers to become familiar with the new screening requirements. The second amount of time lost assumed is 15 minutes. The additional 15 minutes represents the incremental time lost once both TSA employees and passengers become familiar with the new regulation screening requirements and procedures. Therefore, at the extreme end, a passenger will need to show up at the airport an additional hour earlier than he/she is already accustomed to when the full body scanners are implemented nationwide, but once full body scanners have been implemented and the learning curve takes effect, a passenger should expect to add only an additional 15 minutes to his/her arrival time. Offsetting this value of time lost is the perceived benefit of the additional air travel safety regulation.

The value of the perceived benefit of having full body scanners is subjective and the study acknowledges the difficulty in attempting to place a value on passenger safety and security. The study placed the value of \$20 on the perceived benefit. The study did not place more value on the benefit due to the fact air passenger volume for short-haul flights have historically fallen after the implementation of air travel safety regulations.

This means passengers felt safe before more security was added and would fly without the extra safety regulation. The formula for ‘ ΔP equivalent’ is addressed for both values of time in Tables 3 and 4.

ΔP equivalent = (ΔPrivacy + ΔTime) - Perceived Benefit			
(\$ value to accept scanners)	(\$ value for privacy)	(\$ value cost of time/hr)	(\$ value of safety/security)
20	0	40	20
40	20	40	20
60	40	40	20
80	60	40	20
100	80	40	20

Table 3. Explanation of ΔP equivalent when time is one hour

ΔP equivalent = (ΔPrivacy + ΔTime) - Perceived Benefit			
(\$ value to accept scanners)	(\$ value for privacy)	(\$ value cost of time/hr)	(\$ value of safety/security)
-10	0	10	20
10	20	10	20
30	40	10	20
50	60	10	20
70	80	10	20

Table 4. Explanation of ΔP equivalent when time is 15 minutes

In Table 3, the ‘ ΔP equivalent’ numbers range from \$20 to \$100, when incremental time lost is assumed to be one hour, based on the fact at the lowest end a passenger with no concern over the privacy aspect of the full body scanner placing zero dollars for the ‘ Δ Privacy’ still would have a positive value for ‘ ΔP equivalent’ due to the inconvenience and cost of the time perceived as wasted having to show up early for a flight in order to make it through security. At the high end of the study’s estimates, if a passenger values privacy highly at \$80, he/she would have a ‘ ΔP equivalent’ of \$100 in order for him/her to accept the full body scanner and be subjected to its use.

In Table 4, the ‘ ΔP equivalent’ numbers range from \$0 to \$70, when the incremental time lost is assumed to be only 15 minutes, based on the fact at the lowest end a passenger with no concern over the privacy aspect of the full body scanner would have a negative value for ‘ ΔP equivalent’ due to the benefits of the machine outweighing the cost of his/her additional time waiting at the airport. This would mean the full body scanner would have no effect on the passenger deciding to fly. At the high end, a passenger would have a ‘ ΔP equivalent’ of \$70, which is less than the previous assumption but reflects the difference between the incremental time lost from one hour to only 15 minutes.

1. Forecasting Impact if Demand Elasticity Is -1.5

a. Question

What is the forecasted impact of full body scanners on air travel passenger volume and passenger safety if demand elasticity is -1.5? Identification and description of the impact of full body scanners with elasticity at -1.5 will be discussed in the following sections.

b. Data Manipulation

The passenger enplanements data from 2007 were entered into an access spreadsheet and separated by distances traveled. Only passenger enplanements that were for travel of 500 miles or less, or less than 1000 miles round trip, were included. The ticket price for short-haul air travel was computed by averaging all short-haul fares from

