EXPLORING THE EXISTENCE OF AN ANIMAL WELFARE KUZNETS CURVE

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EXPLORING THE EXISTENCE OF AN ANIMAL WELFARE KUZNETS CURVE

A Thesis

by

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Abstract

of

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Madhavi Knickerbocker Kennedy

This thesis examines the relationship between an animal welfare measurement (per capita hunting license sales) and economic growth in the framework of an Animal Welfare Kuznets Curve (AWKC). The data covers all 50 states over the period 1963-2009 yielding 2,350 observations for each variable. Following previous studies for an Environmental Kuznets Curve (EKC), the dependent variable is regressed on income in a linear, quadratic, and cubic fashion to allow for non-linearity of the Kuznets curve. Using panel data techniques, results with state fixed effects show that state differences matter and thus motivate the estimation of a state-specific model. This model allows for curves to vary across states and results show that some states display an inverted-U while others display a U-curve or are monotonically increasing. Thus, a model that allows for differences between states is the best approach.

____________________________, Committee Chair
Jonathan D. Kaplan, Ph.D.

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Date

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Finally, I dedicate this thesis to my husband, my cat-kids, and to the rest of my family and friends – all of whom I get to spend more time with now that I am FINALLY done with school.

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Chapter 1

INTRODUCTION

This thesis examines whether an animal welfare Kuznets curve exists in the United States. Animal welfare has long been a part of our culture, but has increasingly gained momentum since the late-nineteenth and early-twentieth centuries. Mahatma Gandhi proposed that one can judge a nation by how it treats its most vulnerable, as when he said: "The greatness of a nation and its moral progress can be judged by the way its animals are treated."

From the extreme People for the Ethical Treatment of Animals (PETA) protests over the past few decades to more recent voter-driven initiatives, it seems that some segment of society has always been concerned with the treatment of animals. In 2008 California, voters passed Proposition 2 by a margin of 63% to 37%: a tremendous victory for the Humane Society of the United States (HSUS). The Proposition 2 initiative prohibits pregnant pigs, calves raised for veal, and egg-laying hens from being confined in such a manner that they cannot freely turn around, lie down, stand up, and extend their limbs. Violations are punishable as misdemeanors with fines of up to $1,000 and/or imprisonment for up to six months in a county jail. Interestingly, this initiative passed during an economic slump and after proponents admitted that the measure would increase consumer prices. In 2002, Floridians passed Amendment 10 by a margin of 55% to 45%. This amendment to the Florida Constitution changed the way pregnant pigs are housed by banning the use of gestation crates that do not allow a pig to even turn around. Georgia passed Measure 6 in 2002 by an even more impressive 71% to 29%. This measure created a specialty spay/neuter license plate, the proceeds of which would fund low-cost spay and neuter programs. These examples represent a tremendous leap forward from the founding of the American Society for the Prevention of Cruelty to Animals in 1866 and its early efforts in New York to pass laws preventing the abuse of animals (Brinkley, 2009, p. 48).

Capitalism has been and will remain the backbone of our nation's economic growth (Norton et al., 1994, p. 276). Natural resources were heavily used and even abused to propel the economy forward in this country's early history (Morison, Commager & Leuchtenburg, 1980, p. 726). As the nation develops, more and more emphasis is being placed on preserving and restoring the environment for the benefit of future generations. This trend can be traced from the establishment of our first national park in 1872 to passage of the Clean Air Act and Clean Water Act in 1970 and 1972, respectively.

Some scholars, including List & Gallet (1999), have hypothesized that a Kuznets curve exists for environmental pollutants. They argue that as a nation develops and per capita income rises, the use of natural resources rises along with a growth in environmental pollutants until some peak point when it starts descending. Exploitation is in some sense a central part of capitalism. Thus it can be argued that animals have been and will be another commodity for society to exploit along the path toward economic growth. Over the last century, the use of animals for labor has significantly declined in the United States as a result of technological advances that allow machines to harvest our crops and transport our goods. This has been complemented by a rise in vegetarian life-style choices, which gives rise to new "fake" meat products that are developed and marketed to consumers. While draft animals are no longer ubiquitous in today's American society, this does not necessarily mean that the treatment of animals has improved. We continue to exploit them in large-scale egg laying productions, factory farming, and animal testing of various consumer products, chemicals, and pharmaceuticals. As such, the question of determining if society has improved in the way it treats its most vulnerable is an interesting and dynamic one that can be viewed on many levels and from many angles.

The hypothesized Kuznets curve assumes an inverted U-shape with per capita income on the horizontal-axis and income inequality on the vertical-axis. It is assumed that income inequality increases with greater economic growth and decreases after a period of time. An environmental Kuznets curve (EKC) examines the relationship between per capita income and environmental pollution. The hypothesis of the EKC is that there will be more environmental pollution at low levels of income when a country is growing, with pollution increasing until the level of income reaches a turning point. Once the turning point is reached, income will continue to grow but environmental pollution will decline. This thesis will apply the concept of a Kuznets curve to animal welfare in the United States, with the principle question being: Does an animal welfare Kuznets curve exist in the United States?

The following chapters are organized as follows: Chapter 2 reviews relevant Kuznets curve literature; Chapter 3 describes the data that will be used as well as presents data sources and summary statistics; Chapter 4 will present the methodology, regression results, and a detailed empirical analysis; and Chapter 5 presents the conclusion, summarizes the results, and makes suggestions for future research.

Chapter 2

LITERATURE REVIEW

There are three distinct areas of research/literature on Kuznets curves. The first area of literature covers income inequality, building upon a paper published by Simon Kuznets in 1955 that examined the relationship between economic growth and income inequality. The so named Kuznets Curve was widely researched afterward and delved into areas other than just income. The second area of literature is rapidly expanding, largely due to a recent focus on environmental issues. The Environmental Kuznets Curve (EKC), evaluates the relationship between environmental pollutants and economic growth. The last, and newest, research area is in animal welfare. The Animal Welfare Kuznets Curve (AWKC) is a relatively new term and only has one peer-reviewed journal article available in scholarly research databases. This research uses a measurement of animal welfare and per capita income to evaluate the existence of a Kuznets Curve for animal welfare.

2.1. Kuznets Curve

The birth of the Kuznets Curve started with Simon Kuznets' paper (1955), in which he asked if income inequality increased or decreased with a country's growth. Since there was a lack of data at the time, he made tentative guesses and searched for additional evidence to back up his assumptions. In general, he found that the more developed the country as a whole, the less income inequality there was. He surmised that as countries grow, so too do political and social pressure to "spread the wealth." In developed democratic countries, individuals from lower-income backgrounds can be elected to political office, which can result in legal changes to benefit the lower-income groups.

Kuznets (1955) found that developed countries with a tax base have less income inequality due to having a form of government that redistributes wealth by taxing the wealthy and making payments to those with less. Thus "legislative interference" results in less income inequality. However, the decreased inequality draws the poor from less developed countries to more developed countries like the United States, thereby perpetuating the income inequality cycle.

The United States has taken advantage of new technologies and kept growing, but has lower levels of income inequality relative to its past and less developed countries due to government taxation and transfer of wealth. Developing countries have a chance to become rich quickly through rapid technological growth. Increased per capita income resulting from industrialization increases the per capita income of the country as a whole. To grow, a country must experience income inequality while transitioning from pre-industrialization to industrialization and the development of new technologies. This is where the inverted-U takes shape: the least developed countries have low levels of income inequality and as they move toward moderate development their income inequality grows until a turning point is reached, at which point the most developed countries continue to grow and income inequality declines. Kuznets (1955) argued that to grow, a country must first experience an increase in income inequality followed by decreased inequality after the inequality "turning point" is reached.

Over time, income inequality data became available through the development of a GINI coefficient by Corrado Gini, an Italian statistician. The GINI coefficient provides a measure between 0 and 1 of income inequality in a country or state. List & Gallet (1999a) used data from lower-developed and higher-developed countries and found that low and middle income countries follow an inverse-U curve in which income inequality first increases with economic growth and then decreases; however, income inequality starts increasing again for countries with per capita incomes above $12,115 (1985 international dollars), including Australia, Japan, Sweden, and the United States. While the authors were not able to determine what causes the increase, they hypothesized that the wage gap is due to countries switching from a manufacturing to a service-based economy in which education is valued and rewarded with higher wages. Again, List & Gallet (1999a) reference the relevance of government by remarking that these "bimodal pay scales" are an area of concern for policymakers due to equity issues.

