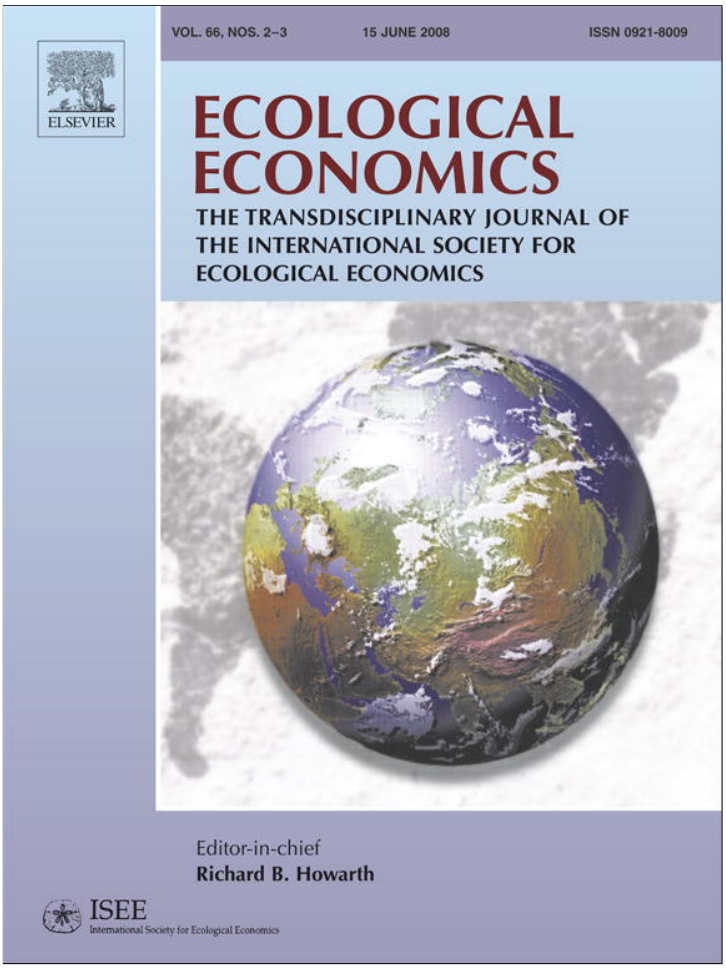

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ANALYSIS

Is there an "animal welfare Kuznets curve"?

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ABSTRACT

The concept of a Kuznets curve has been applied to income inequality and to the environment. The Kuznets curve takes an inverted U-shape, with income or GDP on the X-axis and environmental degradation or inequality on the Y-axis. It is hypothesized here 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. Why an Animal Welfare Kuznets Curve might theoretically exist is explored. Empirical evidence supporting or refuting the existence of such a curve is also examined. The evidence is both quantitative and qualitative in nature, since some issues in welfare cannot be easily quantified. The evidence and theoretical presentation explores multiple areas of concern to animals, including animal agriculture, the use of animals in laboratories, companion animals (pets), and the fur industry. The conclusion is that evidence is mixed, with some measures indicating a turning point while other measures showing no sign of peaking/improving animal welfare.

1. Introduction

The concept of a Kuznets curve has been applied to income inequality and to the environment. Kuznets (1955) originally hypothesized the presence of an inverted U-shaped relationship between economic development and income inequality. According to this hypothesis, at low levels of economic development, economic growth increases income inequality, but at some point a peak would be reached where further economic development decreases inequality. More recently, the concept of this U-shaped relationship with economic development has been applied to the environment using the concept of the environmental Kuznets curve or EKC. In a recent survey of the EKC literature, Dinda (2004) concludes that the evidence for the EKC depends on the type of pollutant or environmental issue considered, with only some pollutants, particularly those with short-term and local effects showing evidence of a Kuznets curve relationship. Other surveys include Cavlovic et al. (2002) and Stern (2004), with evidence of an EKC curve generally being mixed or weak.

It is hypothesized here that an "animal welfare Kuznets curve" (AWKC) may exist, with harm to animals initially rising with economic growth, followed by improvement in the treatment of animals after some peak value. Although this concept has never been explicitly stated, the idea that animal welfare and economic development may go together is not new. This view has been expressed in newspaper and popular journal articles such as McDonald (2005) and Associated Press (2006).

The possible existence of an AWKC has important economic and public policy implications. As noted above, some authors have implied that further economic growth is associated with improving animal welfare. However, others, such as the sociologist Nibert (2002) sees capitalism as inevitably tied with large-scale animal exploitation. The absence of such a curve suggests that future economic growth will likely come at the cost of declining animal welfare, among

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other costs. On the other hand, the existence of such a curve would imply that future economic growth and improving animal welfare can go hand in hand, though as noted in the discussion, such animal welfare improvements may require continued vigilance by those concerned with the issue.

1.1. *Prior work related to an animal welfare Kuznets curve*

There have been some studies dealing with the EKC and biodiversity/preservation of endangered species. McPherson and Nieswiadomy (2005) as well as Naidoo and Adamowicz (2001) both find evidence of an EKC relationship when looking at endangered bird and mammal species, while Kerr and Currie (1995) find evidence that higher income levels are associated with fewer threatened species. On the other hand, Asafu-Adjaye (2003) and Dietz and Adger (2003) do not find evidence of an EKC relationship regarding biodiversity. Preservation of endangered species typically is correlated with improving or maintaining wild animal welfare. This occurs both because the endangered species itself may be an animal (and in particular a sentient animal, which presumably are the only ones to experience welfare) and because preservation typically comes from habitat preservation and other actions that may benefit other wild animals. However, it is important to note that promoting biodiversity can at times lead to quite different actions than promoting wild animal welfare. Varner (1998) acknowledges that ecosystem preservation and animal rights are often perceived to be at odds, but Varner concludes that a true animal rights view is not necessarily at odds with ecosystem preservation. However, to reach this conclusion, Varner relies on the belief that a true animal rights view would not be opposed to "necessary" hunting, which occurs when animals regularly overshoot carrying capacity, degrading their habitat. Endangered species/biodiversity concepts ignore individual animals, especially those from species that are thriving. Although policies that promote biodiversity (habitat protection, reducing pollutants in wilderness area, reducing poaching, etc.) most often coincide with policies that improve the welfare of animals, this is not always the case. Sometimes the interests of endangered species or native species conflict with those of other animals. For example, saving a small number of members of an endangered species sometimes can be accomplished by killing a large number of members of a common species of sentient animal.