2007. Next, using an access spreadsheet and the elasticity formula, the researchers computed the impact full body scanners are likely to have on air travel volume and passenger safety. Using a range of ‘ ΔP equivalent’ found in Tables 3 and 4 and the average short-haul ticket fare for ‘P’ found in Table 2, the percentage change in price (which is the bottom half of the elasticity formula) was formulated. Using elasticity of -1.5 and knowing our ‘Q’ quantity of short-haul passenger enplanements found in Table 2, it was then possible to solve for ‘ ΔQ ’ to discover the effect on air travel passenger volume. Next, a range of “percent diversions” was chosen. The percent diversion is the percent of passengers who, having decided not to fly in response to the “price” increase, decide instead to drive. This percentage can, in theory, range from 0 to 100. The range created went from 10 to 50 percent. The additional fatality numbers were calculated by multiplying how many miles those diverted passengers who substituted driving for flying now drive and multiplying that answer by the highway driving fatality rate per 100 million miles. The results are shown in Tables 5 and 6.

% diversion ΔP equivalent					
	10	20	30	40	50
20	11	22	33	44	55
40	22	44	66	88	110
60	33	66	99	132	165
80	44	88	132	176	220
100	55	110	165	220	275

Table 5. Annual fatalities with elasticity at -1.5 based on Table 3 data

% diversion ΔP equivalent					
	10	20	30	40	50
-10	-6	-12	-17	-23	-29
10	6	12	17	23	29
30	17	35	53	71	89
50	29	59	89	119	149
70	41	83	125	167	209

Table 6. Annual fatalities with elasticity at -1.5 based on Table 4 data

c. Description

The y-axis represents the ‘ΔP equivalent’ range from Tables 3 and 4 and the x-axis represents the diversion percentage of passengers who choose to substitute driving for flying (a percent of ‘ΔQ’). With an elasticity of -1.5, the additional deaths per year from Table 5 ranged from a low of 11 when ‘ΔP equivalent’ is 20 and only 10 percent of those choosing not to fly substitute driving for flying, all the way to an additional 275 deaths when the value of ‘ΔP equivalent’ is 100 and 50 percent of passengers choosing not to fly substitute driving as their mode of transportation. The numbers in Table 6 ranged from a low of zero up to an additional 209 deaths.

2. Forecasting Impact if Demand Elasticity Is -1.0

The numbers for annual fatalities based upon 2007 air travel passenger data with elasticity at -1.0 are displayed in Tables 7 and 8.

% diversion ΔP equivalent					
	10	20	30	40	50
20	7	14	22	29	36
40	14	29	44	58	73
60	22	44	66	88	110
80	29	58	88	117	147
100	36	73	110	147	183

Table 7. Annual fatalities with elasticity at -1.0 based on Table 3 data

% diversion ΔP equivalent					
	10	20	30	40	50
-10	-4	-8	-12	-15	-19
10	4	8	12	15	19
30	12	23	35	47	59
50	19	39	59	79	99
70	27	55	83	111	139

Table 8. Annual fatalities with elasticity at -1.0 based on Table 4 data

Tables 7 and 8 illustrate that the additional deaths are lower than in Tables 5 and 6 due to the fact that -1.0 is less elastic than -1.5 and fewer travelers will chose to substitute driving for flying when elasticity is smaller. Less substitution is better for air travel volumes and for passenger safety as air travel is much safer than highway driving.

3. Forecasting Impact if Demand Elasticity Is -0.5

The numbers for annual fatalities based upon 2007 air travel passenger data with elasticity at -0.5 are displayed in Tables 9 and 10.

% diversion ΔP equivalent					
	10	20	30	40	50
20	3	7	11	14	18
40	7	14	22	29	36
60	11	22	33	44	55
80	14	29	44	58	73
100	18	36	55	73	91

Table 9. Annual fatalities with elasticity at -0.5 based on Table 3 data

% diversion ΔP equivalent					
	10	20	30	40	50
-10	-2	-4	-6	-8	-10
10	2	4	6	8	10
30	6	12	17	23	29
50	10	19	29	39	49
70	13	27	41	55	69