2.2. Environmental Kuznets Curve

There is an extensive amount of written work focusing on environmental pollutants and the Kuznets curve (sulfur dioxide, suspended particulate material, nitrates, fecal matter, etc.); however, Grossman & Krueger (1991) were the first economists to use data collected by the World Health Organization (WHO) and the United Nations Environment Programme (UNEP) and made available through the Global Environmental Monitoring System (GEMS) to test the relationship between economic growth and three air pollutants: sulphur dioxide (SO_2), suspended particulate matter, and smoke. With environmental organizations insisting that free trade with Mexico would increase pollution and decrease air quality as a result of companies choosing to locate in Mexico (instead of the United States which has stringent pollution requirements and higher pollution abatement costs), Grossman & Krueger (1991) examined the claim. Since Mexico neither monitored nor measured pollutants, the authors tested their hypothesis that air quality is lowered with economic growth by using panel data from forty-two countries made available through GEMS. They were able to reject their hypothesis using air quality data from a wide range of geographic areas (urban, suburban, rural, agricultural, oceanside, for example). Grossman & Krueger (1991) found an inverse-U curve that was similar in shape to the one originally proposed by Kuznets in 1955. The Environmental Kuznets Curve (EKC) showed that while the level of pollutants increased during the beginning stages of economic growth for low income countries, the turning point was reached at a relatively low level of per capita income of $5,000 U.S. dollars (1985). In 1988, Mexico was near the turning point in the inverse-U curve with a per capita income of $4,996. Grossman & Krueger followed up their 1991 study with additional pollutants in 1995 and found similar results. They surmised that changes in policy are one of the factors contributing to the turning point. As a country grows and per capita income increases, the citizens of the country demand better living conditions from their government. Like Kuznets (1955) remarked, pollution decreases as a result of "legislative interference."

Following up on Grossman & Krueger (1991), Selden & Song (1994) used the same air quality database but added two other air pollutants, nitrogen oxides (NO_x) and carbon monoxide (CO). Instead of focusing on urban air quality, Selden & Song (1994) used aggregate emissions data and included forecasts for income and population growth. They found essentially the same results except with slightly higher turning points than those in Grossman & Krueger (1991). One reason the authors gave for the difference in turning points is that Grossman & Krueger (1991) focused on urban air quality emissions while Seldon & Song (1994) used aggregate emissions. They proposed that populations in urban areas are typically higher and denser than in rural areas and thus have greater health risks for the population as a whole, which is of concern to policymakers. In addition, urban residents usually have higher incomes and thus more political clout to get laws changed.

While previous studies have found a clear inverted-U shape for pollutants, some question the reliability of cross-country studies because of data issues. Not all countries have testing and data gathering requirements that are found in wealthy countries like the United States. To compare, List & Gallet (1999b) used state-level data for the United States only to see if sulfur dioxide and nitrogen oxide emissions exhibit an inverted-U. In short, they find these pollutants have the typical inverted-U shape but comment that their findings, like cross-country studies, do not take state differences over time into account, which is a problem.

One area of study linking economic growth and animals together, but not quite into the animal welfare topic, is biodiversity conservation/loss. Dietz & Adger (2003), Asafu-Adjaye (2003), McPherson & Nieswiadomy (2005), and Mills & Waite (2009) all examine the relationship between the two. One of the by-products, or necessities, of economic growth is resource use, for example: forests are cut down for lumber or to make way for agricultural use. The consequences of such actions include not only the loss of aged trees but loss of habitat for many species of plants and animals. However, citizens also demand open space and wilderness areas for recreational use, presenting a quandary. Once a species faces extinction due to habitant loss, it is very difficult to bring that species back, as found by Dietz & Adger (2003). They use “predicted species richness at the national level” and “protected area designation and implementation of international trade regulations” as their measures of biodiversity. Using the Kuznets curve theory, the shape of the curve should not be an inverted-U but a U shape to indicate first a loss of biodiversity with economic growth then rising after the turning point to indicate a gain in biodiversity. The results of their analysis indicate that there is a loss in economic growth followed by a leveling off because species do not populate as fast as they are lost; however the lack of reliable and consistent data on species biodiversity does not allow them to draw conclusive results.

Not all authors agree on the existence or robustness of a Kuznets curve. Harbaugh, Levinson & Wilson (2002) question the robustness of results in previous studies and to prove their point they used additional data and specifications for two previously published papers that concluded an EKC exists. Published research by the World Bank (1992) and Grossman & Krueger (1995) both found strong evidence of the existence of an EKC. Harbaugh et al. (2002) use data from GEMS for measures of three air pollutants: sulfur dioxide, smoke, and total suspended particulates. This is the same data used by Grossman & Krueger (1995), but these authors use an additional 10 years of data at both the front and back end of the range provided by Grossman & Krueger (1995). Additionally, some of the original data was revised during the period between these two studies. With revised pollutant values, Harbaugh et al. (2002) started their analysis with the same observations and econometric specification as used by Grossman & Krueger (1995). They find that just this small change in the original pollutant data yields “large changes in the regression results and the shape of the predicted pollution-income relationship" (p. 544). Harbaugh et al. (2002) find that results are "fragile," with the underlying reason being "revisions and additions to the underlying data," and conclude that empirical evidence for the three air pollutants does not support the theory that environmental pollutants either increase or decrease with economic growth.

2.3. Animal Welfare Kuznets Curve

While Kuznets curves are widely analyzed and articles can easily be found, animal welfare articles are few and far between in economic journals. While there are many studies on the EKC and endangered species, biodiversity, and animal habitat loss through deforestation, they do not necessarily translate well into animal welfare as far as animal rights are concerned. The typical animal-related articles in economic journals, particularly in the agricultural area, focus on livestock in terms of consumer demand – like beef, pork, or chicken – or as a factor in agriculture. Most animal welfare, or more accurately, animal rights articles can be found in disciplines other than economics, like food policy journals such as *Journal of Food Products Marketing* and *Food Policy*. There is only one economic journal article which melds together both the Kuznets curve and animal welfare/rights. Frank (2008) looks at various indicators of animal welfare, from the rise in pet-keeping, factory farming, consumption, and the experimentation of animals in laboratories. Frank (2008) hypothesizes that "…an "animal welfare Kuznets curve" may exist, with harm to animals initially rising with economic growth followed by improvement in the treatment of animals after some peak value." Frank (2008) uses a "simple two-variable regression model" with the animal welfare measurement dependent on income. These animal welfare measurements are: European residents opinion of farmed animal welfare; laboratory animal use in Europe, Canada, Greece, and Japan; live animals used in vet schools in the United States; companion animal euthanasia; number of animal protection organizations in countries; and length of time since a felony animal cruelty statute was passed in a U.S. state.

While Frank (2008) finds that most results are mixed, the treatment of companion animals displays a clear inverted-U curve. Like many other authors have commented on environmental degradation, Frank (2008) also finds that changes at the policy level are often what bring about change in animal welfare. This is the article that will provide the best background for this research and will further explore the existence of an animal welfare Kuznets curve by using a new previously untested dependent variable, per capita hunting license sales, over a longer time period than previously studied and additional model specifications.

Chapter 3

DATA

This chapter describes the data used to explain how income affects animal welfare. The panel data are annual observations from all 50 states covering the time period of 1963-2009. Descriptions of the variables used are presented in the following paragraphs along with summary statistics. The methodology and analysis of results will follow in the next chapter.

While hunting is frequently regarded as recreational, killing any animal for food is morally objectionable for those fighting for animal rights: no matter if it is a deer, bear, chicken or cow (Ozoga, 2010). Thus, this analysis uses state-level hunting license sales data as a measure of animal welfare. The data are for all 50 states and are available for the years 1963-2009. This yields a total of 2,350 observations.