2. Why should there be an AWKC?

There could be direct connections between the AWKC and the EKC. As already discussed, efforts to help endangered species may also improve wild animal welfare in general such as by preserving habitat, though this will not always be the case. If meat-based diets are thought to negatively affect animal welfare, then EKC and AWKC may also be correlated because meat-based diets (and red meat diets in particular) are a significant source of greenhouse gas emissions (Eshel and Martin, 2006). There are likely other direct linkages as well which may be complex and beyond the scope of this paper to test. However, in addition to any direct linkages between the two curves, the EKC can serve as a useful point of reference for understanding the possible causes of an AWKC, since most of the general reasons for an AWKC are analogous to reasons already explored in the literature for an EKC. This literature is used here as a starting point for exploring possible reasons for an AWKC.

2.1. *Composition of economy*

In justifying an EKC, it has been argued that as economies move from agrarian societies to industrial societies, pollution increases, then when the economy develops further into being primarily service-based, pollution declines again (Arrow et al., 1995). A similar situation may occur with animal welfare. Although animals still have many commercial uses, in economies below a certain level of economic development, animals play a much more vital role. Animals in some economies are a source of transportation, a vital piece of "equipment" for farming land, and even a source of power.

2.2. *Technology*

As economies advance, they are more able to invest in developing technologies that reduce environmental damage (Komen et al., 1997). These technologies allow advanced economies to maintain high standards of living while reducing environmental degradation. Technological progress has been a double-edged sword for animal welfare. While some technological changes, such as in vitro laboratory techniques and the technology to create meat substitutes have helped animal welfare, other technological changes such as intensive animal agriculture techniques and genetic modification of laboratory animals may have diminished animal welfare.

Income growth and technology are distinct concepts, but they clearly are related. Long-term national income growth may have been driven in large part by productivity-enhancing technology (Fagerberg, 1994). Therefore, rising average income levels are associated with rising levels of technological advancement, which in turn can lead to changes in animal use. The level of technology required to cause a positive shift in animal welfare varies from topic to topic and can depend on specific breakthroughs. Examples of important technological discoveries in this regard include the creation of substitutes to animal research (such as in vitro technologies), discovery of processes to create high-protein meat substitutes, and spay/neuter surgical techniques for companion animals. Some specific technological advances and issues will be discussed in the sections relating to specific animal welfare issues to follow.

2.3. *High income elasticity*

One of the more common explanations for a hypothetical EKC relationship is that concern about the environment is a luxury good with an income elasticity greater than one. At higher income levels, people show higher levels of concern about the environment (Pezzey, 1989; Selden and Song, 1995 and Baldwin, 1995, Roca, 2003).

This same logic might hold for animal welfare. One distinction is that people may have both a selfish and altruistic interest in the

environment. For animal welfare, on the other hand, there is little if any personal benefit involved. For this reason, it may have somewhat different dynamics. It is possible that altruistic concerns become important only at higher levels of income than concerns about the personal health and aesthetic consequences of environmental degradation, leading to a turning point higher on the income scale for AWKC than for the EKC.

Maslow (1968) places human needs on a hierarchy that would be consistent with an EKC and AWKC. Physiological needs are lowest on the hierarchy, and must be satisfied before people focus on higher-level needs. Therefore, high enough per capita income to satisfy basic needs such as food and shelter are necessary before people consider the longer-term security of their environment or altruistic concerns. Furthermore, self-actualization concerns (which include altruistic motives such as "goodness/benevolence") are at the highest level, which is several levels above safety and security, a category that includes some reasons for environmental concern.

Higher income may also allow more animal (or environmental) protection organizations to exist. These organizations often conduct awareness campaigns that have the potential to shift public opinion. Evidence of regional income being associated with animal welfare is explored later in the paper.

2.4. *Increased animal welfare awareness due to scientific, philosophical and theological advances and companion animals*

Public opinion surveys in developed countries have shown that concern about the welfare of animals has grown over the last 30 years (Baird and Rosenbaum, 1991; Kellert, 1993; Singer, 2005). Progress in both attitudes and some areas of animal welfare regulation has also been seen in China recently (Davey, 2006). Increased concern about animals could occur because of a high income elasticity for animal welfare, as previously discussed. However, there are other important reasons that animal welfare concerns may be increasing over time.

First, scientific advances have been decreasing the conceptual and perceived moral gap between humans and animals (McDonald, 2005). Griffin (1992), Dawkins (1993), and Beckoff and Goodall (2003) all cite considerable evidence of the cognitive capacity of animals, include complex behavior, novel behavior, and evidence of abstract thought, while Masson and McCarthy (1995) and Beckoff and Goodall (2003) provide many examples of the rich emotional world animals possess. Many of the characteristics that had previously been thought to make humans unique have been found in animals. Tool use, rudimentary language capabilities, self-concept, and other advanced cognitive functions have all been discovered in animals. Compassion, play, and grieving for the dead have also been recently received more widespread recognition as taking place in a variety of animal species, though their original observation dates back at least to Darwin. DNA evidence has also demonstrated the small genetic distance between humans and some primates, particularly chimpanzees. Personality traits have also been systematically observed in dogs (Gosling et al., 2003) among other animals. Much has been discovered to dispute Descartes' view centuries ago of animals as unfeeling machines, making the denial of some level of moral consideration to animals increasingly difficult to justify.

Along with scientific progress, changes in philosophy and theology have also increasingly recognized the importance of animal welfare. A number of philosophical works have argued for greater consideration for animals, including Singer (1975), Regan (1983), Midgley (1983), Francione (1995), and DeGrazia (1996). Theologians as well have increasingly recognized the issue of animal welfare. Videras (2006) found that religion affected voting behavior on an animal welfare issue (Catholicism in particular was associated with higher likelihood to vote in favor of the animal welfare measure). Linzey (1994) has argued for better treatment of animals from a Christian theological perspective. Meanwhile, Thomas (1995) argues that theological changes in England between 1600 and 1800 caused changing attitudes towards nature and animals, which may have preceded scientific arguments. Since the worldview of scientists can be limited by the social, philosophical and theological frames of their times, it could be argued that changes in philosophy and theology were necessary for scientists to start to look for cognition and emotion in animals.