Table 10. Annual fatalities with elasticity at -0.5 based on Table 4 data

With elasticity at -0.5 the study found, based on Table 9, a range of additional deaths per year from 3 when ‘ΔP equivalent’ is 20 and 10 percent of those choosing not to fly substitute driving for flying all the way to an additional 91 deaths when the value of ‘ΔP equivalent’ is 100 and 50 percent of passengers choosing not to fly substitute driving as their mode of transportation. Table 10 ranged from zero additional deaths up to 69 per year from passengers choosing to substitute driving for flying. Tables 9 and 10 illustrate that the additional deaths are lower than in Tables 5 through 8 due to the fact that -0.5 is less elastic than -1.5 and -1.0 and fewer travelers will again chose to substitute driving for flying when elasticity is smaller. The forecasted results support the idea that the smaller the elasticity the smaller the substitution factor. However, even with a small elasticity such as -0.5 the study found there was still a rise in additional deaths due to substituting driving for flying as a result of implementing full body scanners.

B. APPLICATION OF 9/11 IMPACT STUDY FINDINGS

1. Question

Once the forecasted models were created, the researchers wanted to know just how plausible were those predictions. One way to test the plausibility of the results above is to compare them with results from another study of air travel regulations. The study selected to compare the forecasted full body scanner models against was a report containing the findings of three economists (Blalock, Kadiyali & Simon, 2005) regarding the results of post- 9/11 air travel safety regulations on demand for air travel. The 9/11 impact study examined what percentage of passengers were affected by the air travel safety regulations and, the fact that those regulations caused passengers to substitute driving for flying, how many additional deaths were caused by the air travel safety regulations. The 9/11 impact study is discussed in the following sections.

2. Data Manipulation

The 9/11 impact study found that after baggage screening requirements were added, airline passenger volume fell by approximately 16 percent on short-haul flights (trips of 500 miles and 1,000 miles or less round trip). The study found that short-haul passengers were strongly affected by the new air travel safety regulations and substituted driving, taking a bus, or taking a train in place of flying. The study attributed to the regulations an increase of 242 driving fatalities per month from October through December 2001 and, in total, suggests about 1,200 driving deaths are attributable to the safety regulations imposed post- 9/11 (Blalock, 2005, p.1).

The researchers created a model to view the predicted effect of the full body scanner security measure and compare this effect against the findings of the 9/11 impact study. The full body scanner model used the 9/11 impact study finding of passenger volume falling by 16 percent following the implementation of baggage screening as an assumed standard. To create a broader range of data, the 16 percent was doubled and halved to 32 and 8 percent, respectively.

Using passenger short-haul volume data from 2007, the researchers' model shows what would happen if 8, 16, and 32 percent of passengers chose not to fly and instead substituted driving for flying. This model shows how many more driving fatalities would occur if passengers choose to substitute driving for flying. In accounting for the fact that air passengers on short-haul flights have alternate options to substitute for flying (car, bus, train), a range was created showing the fatality rate if 10 percent choose to substitute driving for flying all the way up to 100 percent of those passengers choosing not to fly short haul and drive instead. The results are shown in Table 11.

3. Presentation

The numbers for annual fatalities using the assumption of the 9/11 impact study and 2007 data discussed above are displayed in Table 11.

% air passengers no longer flying % no longer flying substituting driving instead			
	8	16	32
10	9	19	38
20	19	38	76
30	28	57	114
40	38	76	153
50	47	95	191
60	57	114	229
70	66	133	267
80	76	153	306
90	86	172	344
100	95	191	382

Table 11. Predicted annual fatalities based on 9/11 impact study

4. Description

Table 11 illustrates the probable impact of implemented full body scanner security measures. The greater the percentage of short-haul travelers diverted to highway travel by the implementation of full body scanners, the higher the probable death rate will be.

Therefore, of the 16 percent of passengers choosing not to fly, if 10 percent chose to substitute driving, an additional 19 deaths a year would occur. If 100 percent chose to substitute driving for flying, an additional 191 deaths would occur as a result of the full body scanner travel safety regulations. Although the numbers are not as high as the 242 a month the 9/11 study found, the numbers support the theory that safety regulations cause very real and unsafe unintended consequences. A case can be made that the safety regulations imposed post-9/11 pushed out many of those passengers most sensitive about their privacy to substitute driving for flying. Therefore any new results from safety regulations dealing with privacy, like the full body scanners, would not have as great an impact as previous safety regulations because many passengers who are sensitive about privacy are already substituting driving for flying. With this in mind, the researchers think the size of the predictions for how full body scanners will affect air travel and passenger safety is understated and highly plausible.