The dependent variable is Sales of Resident Hunting Licenses, Tags, Permits, and Stamps and was obtained from the United States Fish and Wildlife Service (FWS); however, it is important to note that residency laws vary by state. To be considered a resident for the purpose of purchasing a hunting license in California, that person must reside within the state for at least six months.[1] Because hunting is considered a recreational activity that draws hunters from out of state, only resident data are used to capture differences between states. Every person who desires to hunt birds or mammals

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[1] California Fish and Game Code, Sections 57 (nonresident) and 70 (resident).

is required to purchase a hunting license. To hunt certain big game mammals, like deer and bear, tags must be purchased and many states set a limit to how many a person may purchase in a single year. Stamps must be purchased to hunt waterfowl and permits are issued to hunt in certain state-operated wildlife areas of a state. The calculation year of the FWS data is two years later than the license year given for the data on the FWS website[2]. The data was thus adjusted to reflect the actual license year. Hunting license sales data were divided by the population of the state to obtain hunting license sales per capita (*pchunt*).

Population and per capita personal income data are available through the Bureau of Economic Analysis (BEA): Regional Economic Accounts. Population (*population*) data were used to calculate per capita hunting license sales as described above. Per capita personal income was adjusted to real 2010 dollars using the Bureau of Labor Statistics (BLS) Inflation Calculator to give the *pcincome* variable. Table 3.1 provides a description of these variables, sources, and internet links.

[2] This is per an email from Richard Aiken, a FWS employee, on February 10, 2011.

Table 3.1: State-Level Variable Sources and Web Links

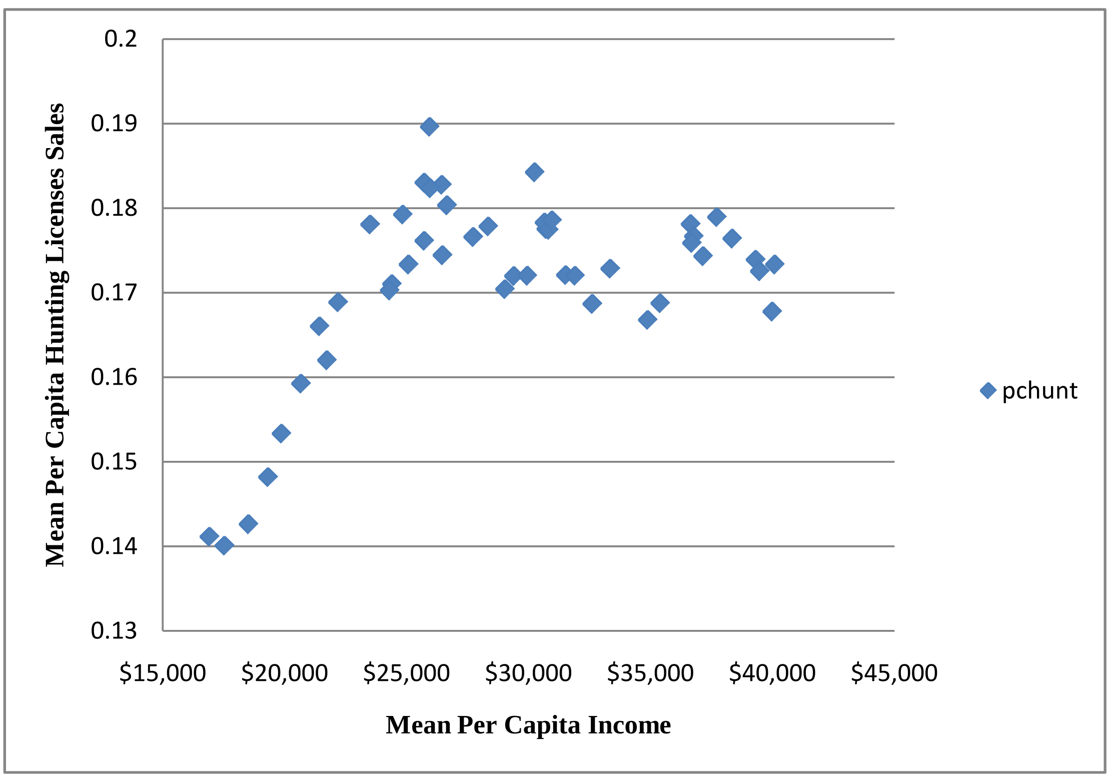
Variable	Description	Source	Web Link
pchunt	Per Capita Resident Hunting Licenses, Tags, Permits & Stamps (divided by population of state to achieve per capita sales data)	*U.S. Fish & Wildlife Service (note: calculation year on website is two years later than actual sales data. Thesis data was adjusted to reflect actual sales for correct year)*	1963-2001: http://wsfrprograms.fws.gov/Subpages/LicenseInfo/Hunting.htm 2002-2009: http://faims.fws.gov/reports/rwservlet?faimskeys&report=fwri0020&program=25
pcincome	Per Capita Personal Income	*Bureau of Economic Analysis: Regional Economic Accounts*	http://bea.gov/regional/spi/default.cfm?selTable=summary
population	Population	*Bureau of Economic Analysis: Regional Economic Accounts*	http://bea.gov/regional/spi/default.cfm?selTable=summary

Table 3.2 provides summary statistics for these variables. The summary statistics below show the mean for per capita hunting licenses sales (*pchunt*) is 0.171 for every one person. In the table and graph below, the maximum is greater than one because a resident can purchase multiple tags in a given year. For example, a resident must purchase a license to hunt and then they purchase a tag for a deer and one for an elk. There was only one state that had per capita sales greater than 1; Montana had per capita sales of 1.33 and

1.09 in 1981 and 1982, respectively. The average over the forty-six year period for Montana was 0.798.

Figure 3.1 shows the mean of *pchunt* and *pcincome* graphed over time. Looking at only the mean of all 50 states, graphically it appears that hunting increased with income following by a slight decline. In Figure 3.1 below, the maximum mean value for per capita hunting licenses sales is 0.1896 and is at its maximum at $25,943 in 1981.

Figure 3.1: Mean Per Capita Hunting License Sales (1963-2009)



Per capita personal income (*pcincome*) displayed a large gap with a low of $10,581 (Mississippi in 1963) to a high of $59,336 (Connecticut in 2007) and averaged $28,998 per year (in 2010 dollars) for the forty-six year period studied.

Table 3.2: State-Level Variable Descriptions and Summary Statistics, 1963-2009

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
pchunt	Per Capita Resident Hunting Licenses, Tags, Permits & Stamps	2350	0.1713942	0.1614515	0	1.325638
pcincome	Per Capita Personal Income	2350	28998.07	7822.58	10580.92	59335.5
population	Population	2350	4868331	5333359	256000	3.70e+07

Table 3.3 displays summary statistics divided into decades for the forty-six years of data. The mean of *pchunt* increased in the 1960's through the 1980's followed by a slight decline in the 1990's and then an increase in the 2000's. While the change over time is subtle, a peak can be seen in the 1980's, suggesting the United States may display an inverse-U curve with respect to the animal welfare measurement. The mean of *pcincome* steadily increased every decade as did the minimum values. The maximum values of *pcincome* decreased slightly in 1980's but overall the highest annual per capita income values increased almost $30,700 between the 1960's and 2000's.

Table 3.3: Summary Statistics by Decade

	Variable	Obs	Mean	Std. Dev.	Min	Max
1963-1969	*pchunt*	350	0.150095172	0.121204088	0.009675714	0.806459654
	pcincome	350	19177.02	3654.85	10580.92	28636.74
1970-1979	*pchunt*	500	0.174193827	0.155305046	0.012167103	0.981672805
	pcincome	500	24485.79	4114.23	14769.36	46377.47
1980-1989	*pchunt*	500	0.177564274	0.167822004	0.009188845	1.325637947
	pcincome	500	27927.74	4667.13	18563.25	44698.72
1990-1999	*pchunt*	500	0.173956824	0.164043237	0.007573329	0.885385584
	pcincome	500	32235.18	4861.11	21905.39	50720.58
2000-2009	*pchunt*	500	0.174770981	0.181260814	0	0.945612685
	pcincome	500	38218.33	5611.82	27374.85	59335.50

Picking a year from each decade and graphing does not provide any revealing insight other than furthering the knowledge that each of the 50 states has differing levels of per capita hunting license sales over time.