The second trend that likely is leading to greater concern for animals in general is the rising level of pet keeping. The level of pet keeping has been rising over time (American Veterinary Medical Association, 2002). Not only has the number of people keeping pets been rising, but so has the level of care given to these companion animals. People are increasingly spending money on luxury items for their pets and treating their pets as "members of the family". This in turn allows people to see animals as more than just a product to be exploited by humans. Companion animals allow people to interface with the animal world, and see animals as possessing a personality, preferences, and the capacity for suffering. A connection has been seen between childhood pet-keeping and humane attitudes toward animals, with childhood pet-keeping being associated with more concern toward animals (Paul and Serpell, 1993; Miura and Bradshaw, 2002). Therefore, the increased pet-keeping we are seeing now might lead to more concern for animal welfare in future decades. The increased concern for animal welfare in China might also have been driven by rising pet-keeping, which more than doubled for both dogs and cats in the last five years (Euromonitor International, 2007).

Another trend that has both positive and negative effects is the growing separation of the means of production of animal products from consumption of the final product. Results of this change and its impact on animal welfare have not been studied previously and therefore discussion of possible impacts is purely speculative. There may be a positive effect on animal welfare by allowing people to become less desensitized to animal suffering. People may become desensitized if they are surrounded by the killing and suffering of animals from an early age, as they often are in agriculturally based communities. There is evidence that exposure to violence can cause desensitization and a reduction in empathy. For example, Funk et al. (2003) and Bartholow et al. (2005) find that violent video games can cause desensitization and a reduction in empathy. Therefore, separation of means from ends of animal production can help public sympathy for animals to grow. On the other hand, it has been said that if slaughterhouses had glass walls we would all be vegetarians. This is quite likely true now, and given current public levels of sympathy toward animals, the lack of

exposure people have to the conditions of industrialized animal use may have more adverse consequences for animal welfare than positive consequences.

2.5. *Investment in abatement and positive returns to scale*

Dinda (2004) created a model where investment in abatement activity leads to the shape of the Environmental Kuznets Curve. It is possible in some areas of animal welfare that investment in abatement activities and positive returns to scale for investment in abatement leads to welfare improvements. For example Frank (2005) describes how technological alternatives to laboratory animals may experience positive returns to scale. As technologies such as in vitro methods and bioinformatics gain in popularity, the work of various researchers build on each other, making these technologies more viable as alternatives to animal experimentation. Many of these research technologies have inherent positive returns to scale both because the actual techniques build on prior methodologies and because successful interpretation of research results often depends on access to a library of prior research results. In addition to replacing laboratory animal experiments with alternatives, those concerned with abatement in this animal welfare arena also stress reduction and refinement of experimental methods (reduction, refinement, and replacement are often referred to in animal experimentation as the "three R's", a term that is credited originally to Russell and Burch, 1959).

Positive returns to abatement activities can occur for more than technological reasons. Frank (2005) discusses how institutional factors can also lead to positive returns for alternatives to laboratory animals. Frank (2007) discusses how preferences and institutional factors may demonstrate positive returns for alternatives to consumption of factory-farmed meat. Among other things, it is argued that tastes in food consumption are guided by habits and by preferences of family, others in one's social network, and by social norms. Therefore "abatement" of factory farming, in the form of the substitution of consumption of alternatives, can be self-reinforcing. Abating companion animal death and abandonment also likely has a self-reinforcing component. The primary methods of abatement include increasing adoption levels, increasing spay/neuter rates, and decreasing the number of animals relinquished to shelters or abandoned to the streets (Frank, 2004). All of these methods of abatement may be socially self-reinforcing.

3. Evidence by consumption activity

This section explores whether the empirical evidence supports the existence of such a curve. Many dimensions of animal welfare are difficult to measure, just as many dimensions of environmental quality relevant to the EKC are difficult to measure. In principal, however, the AWKC refers to both animal usage levels (e.g. number of animals raised for meat, experimented on in laboratories, destroyed through harvesting or habitat loss in the wild) as well as the level of harm that occurs to each animal used (e.g. humane standards in meat and dairy production, laboratory standards, and laws regarding cruelty to pets). The focus here is on looking at levels of use and intensity of harm separately and issue by issue. In particular, the level of harm to animals for any economic activity that has a significant animal welfare impact can be quantified as:

$$\text{Animal Welfare Impact} = \sum_i \sum_t [(U_{it1} - U_{it0})^* W_i]$$

where U_{it1} is the utility in period t of the ith animal affected assuming the activity does take place, U_{it0} is the utility in period t of the ith animal affected assuming the activity does not take place, W_i is a weighting that can be given to the ith animal if different animals (or species) are given different weights. It is assumed that animal welfare in any period is equally valuable, therefore there is no discount rate. However, if it is assumed that welfare in future periods should be discounted, the equation could easily be adjusted to incorporate a discount rate. This equation can be considered in concept to be an extension of Zeckhauser and Shepard's (1976) suggestion to use Quality Adjusted Life Years as a measure to guide policy for concerning human welfare. Here, the concept is extended to animal utility, and a difference is explicitly taken between a default state and an alternative policy choice or activity. The choice of policy or activity is assumed to take place once, at time zero, with implications that spread over many years. The values for U in the equation can be positive or negative. This allows for non-existence to possibly be superior from an animal welfare perspective to a state of constant suffering. For example, if an animal is raised solely for slaughter or laboratory use in conditions that create negative utility in every year, the default state of nonexistence could be preferred from an Animal Welfare Impact perspective. In practice, determining whether the utility of an animal raised in conditions where they can barely move, have no stimulation, and occasionally suffer from painful procedures or outcomes has a utility more or less than the zero level defined as nonexistence is cannot be stated with certainty. However, it is certainly possible that a life of suffering with no offsetting positive experiences can have a utility less than zero.

Since animals are not economic actors, the use of such an equation assumes that policymakers and possibly economic agents are concerned with maximizing animal welfare/minimizing the negative animal impact along with other goals. If economic agents are unconcerned with animal welfare, then the above equation only impacts the consumer's utility maximization and the producer's profit maximization decisions to the extent that policymakers implement policies to improve animal welfare that constrain economic agents.