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V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

“Destruction is not profit” –Frederic Bastiat

A. SUMMARY

The use of full body scanner machines invades privacy in a vivid manner. Essentially, a graphic nude photograph of each passenger is captured and possibly held for posterity. Organizations and officials within the United States continue to deliberate when communicating with the general public what is actually being done with these images in so far as how they are captured, who can view them, what information is carried with the image, and is it stored permanently or is it destroyed? Even if the invasion of privacy were not enough, officials have stated the full body scanner is not foolproof and the machine is not capable of detecting objects inside body cavities. Therefore, why use them in the first place? Thus, the invasion of personal privacy coupled with how high a value a passenger places on his/her privacy will determine the effect the full body scanner will have on air travel and passenger safety. This study produced a simple, conservative estimate of the probable impact on air travel passenger volume as a result of implementing full body scanners in airports. If demand elasticity for short-haul travel is -1.5, highway driving fatalities will increase up to 275. If demand elasticity is -1.0 highway, driving fatalities will increase up to 183. If demand elasticity is -0.5, highway driving fatalities will increase up to 91.

The researchers analyzed previous studies dealing with air travel safety regulations to understand the unintended consequences that accompany air travel security decisions. One of the objectives of this study was to predict the impact full body scanners will have on air travel and passenger safety. The study was intended to answer the following questions:

What will be the effect full body scanners will have on air travel and passenger safety?

What were the previous effects of increased air travel security measures on air travel and passenger safety?

Does evidence exist to support the idea that more air travel security measures actually leads to less safety for passengers?

The literature review highlighted studies that looked at previously implemented air travel security measures, and how those measures, originally created for safety, caused such an inconvenience and privacy invasion that they led a percentage of air travel passengers to chose to substitute driving for flying and switch from a safer mode of transportation (flying) to a less safe one (driving).

The 2005 studies performed by Blalock, Kadiyali, and Simon looked at the unintended consequences of baggage screening post-9/11. The studies determined baggage screening was seen by a small percentage of passengers as such an invasion of privacy that they elected to substitute air travel with another mode of transportation. Short-haul passenger volume fell by 16 percent as a result. The impact the security measures had on highway driving safety was reviewed and over 1,200 deaths were attributable to the post-9/11 air travel security measures. The percentage of passengers who chose to substitute air travel with an alternate mode of transportation highlighted the sensitivity and importance privacy plays in a passenger's decision-making process.

An earlier study, by McKenzie and Warner, looked at the impact airline deregulation had on highway safety. The study estimated deregulation of the airline industry lowered the congestion on the highways and was attributable to saving 1,700 lives each year for a period of six years. The research highlighted the correlation between flying and driving: the more passengers that fly, the less congestion there is on the highways. Therefore, due to the ease and accessibility of flights, the highways were safer than otherwise.

A further study conducted by InterVISTAS estimated air travel demand elasticities for both short and long-haul flights based on air travel fares. The study

estimated short-haul travel in the United States had an elasticity range from -1.54 to -0.88 with short-haul leisure passengers being more price-sensitive than business passengers.

In this study, the researchers used a range of elasticities to predict the impact full body scanners will have on air travel and passenger safety. Finally, this research used previous studies involving air travel security measures for comparison to find if the researchers' predictions seem plausible.

Mathematical tables were created using the elasticity formula to predict the impact full body scanners will have on air travel and passenger safety. The predictions for the impact full body scanners will have on air travel and passenger safety are presented below.

With demand elasticity at -1.5, annual highway driving fatalities attributable to full body scanners range from zero to 275.

With demand elasticity at -1.0, annual highway driving fatalities attributable to full body scanners range from zero to 183.

With demand elasticity at -0.5, annual highway driving fatalities attributable to full body scanners range from zero to 91.