Figure 3.2: Per Capita Hunting License Sales for 1965

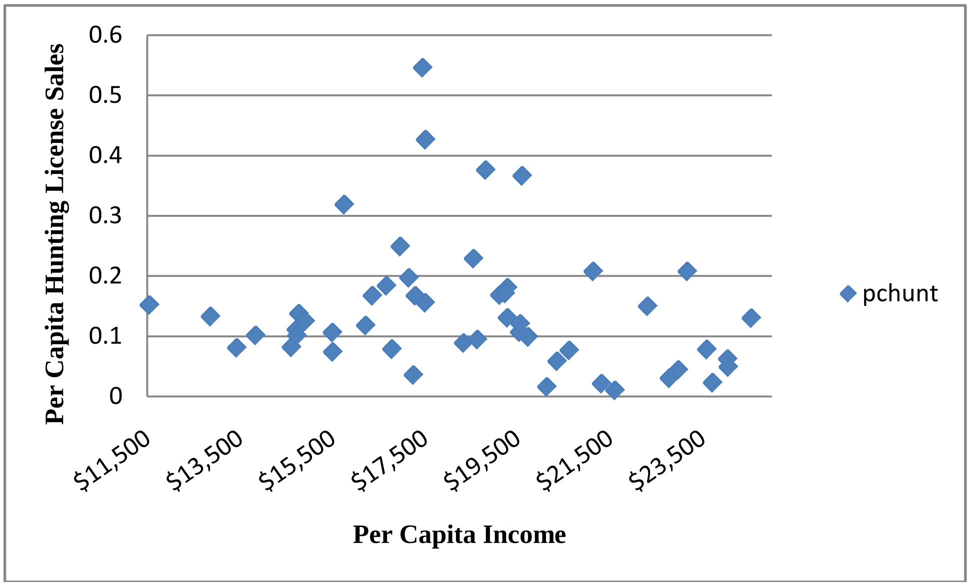


Figure 3.3: Per Capita Hunting License Sales for 1975

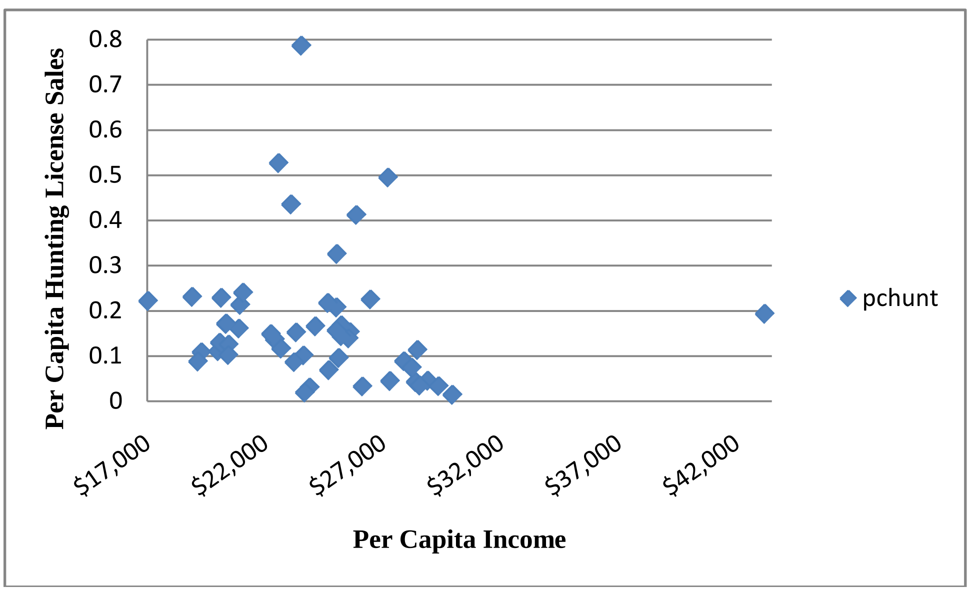


Figure 3.4: Per Capita Hunting License Sales for 1985

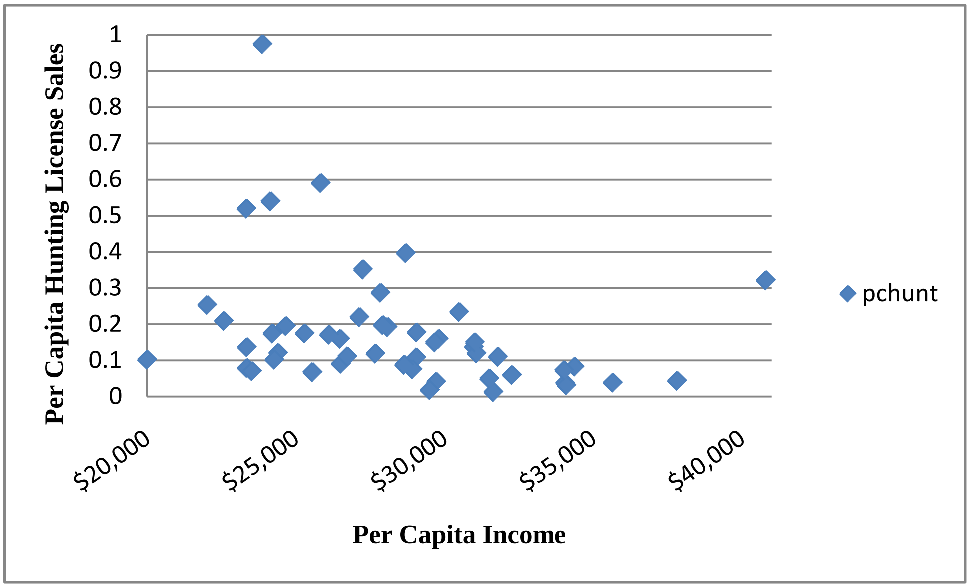


Figure 3.5: Per Capita Hunting License Sales for 1995

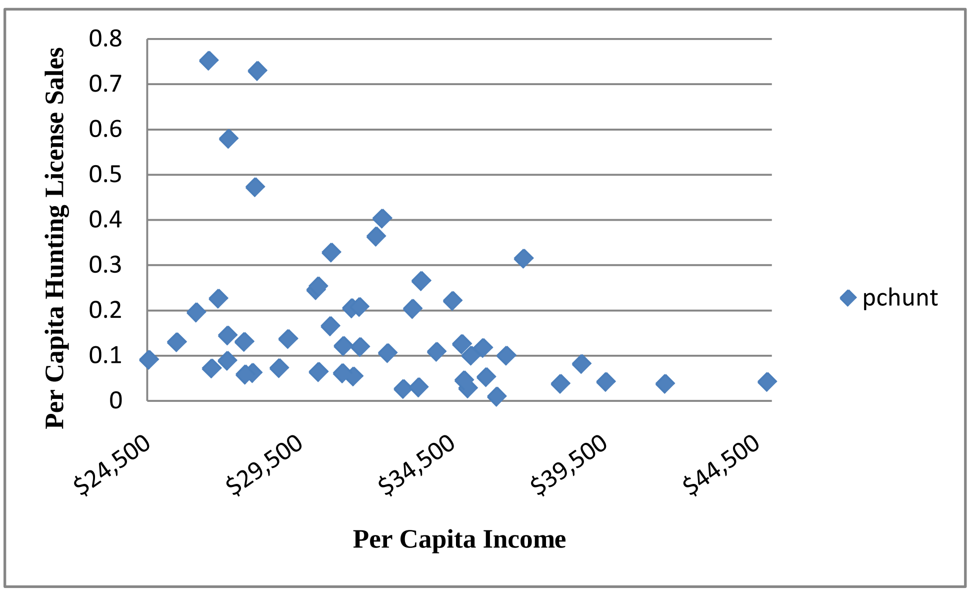
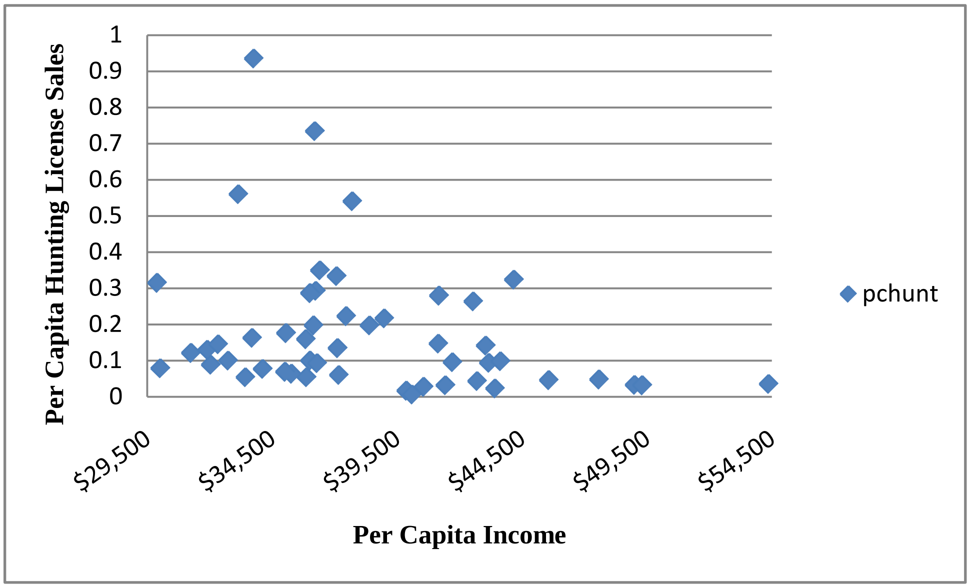
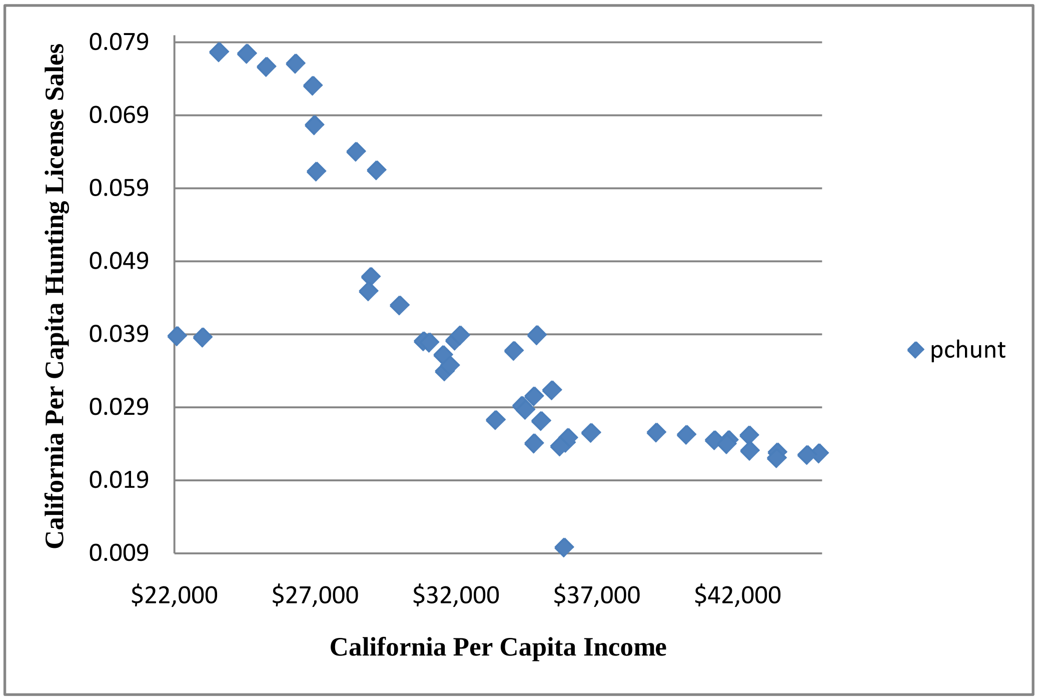


Figure 3.5: Per Capita Hunting License Sales for 2005



Data for California from 1963-2009 was graphed for a glimpse at a state-specific result. Following a rapid jump in the mid-1960's, there appears to be a steep decline and then a leveling off throughout the 2000's. Due to the limited number of years in the data set, the data for California could either indicate that the state is either at the bottom of a U-shaped curve or is at the tail-end of an inverted-U. Additional data from years prior to 1963 could clarify this if such data exists.

Figure 3.6: California Hunting License Sales and Income Growth



Chapter 4

EMPIRICAL ANALYSIS

4.1. Methodology

The objective of this thesis is to evaluate the relationship between income growth and animal welfare, in this case: hunting license sales at the state level. While many other variables besides income could conceivably influence the sales of hunting licenses, such as the cost of attaining a license or the price of meat in the grocery store, the goal of this thesis is to simply examine if animal welfare increases or decreases as per capita income grows over time. The Seldon and Song (1994) article referenced in the literature review used air emissions data as their dependent variable and per capita GDP and population density for multiple countries as the independent variables in their regression. They addressed potential criticism for not including other variables as follows:

> "*A basic issue to address concerns the exclusion from Eq. (1) of explanatory variables other than per capita GDP and population density. It is important in this regard to distinguish between variables that are the endogenous consequences of growth and other, more exogenous factors. Potential examples of the former include the composition of output, the level of education, and the political structure. These factors* ***should*** *(emphasis from authors) be omitted from this single-equation model, insofar as our objective is to assess both the direct and indirect consequences of growth.* (page 149)