When all impacts are in a single time period, all animals are equally affected, and all receive equal weight, then the animal welfare impact is simply the change in utility per animal ($U_{it1} - U_{it0}$) times the number of animals affected (i). The quantitative data presented here typically gives an estimate of "i", the number of animals affected. However, depending on how animal production processes change, ($U_{it1} - U_{it0}$) can also exhibit large changes that are more difficult to capture. Changes in welfare per animal can be difficult to quantify. One method that may be particularly appealing to economists would be to use a revealed preferences approach in experiments (Dawkins, 1990), either by examining which of two

options (such as cage floor in poultry) are preferred, or by examining "willingness to pay" in terms of work. However, there are a variety of animal welfare measures which have be used to estimate animal welfare impacts (though even the entire range may not give a complete assessment) including, stress hormone levels, evidence of injuries or mutilation, behavioral observations (such as the presence of stereotypical behaviors and natural behaviors), illness rates, productivity (such as egg production), and growth rates (Dawkins, 1993; Appleby et al., 2004). In the discussion of the various animal issues provided here, the focus will be both on the quantity of animals used (i) in that activity, and on the typical utility impact on animals ($U_{it1} - U_{it0}$) from that activity.

Generally, any empirical evidence presented here using quantifiable animal welfare measure are calculated per capita. This is done to be consistent with the prevailing methodology for examining evidence for an EKC, and to facilitate cross-regional comparisons. While per capita values allow separation of income effects from population growth, it does ignore the interrelated nature of income and population trends; as long as population is generally increasing, a decline in per capita harm in an AWKC curve does not always imply a decline in total harm.

3.1. *Meat consumption*

In terms of the number of animals involved, animal agriculture presents the largest potential animal welfare issue. The rising side of a possible Kuznet's curve for meat consumption is easy to establish. Meat consumption is associated with growing income in developing countries, with meat consumption internationally expected to continue to grow due to income growth in the developing world (Rosegrant et al., 1999). Historically, meat has been highly valued because of its difficulty to acquire as well as its nutritional abundance (Willard, 2002). Within the United States, higher income is associated with greater meat consumption (Park et al., 1996). Since 1970, meat and poultry expenditures in the United States have increased. However using USDA data for meat consumption, as a percentage of disposal of personal income consumption has been declining over time.

A turning point where the total quantity of meat consumed per capita declines is not evident in data for the United States. Evidence of a decline in demand for red meat, particularly beef, has been documented in studies such as Marsh (2003) and Eales and Unnevehr (1988). However, poultry consumption has increased over the same period, with evidence in Eales and Unnevehr (1988) of substitution from beef to poultry products. Kinnucan et al. (1997) shows evidence suggesting that health information may have been in part responsible for substitution from beef to poultry. The welfare implications of the shift in meat sources depends on how welfare is measured or defined. Since a given quantity by weight of chicken products takes more animals to produce than a given quantity of beef, chicken uses more animals and arguably from the perspective of the number of animals adversely affected has a more adverse animal welfare impact. While the number of hogs and pigs slaughtered per capita has declined since 1970, total animals slaughtered per capita has doubled (see Fig. 1). Over the same period, meat consumption per capita by weight has gone up just 13%. The much more rapid increase in animals slaughtered than quantity by weight was due to switching of sources to poultry which currently make up 98.5% of the total number of animals slaughtered in the United States but only 36% of the weight of meat products produced. If welfare was defined by the number of animals slaughtered, then the switch to poultry has clearly had negative consequences However, this assumes that all animals' lives are given equal weight. Singer (1975) treats animal suffering to be of equal weight across species as long as they surpass the threshold of "sentience". However, Appleby et al. (2004) suggests that it makes sense to consider suffering and consciousness not as "all-or-nothing" phenonenon, but as something that different animal species may have different abilities to experience.

As for the utility change per animal in the animal welfare impact equation, there is a mixed conclusion. There has been growing concern about the impact of capital intensive, large-scale agriculture on animal welfare (Blandford et al., 2003). Some authors believe that the use of intensive confinement and large-scale animal agriculture leads to reduced quality of life (Harrison, 1964; Eisnitz, 1997; Scully, 2002), which would in

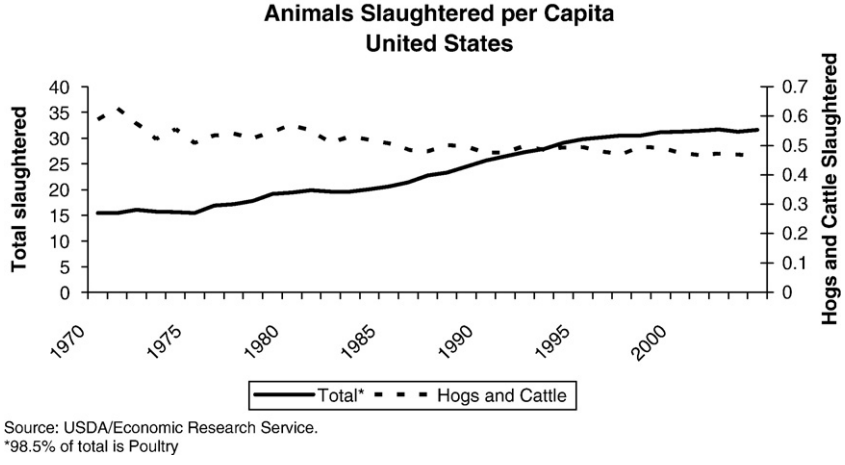


Fig. 1.

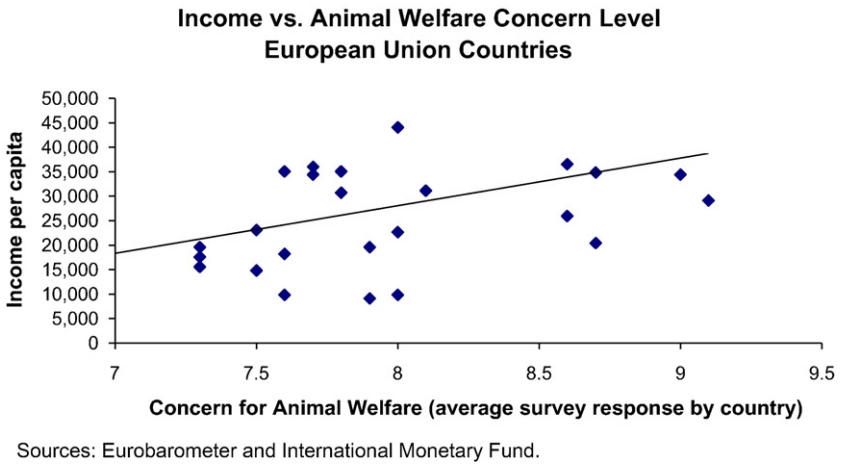


Fig. 2.