The impact of full body scanners on passenger safety decreases when the demand elasticity goes down. Additionally, the effect would likely decrease once the new security measure becomes the norm and is more accepted by air travel passengers. However, with the cost of \$150,000 per machine and the security measure invading passenger privacy to the point passengers choose to substitute driving for flying, a review of the decision to use these machines should be conducted to re-evaluate the actual costs and benefits.

This study highlights the importance of making a decision only after understanding the consequences that are both seen and not seen.

B. CONCLUSIONS

Millions of passengers fly short-haul trips every year, and a certain percentage of those passengers will choose to substitute an alternate mode of transportation for flying as a result of the use of full body scanners. Though only a small percentage will choose to substitute driving for flying, those passengers place themselves into a more precarious situation. Previous studies of air travel security measures have highlighted the costs of driving versus flying and how air travel security measures have impacted highway driving fatality rates. Based on the findings from previous studies, one must agree that implementing full body scanners at airports will reduce air travel volume and increase risks from other hazards. It would be fair to assume that passengers on the margin in regards to the inconvenience and invasion of privacy the current security measures impose will finally be turned away from flights by the use of full body scanners. The substitution of driving for flying will result in more congestion on the highways and are forecasted by this study to increase highway driving fatalities by as many as 275 deaths per year.

When air travel passengers decide to substitute driving for flying, they create more congestion on the highways. This congestion not only creates a riskier mode of transportation for the air travel passengers, but also places a higher level of risk on every other driver on the same highways. The decision to implement full body scanners needs to be revisited with the full picture in mind to thoroughly weigh all the costs and benefits of this particular security measure. The loss of life forecasted from the implementation of the full body scanner should, in and of itself, demand revisiting and possibly revoking, this decision.

This study's predictions are constrained by factors relating to the data available for collection. First, there are no data on the sensitivity of short-haul passengers to full body scanners. Second, there are no data on the probability that those passengers choosing not to fly will choose to drive instead. Actual numbers would have provided a more concise and clear projection of the impact full body scanners will have on air travel and passenger safety. Third, data on the time delays associated with full body scanner

use were not complete and the predicted times may bias the fatality predictions. One conclusion that can be made, based solely on the elasticity data collected, is that short-haul passengers are much more likely than long-haul passengers to have their transportation mode affected by the usage of full body scanners.

This study has highlighted that evidence does exist to support the theory that more air travel safety regulation leads to less realized safety for the passengers. Full baggage screening resulted in a 16 percent decrease in passenger volume that pushed more air passengers back onto the nation's highways. Previous studies showed that more regulation created crowded dangerous highways while less regulation relieved congestion on the highways, making them safer. It is highly probable that this next step, full body scanners, will hit a nerve with those who value their privacy and, once again, cause more passengers to take to the highways.

C. RECOMMENDATIONS

Further follow-on study needs to be done to analyze the forecasted model results after there is complete implementation of full body scanners across the nation. Only time will tell to what degree passengers value their privacy and how many chose to substitute driving for flying. The Department of Homeland Security and Transportation Security Administration need to provide the proper rationale behind the decision to use full body scanners in airports, if one exists. Machines can be beaten by hiding objects inside of body cavities; why is there such a need to purchase, train, and maintain additional machines that may or may not make flying safer?

Post-9/11, air travel passengers understood the old paradigm of hijacking was over and a new paradigm had emerged. Gone are the days when hijackers wanted to negotiate and would release hostages. Today's hijackers view an airplane as a cruise missile and passengers understand this fact and will act accordingly. United Flight 93 on September 11, 2001, provided evidence that passengers would no longer cooperate with hijackers. Since then, there have been no new hijackings inside the United States' airspace.