Only functions of per capita income are used as independent variables because the variables in this thesis are already transformed into per capita terms.

The impact of income on the measures of animal welfare used in this thesis is accomplished using simplified regression models, as explained below. The only previously published research on an animal welfare Kuznets curve used a simple linear regression with the dependent variable being the animal welfare measurement and the explanatory variable being an income measurement. For example, one of the regressions done by Frank (2008) used the amount of live animals used in veterinary schools in the United States as the dependent variable and state per capita income as the independent variable. Many other Kuznets curve analyses use quadratic and cubic functions of per capita income, as discussed in Chapter 2, and this analysis follows that form.

The Ordinary Least Squares (OLS) equations used here for the state level data are based on List & Gallet (1999b) for an EKC analysis. The empirical models used for this animal welfare analysis with state level data are expressed below in linear, quadratic, and cubic forms.

$$pchunt_{st} = \alpha + \beta_1 pcincome_{st} + \lambda_s + \theta_t + \varepsilon_{st} \tag{4.1}$$

$$pchunt_{st} = \alpha + \beta_1 pcincome_{st} + \beta_2 pcincome^2_{st} + \lambda_s + \theta_t + \varepsilon_{st} \tag{4.2}$$

$$pchunt_{st} = \alpha + \beta_1 pcincome_{st} + \beta_2 pcincome^2_{st} + \beta_3 pcincome^3_{st} + \lambda_s + \theta_t + \varepsilon_{st} \tag{4.3}$$

In these specifications, *pchunt* symbolizes hunting licenses sold per state over time, *pcincome* symbolizes annual income per capita in 2010 dollars, λ symbolizes state-fixed effects, and θ symbolizes time fixed effects. Entity fixed effects control for "…variables that differ across entities but are constant over time" (Stock & Watson 2007). As used in this thesis, fixed effect specifications control for omitted variable bias such as: differences in lifestyle towards a more plant-based diet, differences in the culture or view of hunters and hunting, differences in the species allowed to be hunted (thus changing interest in the purchase of specific licenses), etc. While time and state-fixed effects are denoted in the models above, the results presented in the next section will contain multiple regression results including those with no fixed effects, with time fixed effects, and with state fixed effects.