turn imply that the growth in use of these techniques has lead to a decline in welfare for the average farm animal. Practices with potentially negative welfare impacts include as "tail docking" of pigs, "debeaking" of poultry, and minimizing animal care/contact to maximize profit and breeding for unhealthily rapid growth/distorted growth (such as oversized breasts in chickens to the extent that they cannot stand properly), among others (Fraser et al, 2001; Scully, 2002). Intensive animal agriculture, efforts to minimize production costs, and a need to keep up with meat production demand have resulted in high speeds in the slaughtering process that can lead to shortcuts and errors in animal welfare compliance and a decline in animal welfare (Eisnitz, 1997). As early as 1965, the Brambell report issued by the British government (Brambell, 1965) found intensive confinement in animal agriculture to lead to many serious negative animal welfare consequences. Among other things, intensive coonfinement systems tend to prohibit the freedom to display most normal patterns of behavior, one of the "Five Freedoms" described in the Brambell report. Counterarguments from the scientific community have challenged the negative impacts said to come from modern animal agriculture techniques, and the debate still continues (Albright, 1998). However, scientific study in animal welfare has traditionally focused on observable signs of suffering, which are much easier to quantify, than broader quality of life question that may be even more important to welfare, but have been not been adequately examined (Mench, 1998). It is likely that these harder to quantify negative impacts (such as a lack of positive experience and unobserved frustration and boredom) are particularly relevant for today's intensive confinement systems. Furthermore, research into animal welfare in agriculture by animal scientists may have historically been biased towards supporting the status quo (Rollin, 1995; Halverson, 2001). As Halverson (p. 157) puts it, in a field that depends on substantial funding from producer organizations and commercial groups, "to be a successful research it does not hurt to maintain good industry connections and a reputation for supporting the status quo." However, there is some evidence of a consensus among scientists that intensive confinement has negative consequences. In a Delphi method assessment of the opinions of 22 animal welfare scientists, Anonymous (2001), showed "a broad consensus" regarding farm animal welfare issues. Across various animal species and types of animal products, space issues and other issues linked to intensive agriculture techniques were repeatedly identified by the panel of scientists as among the top welfare concerns, and the study concludes that the most common housing systems[1] lead to a number of serious animal welfare problems.

On the other hand, there is some evidence that growing concern may eventually cause a turning point in the utility per animal. Major fast food chains have animal welfare committees, and the corporations are increasingly implementing recommendations to improve the welfare of animals even when they may negatively impact production costs (Reuters, 2007). Major submarkets are developing for meat and animal food products from animals that are raised under elevated welfare standards. Multiple organizations are creating their own welfare students in response to consumer demand, with new standards continuing to be created in the last twelve months including an "animal welfare approved" (AWA) standard label by the Animal Welfare Institute, and an in-store "Animal Compassionate" standard by Whole Foods Markets (Miller, 2006; Rockwell, 2006). Legislation is also starting to take hold that addresses specific farming practices. In 2002 Florida voters banned sow crates (Videras, 2006), in 2006 Arizona voters passed a similar, more extensive bill, and Oregon past a similar bill in 2007 (HSUS, 2007). Chicago banned the sale of Foie gras, while the state of California has banned its sale and production starting in 2012 (HSUS, 2007). The World Organization for Animal Health adopted animal welfare guidelines for slaughter and transportation of animals in 2005 with 167 countries supporting these animal welfare standards. This was the first time a large number of countries had adopted animal welfare standards. While some welfare improvement measures have taken place in the United States,

[1] Since the study was conducted in Europe, "common" housing systems was based on practices in the Netherlands, however the primary issues identified are common to a number of countries that practice intensive confinement agriculture, including the United States.

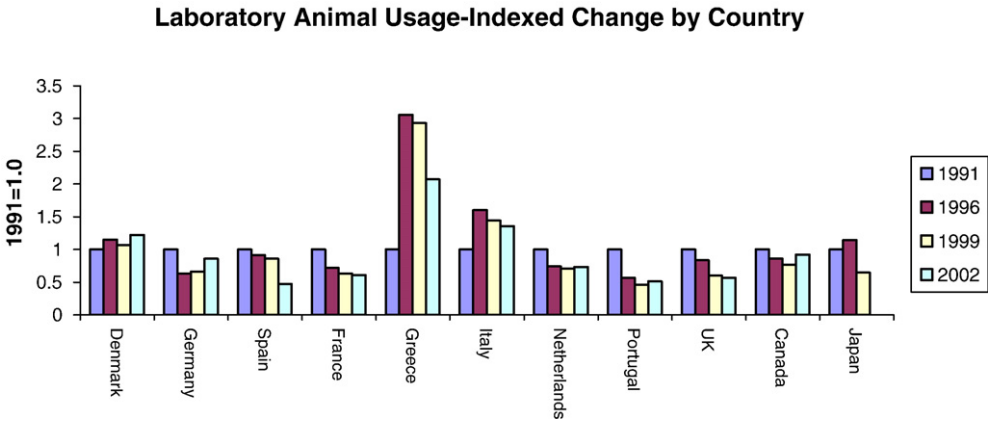


Fig. 3.

European countries have made much more rapid welfare improvements (Singer, 2007). Europe has passed laws phasing out intensive confinement of veal calves, stalls for sows (which is already outlawed in Sweden and the UK), and laying hens.

There is some evidence that concern regarding farmed animal welfare is correlated with income. In a study commissioned by the European Commission (European Commission, 2007), residents of various European countries rated the importance of farm animal welfare. As seen in Fig. 2, countries with higher per capita incomes generally had higher levels of concern for farmed animal welfare. This trend was significant in a simple two-variable regression model.[2] This is consistent with other survey-based studies that have found willingness to pay for greater animal welfare in food products to be correlated with income (Bennett, 1997; Blandford and Fulponi, 1999). The actual income elasticity of demand for environmentally conscious and ethically produced food also tend to be high, unlike other food products which tend to have an income elasticity less than one (Department for Environment Food and Rural Affairs, 2003).

As noted in Frank (2007), there may be considerable inertia in food preferences. Therefore, the lack of a turning point for the total quantity of meat consumption does not necessarily imply that one may not occur in the future. The current high levels of meat consumption may be due in large part to social and institutional inertia and there are many reasons to expect that meat consumption will start declining as the economy continues to progress. In fact there is evidence of increased consumption of alternatives to factory farmed meat, including increased consumption of organic meats, increased vegetarianism, and increased veganism in some developed countries (Dietz et al., 1995; McDonald, 2005).