Additionally, follow-on study should be conducted to figure out if air passengers would possibly ever simply assume the risk flying entails. When driving a car on public streets, one understands there are certain risks accompanied with that behavior; thus, the market for private car insurance. Could there be a sign at the airport stating, “FLY AT YOUR OWN RISK?” The known risk of possible hijackers has always existed and that did not stop passengers from flying in years past, when minimal security made the behavior “safe” enough to participate in. Why is there the need for added security measures that provide more inconvenience and privacy invasion leading to passengers substituting a less-safe mode of transportation for one that is safer? If a group of individuals truly desires to take over an aircraft, they do not even need typical weapons. Implementing additional security measures that drive passengers away from flying and onto the roads not only creates greater risk to those passengers but also greater risk to the other individuals already driving those same roads. The United States prides itself on the protection of personal freedom. Therefore, measures, however well intended, appearing to breach personal freedom must be duly considered and thoroughly vetted to attempt to capture both the known effect and the possible unseen consequence.

LIST OF REFERENCES

- Bastiat, F. (1998). *The law* (2nd ed.). Foundation for Economic Education, Irvington-on-Hudson, New York.
- Blalock, G., Vrinda, K., & Simon, D. H. (2005). The impact of 9/11 on road fatalities: The other lives lost to terrorism. Working Paper, Cornell University, Ithaca, NY.
- Blalock, G., Vrinda, K., & Simon, D. H. (2005). The impact of post 9/11 airport security measures on the demand for air travel. Cornell University, Ithaca, NY.
- CNN. (2010). Christmas Day bomber had no chance. Retrieved, May 18, 2010, from <http://www.cnn.com>
- EPIC, Electronic Privacy Information Center. (2010). Whole body imaging technology and body scanners (“Backscatter” X-ray and millimeter wave screening). *EPIC*. Retrieved, May 20, 2010, from <http://www.epic.org/privacy/airtravel/backscatter/>
- Gillen, D., Kanchi, S., & Levison, D. (2002). Inter-technology effects in intelligent transportation systems. Working Papers 200202. University of Minnesota: Nexus Research Group.
- Hsu, J. (2010). GAO says airport body scanners may not have thwarted Christmas day bombing. *The Washington Post*. Retrieved, May 25, 2010, from <http://www.washingtonpost.com/wp-dyn/content/article/2010/03/17/AR2010031700649.html>
- InterVISTAS Consulting Inc. (2007). *Estimating air travel demand elasticities*. Washington, DC: Author.
- Jaunted. (2010). Retrieved, May 31, 2010, from <http://www.jaunted.com/story/2010/1/6/165831/7563/travel/Full-Body+Scanners+101%3A+How+Naked+Is+Full-Body+Scan+Naked%3F>
- McKenzie, R. B., & Warner, J. T. (1987.) The impact of airline deregulation on highway safety. *Center for the Study of American Business*, Washington University, St. Louis, Missouri.
- Privacy International. (2009). PI statement on proposed deployments of body scanners in airports. Retrieved, May 25, 2010, from [http://www.privacyinternational.org/article.shtml?cmd\[347\]=x-347-565802](http://www.privacyinternational.org/article.shtml?cmd[347]=x-347-565802)
- Rosen, J. (2010). “Nude awakening: The dangerous naked machines.” *The New Republic*. Retrieved, May 25, 2010, from <http://www.tnr.com/article/politics/nude-awakening>

- Silver, N. (2009) Calculus of terror. *Collective Consensus*. Retrieved May 18, 2010, from: <http://www.benjaminbdaniels.com/nate-silvers-calculus-of-terror-579>
- Smith, F. L. & Cox, B. (n.d.). Airline deregulation. *The Concise Encyclopedia of Economics*. Retrieved, May 20, 2010, from <http://www.econlib.org/library/Enc/AirlineDeregulation.html>
- TPA, Tampa International Airport. (2010). Security information. Retrieved, May 31, 2010, from <http://www.tampaairport.com/security/index.asp>
- Travis, A. (2010). New scanners break child porn laws. *Guardian.co.uk*. Retrieved, May 20, 2010, from <http://www.guardian.co.uk/politics/2010/jan/04/new-scanners-child-porn-laws>
- TSA.gov, Transportation Security Administration. (2010). Imaging Technology. Retrieved, May 31, 2010, from http://www.tsa.gov/approach/tech/imaging_technology.shtm

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