Squared forms of a variable are used to evaluate whether the variable is increasing or decreasing at an increasing or decreasing rate. To use per capita income (*pcincome)* as an example, if the coefficient is positive then we can interpret this to mean per capita income is increasing. If the coefficient on per capita income squared ($pcincome^2$) is negative, then we can interpret this as *pcincome* is rising but at a decreasing rate. The quadratic specification in Eq. 4.2 allows for an inverted-U shape while Eq. 4.3 including per capita income cubed displays an N-shape. The quadratic function has a peak turning point while the cubic function has two; a peak and a trough.

The expectation is that income growth positively affects animal welfare. So over time, the expectation is that animal welfare will first decrease (*pchunt* increases) following by a turning point and subsequent increase (*pchunt* decreases) thus providing the inverted-U associated with a Kuznets curve.

In a developing country or state, the focus is on human life and securing the essentials of food and shelter. Animals are a source of food, labor and transportation. As income continues to grow, the focus can turn elsewhere to improving the conditions around oneself, including the treatment of animals as has been seen in the United States. Per capita income in the United States has steadily increased in the time period studied, even through the recent recession. Throughout that time, animal welfare laws have continued to pass in state legislatures around the country and at the ballot. President Barak Obama signed legislation in 2010 that banned the “creation and distribution of crush videos” (ASPCA, 2010) where small animals are intentionally stepped on or otherwise killed on video. Eight states have banned or severely restricted steel leghold traps. These states recognized them as a barbaric device with those animals caught oftentimes dying from blood loss due to trying to chew off their own limbs. As stated earlier, Florida voters banned pig gestation crates in 2002 followed by numerous other states including California in 2008, which banned battery cages (egg laying hens), gestation crates, and veal crates. Legislation signed by Governor Schwarzenegger in 2009 outlawed “tail docking” of dairy cows to enable them to engage in the natural behavior of swatting flies away. These are all examples of policy changes at the legislative level that have increased animal welfare over time.

4.2. Regression Results

This section presents the results of regressions using the panel data described in the previous chapter. There are several aspects of the OLS regression models that are important to look at: the estimated coefficient; the statistical significance of the coefficient; and the adjusted R-squared.

The coefficient of an independent variable measures the effect of that variable on the dependent variable. For example, if the coefficient of *pcincome* is 10, then holding all else constant, a one dollar increase in per capita income increases per capita hunting licenses by 10. The significance level of the coefficient is the “rejection probability of a statistical hypothesis test when the null hypothesis is true” (Stock & Watson, 2007, p. 781). In this thesis, the null hypothesis is that there is no relationship between the income variables and hunting license sales and the alternative is that there is a relationship.

R-squared and adjusted R-squared provide a measure of fit of the model. Because R-squared increases whenever a regressor is added to an equation without necessarily improving the model, the adjusted R-squared is used to “deflate” the estimate. The adjusted R-squared “quantifies the extent to which the regressors account for, or explain, the variation in the dependent variable” (Stock & Watson, 2007, p. 202).

An important aspect to mention are the expected signs of the coefficients. Because a Kuznets curve is an inverted-U shape, the signs of the income coefficients should be positive and then negative. Specifically, *pcincome* should be positive and $pcincome^2$ should be negative. The N-shaped cubic model would be positive, negative, positive.

The quadratic and cubic models display turning points. The quadratic model turning point can be calculated by taking the first derivative of $y = aI + bI^2$ and setting it equal to zero. Thus the turning point formula is: $I = -a / 2b$. Heteroskedasticity is corrected for by using robust standard errors and the cluster function controls for autocorrelation with each state.

Table 4.1 presents linear, quadratic, and cubic estimation results of the effect of per capita income and per capita income squared on hunting license sales. The income coefficients are significant in both the linear and quadratic model but not the cubic model. The quadratic specification presents the expected signs as does the cubic model. The income turning point in the quadratic specification is $24,031. The adjusted R-squared is small in all of the results in Table 4.1 with the quadratic model only explaining 2.3% of the variation in *pchunt*. However, recall Harbaugh et al. (2002) found results to be “fragile” to specification. Thus the following tables will present the regression results with time fixed effects (Time-FE), state fixed effects (State-FE), time and state fixed effects (Time&State-FE), and results from using the natural log of the variables.

Table 4.1: OLS Regression With No Fixed Effects

pchunt	Linear		Quadratic		Cubic
Constant	0.2443125	***	0.773008		-0.0737039
	(0.0446999)		(0.0509882)		(0.1621465)
pcincome	-2.51E-06	**	9.18E-06	**	0.0000252
	(1.17E-06)		(4.04E-06)		(0.0000186)
pcincome2			-1.91E-10	***	-7.21E-10
			(6.75E-11)		(6.00E-10)
pcincome3					5.51E-15
					(5.84E-15)
Fixed Effects	none		none		none
R-squared	0.0148		0.0245		0.0257
Adj. R-squared	0.0144		0.0236		0.0245
Peak			24,031		
Observations	2350		2350		2350

Robust standard errors are reported in parentheses.
*,**, *** indicates significance at the 10%, 5%, and 1% level, respectively.

Table 4.2 presents the same linear, quadratic and cubic specifications but includes a time fixed effect. Recall that time fixed effects control for variations over time and constant across states. The constant and income coefficients are significant at the 1-percent and 5-percent level, respectively, in the linear model. The quadratic model displays unexpected signs and the coefficients are not significant. The cubic model again has no coefficients with significance. The quadratic income regressors in Table 4.1 were significant but became insignificant in this model. The adjusted R-squared increased but is still very low and thus this model is not a good fit to explain the variation in *pchunt*.

An F-test was conducted to test "the joint hypothesis that all slope coefficients are zero" (Stock & Watson, 2007, p. 229). In the regression output below, the F-statistic is testing the null hypothesis that the time coefficients have slopes equal to zero. The F-statistic is larger than the critical value in the F-distribution table (Stock & Watson, 2007, inside back cover) and thus the hypothesis of homogenous intercepts is rejected at the 10-percent significance.

The turning point in the quadratic model is a very large negative number and the coefficients do not display the expected signs. Both the income coefficients are negative, thus displaying a monotonic decreasing curve. Because the F-statistic is low and the adjusted R-squared only increased minimally, the time fixed effects model displays some problems. Changes at the national level, potentially through federal legislation either related to increasing or decreasing income taxes or changing animal welfare laws which would impact all states, may have a very minor influence.

Table 4.2: OLS Regression With Time Fixed Effects

pchunt	Linear		Quadratic		Cubic	
Constant	0.3060752	***	0.2875779	**	0.0154782	
	(0.0739866)		(0.1207679)		(0.2002701)	
pcincome	-9.75E-06	**	-8.26E-06		0.0000218	
	(3.88E-06)		(8.25E-06)		(0.0000242)	
pcincome2			-2.27E-11		-9.99E-10	
			(8.86E-11)		(8.68E-10)	
pcincome3					9.90E-15	
					(8.82E-15)	
Fixed Effects	Time		Time		Time	
F-Test Time-FE	3.36	***	3.21	***	3.18	***
R-squared	0.0752		0.0753		0.0785	
Adj. R-squared	0.0564		0.0560		0.0588	
Observations	2350		2350		2350	

Robust standard errors are reported in parentheses.
*,**, *** indicates significance at the 10%, 5%, and 1% level, respectively.

Table 4.3 contains results for OLS regressions with just state fixed effects while Table 4.4 has both time and state fixed effects. They both display improved adjusted R-squares across all regression specifications. The income turning point in the quadratic model with state fixed effects is a believable $34,819 while with time and state fixed effects it is over $1 million. The signs for the coefficients in Table 4.4 are also not the expected signs. Together, this leads to a furthering of the belief that the time fixed effects are causing issues. However, this leads to a conundrum: without time fixed effects, states then heavily influence the dependent variable, *pchunt*.