Ultimately, economic and scientific progress may lead to a technological solution to animal welfare considerations in meat consumption. Scientists are working on growing animal muscle tissue in a laboratory environment with the goal of creating a substitute source of meat (Edelman et al., 2005). This has the potential to provide a food source that is cheap, lower in environmental impact and other externalities, and free of ongoing animal suffering. Furthermore, while nutritionally adequate vegetarian and vegan alternatives are available, meat grown in a laboratory would gain greater acceptance due to existing public taste preferences for animal flesh, further benefiting animal welfare.

3.2. *Laboratory animal use*

Data from the USDA for laboratory animal use in the United States suggests the number of animals used per capita has decreased 62.5% since 1973. However, this data may be deceptive due to the interpretation of legal standards for tracking laboratory animal use. The 1966 Laboratory Animal Welfare Act set up both humane standards for laboratory animal use and required record-keeping of animals studied. However, in enforcing the act, a decision was made by the Executive branch to define “animals” as excluding birds, rats and mice. Therefore, the exact number of these species, which are probably the most frequently used, is not known. If there has been substitution of animal species towards those that have the lowest welfare standards and require the least paperwork, the decline in laboratory animal usage in the United States may be illusory.

Data from Europe, Canada, and Japan on animal use is shown in Fig. 3. Data shown is indexed such that the animal usage level in 1991 for each country is set to 1.0. Since that time, animal usage in most countries in the sample has declined.[3] For all countries in the sample combined, animal use decline 21.7% (including rats, mice, and birds) between 1991 and 2002. However, this decline was far from universal, with many countries showing an increase.

When looking across the same set of countries using data for 2002, there appears to be no relationship between income and animal use, though there was a very slight tendency for higher income countries to conduct less animal research per

[2] $p=0.033$; $F=5.09$; $r^2=0.164$, $\beta_1=0.000017$.

[3] Data for Canada is from the CCAC Animal Use Survey, 2002. Data for the European Union is from the First through fourth “Report from the Commission to the Council and the European Parliament on the Statistics on the Number of Animals used for Experimental and other Scientific Purposes” (data for Greece is included in all calculations and analysis but excluded from Fig. 3). Data for Japan comes from Matsuda (2004), with the 1996 column for Japan in Fig. 3 coming from 1995 data and Japan data for Fig. 4 coming from 1999.

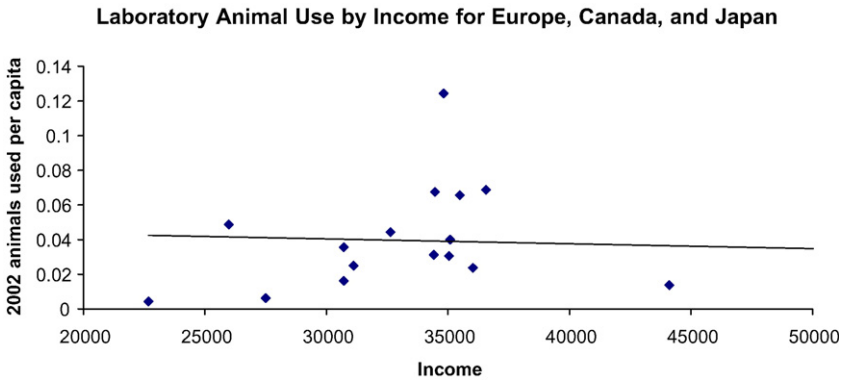


Fig. 4.

capita (see Fig. 4); this relationship was not at all significant using a simple two-variable regression analysis.[4]

In terms of the level of harm per animal, the story is more positive for laboratory animals than it is for animals consumed for meat. Laboratory animals have historically almost always been subjected to intensive confinement. While some experimental techniques have become more intrusive, others have become less intrusive. Laws have been passed, such as the Laboratory Animal Welfare Act in the United States, to improve the welfare of research animals. However, as previously mentioned, this law has loopholes. Furthermore, these laws are only useful if enforced. In general, summarizing evidence across countries, De Greeve et al. (2004) finds that legislative regulations have been widely implemented and "have become rather strict". Furthermore, the number of animals used has generally gone down and review of protocols by animal ethics committees has become commonplace. They also find growing support for the concept of reduction, refinement, and replacement (the "3 R's").

While most people involved in biomedical research consider animal experimentation to be a vital tool, this is to be expected given the strong institutional inertia supporting the practice (Frank, 2005). Furthermore, the number of experts who believe animal research has little to no applicability to humans is growing rapidly, particularly given the growth of sophisticated alternatives. For example, Perel et al. (2007) study the applicability of animal models in multiple medical areas and find a lack of concordance between animal experiments and clinical trials and conclude that this may be due to bias, random error, poor methodological quality, and the failure of animal models to adequately represent human disease. Pound et al. (2004) similarly question the benefit of animal experimentation, while Greek and Greek (2001) make a strong case against animal experimentation's alleged benefits.

Frank (2005) argues that path dependence and institutional inertia is helping to perpetuate laboratory animal research beyond the point when it is the optimal research technology choice. However, the case is also made that economic and scientific growth favors alternative scientific methodologies, with laboratory animal use growing increasingly inferior in cost effectiveness and reliability to newer alternative methods. This is not universally true—some new technologies may help to perpetuate animal use, despite the growth of promising alternatives. These include the creation of "chimeras" that are human–animal hybrids, mapping and manipulation of animal genes, and cloning. Collins (2004) forecasts that New Zealand animal use could quadruple within the next fifteen years due to genetic technologies.

The increasing concern regarding biomedical animal use can be seen in the changing use of animals at veterinary and medical schools. The majority of medical school programs have eliminated surgical training on live dogs or other living animals. Using data for 117 medical schools in the United States collected by the Physicians Committee for Responsible Medicine, 90% no longer use live animal labs, which previously had been a common practice. However, there was no significance difference in income per capita for the states with schools that used live animal labs compared to the states that did not.[5]

A similar trend can be seen in veterinary schools, with schools reducing the number of live animals used for education purposes. However, in the case of veterinary schools, most programs still use live animals. The Association of Veterinarians for Animal Rights surveyed veterinary schools[6] regarding their use of live animals. Only 6 of 26 universities did not perform terminal surgeries on animals in core or elective courses, while half of the universities did not perform terminal surgeries in core courses. On average, the state per capita incomes for universities that did not perform terminal surgeries in any course was significantly higher than for states that did perform terminal surgeries.[7] Furthermore,

[4] $p=0.653$; $F=0.21$; $r^2=0.014$, $\beta_1=-0.0000003$.