Table 4.3: OLS Regression With State Fixed Effects

pchunt	Linear		Quadratic		Cubic	
Constant	0.062854	***	-0.0023377		-0.0430228	
	(0.0181466)		(0.0487027)		(0.1067929)	
pcincome	6.85E-07		5.39E-06	*	9.76E-06	
	(7.56E-07)		(3.12E-06)		(0.0000104)	
pcincome2			-7.74E-11	*	-2.23E-10	
			(4.40E-11)		(3.19E-10)	
pcincome3					1.52E-15	
					(3.09E-15)	
Fixed Effects	State		State		State	
F-Test State-FE	547.48	***	529.72	***	527.86	***
R-squared	0.8849		0.8863		0.8864	
Adj. R-squared	0.8824		0.8838		0.8838	
Peak			34,819			
Observations	2350		2350		2350	

Robust standard errors are reported in parentheses.
*,**, *** indicates significance at the 10%, 5%, and 1% level, respectively.

Table 4.4: OLS Regression With Time & State Fixed Effects

pchunt	Linear		Quadratic		Cubic	
Constant	0.0672161	***	0.0666334		0.1012514	
	(0.0163788)		(0.0669688)		(0.1452104)	
pcincome	-1.52E-06		-1.47E-06		-5.34E-06	
	(1.48E-06)		(5.50E-06)		(0.0000149)	
pcincome2			-6.07E-13		1.27E-10	
			(6.54E-11)		(4.12E-10)	
pcincome3					-1.30E-15	
					(3.79E-15)	
Fixed Effects	Time & State		Time & State		Time & State	
F-Test Time&State-FE	214.93	***	218.72	***	215.74	***
R-squared	0.8888		0.8888		0.8889	
Adj. R-squared	0.8841		0.8841		0.8841	
Peak			1,210,873			
Observations	2350		2350		2350	

Robust standard errors are reported in parentheses.
*,**, *** indicates significance at the 10%, 5%, and 1% level, respectively.

To examine how sensitive the results are to functional form, the variables were converted into natural logs. Changes in these variables are converted into percentage changes by this process. While the significance of coefficients in the linear and quadratic model display an improvement over previous results, the cubic function again does not display any significant coefficients and the fit of the model in explaining *pchunt* is only 5-percent. Because the adjusted R-squared values in the models with state fixed-effects are much larger, this leads to the thought that the intercept differs across states and the slopes may as well. To examine this, the next section presents state-specific results.

Table 4.5: OLS Regression With Logged Variables

pchunt	Linear		Quadratic		Cubic
Constant	4.744399	**	-114.0069	***	413.0973
	(2.09669)		(33.08607)		(656.0662)
logpcincome	-0.6734639	***	22.63984	***	-133.074
	(0.209488)		(6.568464)		(193.7477)
logpcincome2			-1.143256	***	14.17913
			(0.3254903)		(19.05411)
logpcincome3					-0.5022233
					(0.6240128)
R-squared	0.0423		0.0593		0.0599
Adj. R-squared	0.0419		0.0585		0.0587
Peak			19,930		
Observations	2349		2349		2349

Robust standard errors are reported in parentheses.
*,**, *** indicates significance at the 10%, 5%, and 1% level, respectively.

4.3. State-Specific Results

As can be seen in the preceding tables, the models estimated provided weak results except for the state-fixed effects model. Because differences across states could lead to different slopes for each state, a state-specific regression was run. This was accomplished by interacting the continuous per capita income and per capita income-squared variables with the state specific dummy variables.

The coefficient results for the income variables are presented in Table 4.6 for each state as well as a turning point if one exists. Recall from previous sections that an inverted U-shape Kuznets curve will be displayed when the coefficient for *pcincome* is positive and $pcincome^2$ is negative. As can be seen in Table 4.6, only 21 of the 50 state-specific display an inverted U-shape. Twenty-four states display a U-shape and 5 are monotonically increasing. The turning points vary substantially with the lowest having a turning point of $750 (Michigan) compared to the highest turning point at $180,952 (Massachusetts).

The statistical significance of the coefficients is an improvement over previous models. Many are significant at the 1% level and the regression has an adjusted R-squared of 0.9416; thus explaining 94% of the variation in *pchunt*. Allowing the slopes to vary between states allows for much more reliable results because of inherent differences between states (ex. New Jersey is very different from Texas in many respects). The three F-statistics for state fixed effects, interactions between *pcincome, pcincome2* and state dummy variables all surpass the critical value thus allowing the rejection of slope homogeneity.

Table 4.6: OLS Regression With State Specific Regression Results

	pcincome		pcincome2		Turning Point
Alabama	6.68E-06	**	-1.84E-10	***	$18,152
	(3.03E-06)		(6.12E-11)		
Alaska	2.79E-07		1.67E-10	***	
	(9.48E-07)		(3.13E-11)		
Arizona	7.24E-06	***	-2.07E-10	***	$17,488
	(3.21E-07)		(1.10E-11)		
Arkansas	0.0000101	***	-2.51E-10	***	$20,120
	(1.22E-07)		(5.30E-12)		
California	-4.26E-06	***	1.20E-10	***	$17,750
	(9.46E-07)		(3.13E-11)		
Colorado	3.78E-06	***	-3.57E-11		$52,941
	7.75E-07)		(2.70E-11)		
Connecticut	-6.66E-06	***	1.87E-10	***	$17,807
	(1.22E-06)		(3.94E-11)		
Delaware	-5.02E-06	***	1.50E-10	***	$16,733
	(8.37E-07)		(2.81E-11)		
Florida	-5.51E-06	***	1.45E-10	***	$19,000
	(5.61E-07)		(2.01E-11)		
Georgia	1.20E-06	***	2.99E-11	***	
	(2.61E07)		(1.01E-11)		
Hawaii	-7.66E-06	***	1.94E-10	***	
	(8.08E-07)		(2.71E-11)		
Idaho	0.0000355	***	-6.21E-10	***	$28,583
	(2.08E-07)		(6.76E-12)		
Illinois	-8.03E-06	***	2.54E-10	***	$15,807
	(8.70E-07)		(2.92E-11)		
Indiana	-2.94E-07		4.46E-11	***	$3,296
	(4.44E-07)		(1.53E-11)		
Iowa	-3.41E-06	***	2.90E-10	***	$5,879
	(5.24E-07)		(1.82E-11)		
Kansas	-4.93E-06	***	2.05E-10	***	$12,024
	(5.58E-07)		(1.96E-11)		
Kentucky	-2.63E-06	***	1.71E-10	***	$7,690
	(2.58E-08)		(2.55E-13)		
Louisiana	2.29E-06	***	-2.33E-11	**	$49,142
	(2.57E-07)		(9.69E-12)		

Robust standard errors are reported in parentheses.
*,**, *** indicates significance at the 10%, 5%, and 1% level, respectively.

Table 4.6: (continued)

	pcincome		pcincome2		Turning Point
Maine	4.01E-06	***	-1.84E-11	*	$108,967
	(2.94E-07)		(1.11E-11)		
Maryland	-3.47E-06	***	1.19E-10	***	$14,580
	(9.59E-07)		(3.24E-11)		
Massachusetts	-6.84E-06	***	1.89E-11	***	$180,952
	(1.00E-06)		(3.39E-11)		
Michigan	-3.42E-06	***	2.39E-10	***	$750
	(6.20E-07)		(2.10E-11)		
Minnesota	7.25E-08		1.60E-10	***	
	(7.40E-07)		(2.60E-11)		
Mississippi	7.81E-06	***	-2.67E-10	***	$14,625
	(3.53E-07)		(1.49E-11)		
Missouri	2.90E-06	***	2.44E-10	***	
	(4.80E-07)		(1.67E-11)		
Montana	0.0000358	***	-2.85E-10	***	$62,807
	(3.32E-07)		(1.13E-11)		
Nebraska	6.51E-06	***	-4.60E-11	**	$70,761
	(5.69E-07)		(2.02E-11)		
Nevada	9.33E-06	***	-2.20E-10	***	$21,205
	(8.63-07)		(2.87E-11)		
New Hampshire	-3.17E-06	***	1.64E-10	***	$9,665
	(7.10E-07)		(2.55E-11)		
New Jersey	-6.50E-06	***	1.82E-10	***	$17,857
	(1.08E-06)		(3.57E-11)		
New Mexico	-9.31E-07	***	1.02E-10	***	$4,564
	(9.69E-08)		(2.75E-12)		
New York	-3.89E-06	***	1.37E-10	***	$14,197
	(1.01E-06)		(3.34E-11)		
North Carolina	3.61E-07	*	-3.33E-12		$54,204
	(2.10E-07)		(8.39E-12)		
North Dakota	9.42E-06	***	2.53E-10	***	
	(4.72E-07)		(1.71E-11)		
Ohio	-5.79E-06	***	2.09E-10	***	$13,852
	(5.53E-07)		(1.90E-11)		
Oklahoma	2.70E-06	***	-4.83E-11	***	$27,950
	(3.04E-07)		(1.06E-11)		

Robust standard errors are reported in parentheses.
*,**, *** indicates significance at the 10%, 5%, and 1% level, respectively.