[5] This was tested using a t-test with states that had at least one medical school that used an animal lab compared to other states that had at least one medical school, with no difference in mean income per capita. A second test conducted used a linear regression comparing the proportion of schools that used live animal labs (y) for all states with medical schools to state income per capita; again, no significant relationship was found.

[6] Data available at www.avar.org. Medical school data available at www.pcrm.org.

[7] Using a one-tailed t-test assuming equal variance, average state income per capita for schools without terminal procedures = m_1=$36,654; m_2=$32,123; $t=2.43$; $p=0.013$. It should be noted that all but two of the schools were state universities, making statewide public opinion more relevant for guiding program policy.

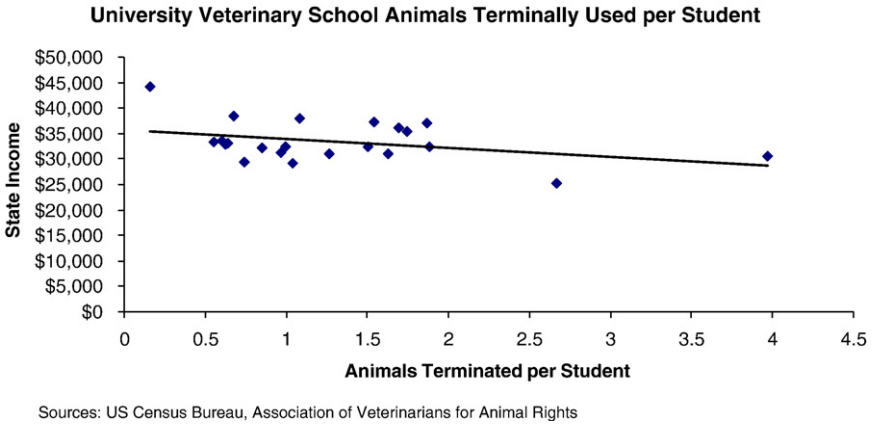


Fig. 5.

as seen in Fig. 5, there was a trend for fewer animals to be used in terminal procedures per student in higher income states. However, this trend was not significant at the 5% level in a simple linear regression.[8]

3.3. *Companion animals relinquishment and euthanasia*

Million of companion animals are killed every year in shelters in the United States (Clifton, 2005). While the treatment of animals in shelters prior to death is typically superior to conditions in intensive animal agriculture or in laboratories, this is still a major animal welfare concern. Relative to other animal welfare issues, companion animal killing in shelters has received a fair amount of attention and resources to fund improvements. This is primarily due to the close link and sympathy many people feel toward companion animals, and in particular dogs and cats.

As a result of public concern and resource commitment, probably the clearest evidence of an animal welfare Kuznets curve can be seen in companion animals. While animal euthanasia initially rose as animals became more common companions in homes, deaths in shelters have exhibited a declining trend in recent decades. There is no uniform source of data for animal shelter deaths. However, major animal welfare organizations and experts in the field do generally agree that shelter deaths have been on the decline. There are some national surveys of shelter animal deaths. However, none have been conducted with a consistent methodology over a long period of time (i.e. across many decades). Looking just at New York City data from the late 1800's on, Zawistowski et al. (1998) show a peak in the shelter death rate per person at around the time of the depression followed by a steep decline to about a tenth of the peak rate in the 1990's. Using long-term data from a California shelter, Savesky (2001) find a sharp decline between 1970 and 1998. Shelter deaths by 1997 were about one-seventh of the number of animals euthanized in 1970. Between 1984 and 1997, New Jersey shelter deaths were cut almost in half (Clancy and Rowan, 2003).

A recent national estimate indicates 4.4–4.6 million dogs and cats are killed per year in shelters in the United States (Clancy and Rowan, 2003) while another estimate comes to a very similar estimate of 4.5 million (Clifton, 2005). While methodologies and figures have varied, over time there has been a clear declining trend over time in the number of animals estimated to have been killed in United States shelters. Rowan (1992) reports that the number of animals being euthanized has declined significantly in recent decades from about 20% of the owned animal population to 5% (or from 13.5 million to 5–6 million in actual values). Some prior shelter death estimates from a variety of sources combined and are shown in Fig. 6. All of these estimates together show a clear decline in animal euthanasia over time. A linear regression for this declining trend in independent euthanasia estimates is significant at the 5% level.[9] While the methodologies of the studies used to create this regression have varied in their specifics, in general they originate from some kind of survey of shelters. Combining data from studies that use a unified metric as their output is a form of "meta analysis", which has received growing acceptance as a methodology in the social sciences. Statistically analyzing variables that vary in a measurable and consistent way across studies is also an acceptable practice in meta analysis (Lipsey and Wilson, 2001). This type of meta analysis has been conducted in economics for example by Card and Krueger (1995) and Tellis (1988), among many others. In these and other meta analysis analyses, the exact methodologies differ across studies included as long as there is a general similarity in metrics and nature of the studies that make them comparable and as long as study selection is kept as free of bias as possible.

Cross-sectional data suggests a possible negative relationship between income and animal shelter deaths by state, using data from eight U.S. states (see Fig. 7). A simple two-variable regression between animals killed and income per capita was not quite significant at the 5% level. However, when a dummy variable is added for the southern states,

[8] $p=0.088$; $F=3.22$; $r^2=0.139$, $\beta_1=-0.00008$ (with y = animals used per student and x = per capita income).

[9] R-squared=0.48, $t=-3.04$, slope coefficient=-0.0019, standard error=0.0006, $p=0.012$. Sources used for estimates include: Arkow (1994), 5.7 million, Rowan (1992) 5–6 million, Mackie (1992) 7 to 15 million, Thornton (1991) 16 million, Carter (1990) 13 to 17 million, American Humane Association (1988) 7.3 and 11.3 million, The Humane Society of the United States (1987) 7.5 million, Rowan and Wilson (1985) 8 to 10 million, McCulloch (1984) 15 million, Hoyt (1983) 13.5 million.

which tend to have a higher death rate regardless of income, the negative relationship becomes highly significant.[10] The southern states of the United States have traditionally had shelter killing rates that are two to three times the national norm as well as the lowest pet licensing compliance rate (Clifton, 2002). The south also has a distinct culture and history, with these states defining the former confederacy.