Table 4.6: (continued)

	pcincome		pcincome2		Turning Point
Oregon	0.0000178	***	-2.53E-10	***	$35,178
	(5.36E-07)		(1.86E-11)		
Pennsylvania	-1.06E-06	*	1.55E-10	***	$3,419
	(6.48E-07)		(2.26E-11)		
Rhode Island	-7.77E-06	***	2.09E-10	***	$18,589
	(6.88E-07)		(2.41E-11)		
South Carolina	-2.90E-06	***	1.07E-10	***	$13,551
	(3.00E-08)		(1.23E-12)		
South Dakota	0.0000318	***	-6.26E-10	***	$25,399
	(3.70E-07)		1.39E-11)		
Tennessee	5.08E-06	***	-5.04E-11	***	$50,397
	(1.73E-07)		(6.84E-12)		
Texas	-1.71E-06	***	7.00E-11	***	$12,214
	(4.66E-07)		(1.68E-11)		
Utah	0.000015	***	-4.20E-10	***	$17,857
	(1.72E-07)		(5.29E-12)		
Vermont	8.86E-06	***	-7.57E-11	***	
	(4.56E-07)		(1.69E-11)		
Virginia	3.80E-06	***	-2.58E-11		$73,643
	(7.03E-07)		(2.52E-11)		
Washington	6.76E-06	***	-9.49E-11	***	$35,616
	(8.11E-07)		(2.77E-11)		
West Virginia	-1.13E-06	***	3.37E-10	***	$1,677
	(5.09E-08)		(3.37E-12)		
Wisconsin	-7.00E-06	***	5.25E-10	***	
	(5.77E-07)		(2.01E-11)		
Wyoming	0.0000203	***	-2.64E-10	***	$38,447
	(9.02E-07)		(3.11E-11)		
Constant	0.0319214				
	(0.0352137)				
F-test	Interaction = 14.92***		Interaction = 7.76***		State-FE = 22.19***
R-squared	0.9441				
Adj. R-squared	0.9416				
Observations	2350				

Robust standard errors are reported in parentheses.
*,**, *** indicates significance at the 10%, 5%, and 1% level, respectively.

Chapter 5

CONCLUSION

The objective of this thesis was to examine whether or not a Kuznets curve exists with respect to animal welfare. The measurement of animal welfare used in this thesis is per capita hunting license sales data. Prior research on an Animal Welfare Kuznets Curve is extremely limited with only one peer-reviewed journal article published to date. A desire to further the research on this topic motivated this thesis.

5.1. Summary of Findings

To access the relationship and linearity between per capita income and animal welfare in the United States, the independent income variable was squared and cubed. Linear, quadratic, and cubic models were estimated with: no fixed effects; time fixed effects; state fixed effects; and time and state fixed effects. The variables were converted into natural logs as well to assess specification fragility. The data covers all 50 states over the period 1963-2009, yielding 2,350 observations for each variable.

None of the cubic models displayed statistically significant coefficients and so this cubic specification is rejected. Regression results for each of the three models with no fixed effects displays a low adjusted R-squared with the quadratic model only explaining 2.36% of the variation in per capita hunting license sales. The explanatory power of the models increase slightly with time fixed effects but display unexpected coefficient signs. Estimating the models with state fixed effects increases the explanatory model considerably to 88%. When both time and state fixed effects are included, the adjusted R-squared remains high but again there are unexpected coefficients signs which the time fixed effects models displayed as well. All models reject slope homogeneity and, coupled with the unexpected results from including time fixed effects, state-specific models could provide more insight.

Following the indicators above, a quadratic state-specific model was estimated. This allowed for observation of differences between states; however, not all states displayed a Kuznets curve. Twenty-one states displayed an inverted-U while twenty-four displayed a U-curve and five were monotonically increasing. Because differences in hunting license sales between states could be explained by factors other than income, such as changes from year to year in animal populations or the urban density of a state, a generalized statement for the existence of a Kuznets curve for animal welfare in the United States cannot be made. Further research and the inclusion of other independent variables could provide more insight into the relationship between economic growth and animal welfare in the United States.

5.2. Suggestions for Future Research

There are many different ways that humans interact with animals and thus many ways for humans to use, abuse, or respect them. Animals are household pets, used as research subjects, used as food, and used for labor in various parts of the world. As a result, there are many different ways in which animal welfare can conceivably be measured.

Fishing license sales data could have been used in this thesis, as it is available from the U.S. Department of Fish & Wildlife Service. It was not chosen because the equipment required to fish and the fishing license itself is relatively inexpensive and thus may not vary much with changes in per capita income. However, hunting requires access and knowledge of firearms and safety regulations and can often involve some degree of travel. Hunting licenses are also typically more expensive than fishing licenses and carry an added requirement of purchasing additional tags for larger mammalian species.

In terms of data on household pets, the ideal scenario would be if Congress or individual states required all animal shelters to report their intake, adoption, reunification with owner, and euthanasia rates to a central reporting location. Some shelters in California report this information to the California Department of Public Health, but the reporting is sporadic and does not represent all shelters, public and private non-profit, within the state. Some non-profit organizations, like the American Humane Association and Maddie's Fund, do conduct voluntary surveys of shelters, but again these data are not reported by all shelters and so the value of those data sets is limited. If this information was available on a state by state basis, it would be very helpful to researchers who could review it and advocate for the passage of laws that would reduce the high euthanasia rates and increase unification with owners – i.e. pass laws requiring pets be microchipped and spayed or neutered. It could also serve as a more valuable proxy for animal welfare.

The amount of meat consumption at the state level would be informative not only to measure a state-level Kuznets curve, but for various other disciplines like health economics. From the viewpoint of someone concerned with the humane treatment of animals, the meat industry is one of the worst in terms of how the animal is treated (raised, slaughtered, etc.). This view has led to political and grassroots campaigns by animal welfare organizations in multiples states, as evidenced by laws like California's Proposition 2 of 2008. State-level meat consumption data would have been used in this thesis if it had been available.

Animals are frequently used in the development of pharmaceuticals for human use and to test many household products. In 1966, the Animal Welfare Act (AWA) was signed into law by President Lyndon Johnson. This law outlined the minimum of care for certain animals used in laboratory research. The list of animals does not include birds, rats, or mice: the animals most often used in laboratory research. As noted by the American Physiological Association, in 2001 1.2 million animals regulated by the USDA were used in research while approximately 30 million rats and mice were bred for research. This number is only an approximation because these animals are not covered under the AWA law. While animals used for research could be used as a measure of animal welfare in future research, it would not adequately reflect the welfare of animals due to a lack of data on the most widely used animals – birds and small mammals.

With respect to hunting license sales, further research can be done on the impact of wars and foreign service of prime-age males on number of hunting licenses issued. Hunters are typically male and during the time period studied, the United States was engaged in two conflicts: The Vietnam War from 1965-1972 and the War on Terror from 2001-2010. Men typically serve in the military between the prime ages of 18-24 and this could conceivably decrease the numbers of licenses that are issued.

Clearly, there is ample opportunity for further research in the area of animal welfare and the possible existence of a Kuznets curve. As more reliable data are collected and submitted to state and federal entities, additional research could very well support the hypothesis that an animal welfare Kuznets curve exists. Although this study was limited by the availability and applicability of relevant data, it helps to provide another building block for further exploration into an area that has not been subject to a great deal of scholarly research.

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