Shelters increasingly rely on foster programs to keep animals in private homes while they are waiting to be adopted. Concern for the health of animals at shelters has grown. Shelter medicine has become a new and growing veterinary field. Cats are increasingly kept in open "catteries" in some shelters instead of small single animal cages. When animals are killed at shelters, methods of euthanasia have improved. At one time stray dogs were even clubbed or drowned by authorities. This has progressed to methods such as shooting, to carbon monoxide gas, to lethal injection. As of 2001, five states mandated lethal injection as the preferred or required euthanasia method (Hofve, 2001). The mean income per capita did not significantly differ between the states that mandated lethal injection and other U.S. states.[11]

The quality of life for companion animals has been improving. Pet treatment in homes is improving, and people are spending record amounts on their pets (APPMA, 2006). Indicators of increasing concern for companion animal welfare in general in the United States include growing numbers of safe havens for animals in domestic violence situations and increasing humane education programs in shelters (Lockwood, 2005). Animals are also increasingly treated as members of the family, with higher levels of spending on luxury items for the animals along with food and veterinary care.

Both in terms of quantity and quality of life, companion animals appear to be benefiting from being beyond the peak of what resembles an animal welfare Kuznets curve.

3.4. *Other indicators*

There are some other indicators that indicate improvements in animal welfare, including the amount of legislation concerning animals and the number of organizations concerned with animal issues. Other indicators of increasing concern for animal welfare in the United States include rising numbers of law schools offering instruction in animal law and increased sympathetic media coverage of animal-related issues (Lockwood, 2005).

Animal protection organization trends suggest growing concern for animal welfare at higher income levels. Countries with higher per capita income have more animal protection organizations, which generally also translates into more animal protection legislation (Trent et al., 2005). The authors also found an increasing trend for the number of animal protection organizations over time across countries. The relationship between national income and number of animal protection organizations per million people is shown in Fig. 8. Using a simple linear regression, there was a highly significant positive relationship between a country's income and the number of animal protection organizations they had.[12]

3.5. *Policy and law*

In the United States, a growing number of significant animal welfare-related laws have been passed into law in the last half a century, including the Humane Slaughter Act in 1958, the Endangered Species Act in 1966, the Laboratory Animal Welfare Act in 1966, the Marine Mammal Protection Act in 1972, and a number of amendments and other laws since that time. As of 2003, forty-one states and the District of Columbia had enacted felony-level animal cruelty statutes, with the pace of laws being enacted accelerating over time (Rowan and Rosen, 2005). States that had felony-level animal cruelty statutes had a significantly higher per capita income on average than states that had no such statute.[13] However, among states that had felony-level animal cruelty statutes, there was no significant relationship between how long ago the law was enacted and state-income.[14]

A growing number of animal protection initiatives have also been put on various state ballots in recent years, with the majority passing. Rowan and Rosen (2005) conclude from examining animal welfare legislation in the United States that while the animal welfare movement had little clout from 1900–1950, this changed in the 1950's. The movement further advanced into more mature and influential stages in the late 1970's to early 1980's.

It should be noted that laws do not necessarily translate into improved animal welfare. Laws can sometimes be put into place to appease the public, with no intention of enforcing those laws for example, Clifton (2006) discusses how the USDA reinterpreted the "Twenty-Eight Hour Law" which limits the amount of time animals can be kept on vehicles to effectively delay any real enforcement of the law as well as arbitrarily reinterpreting the Animal Welfare Act to exempt rats, mice and birds from protection. With the Animal Welfare Act, the exclusion left most laboratory animals unprotected from 1973 to 2000, when they were forced to change due to lawsuits. However, in the same year that it appeared the USDA would be forced to extend the law to include all animals, as originally intended, amendments were added to legally exclude these animals from the act. These are just two examples of how laws are sometimes not enforced when they conflict with the agendas of government agencies, and when the agency is

[10] For 2-variable regression y is animals killed per 1000 people, x is state income per capita, $p=0.077$; $F=4.55$; $r^2=0.431$, $\beta_1=-0.00081$. For 3-variable regression y is animals killed per 1000 people, x_1 is state income per capita, $x_2=1$ for southern states, p (t-test for income coefficient)=0.004; $t=-4.989$; $r^2=0.936$, $\beta_1=-0.00069$. States in analysis include CN, NJ, VI, NC, UT, MI, OR, WA. Southern states included North Carolina and Virginia.

[11] Mean income was $290 higher in states that mandated lethal injection, however this difference was not significant using a one-tail t-test ($p=0.45$; $t=0.12$).

[12] $p=0.0001$; $F=21.4$; $r^2=0.505$, $\beta_1=0.0003$.

[13] Mean income was $3960 higher in states that had felony statutes, and this difference was significant using a one-tail t-test assuming equal variance ($p=0.012$; $t=2.31$).

[14] $p=0.825$; $F=0.049$; $r^2=0.0014$, $\beta_1=0.00003$ (where a positive coefficient indicates that higher income states enacted the law earlier—i.e. y = years since statute was enacted).

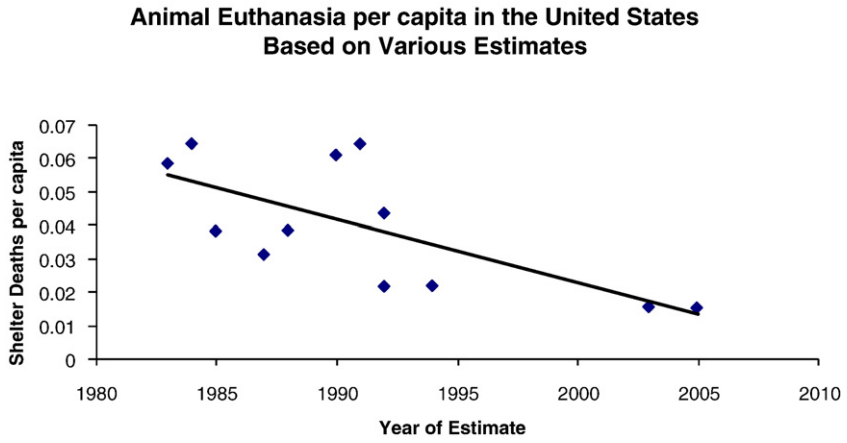
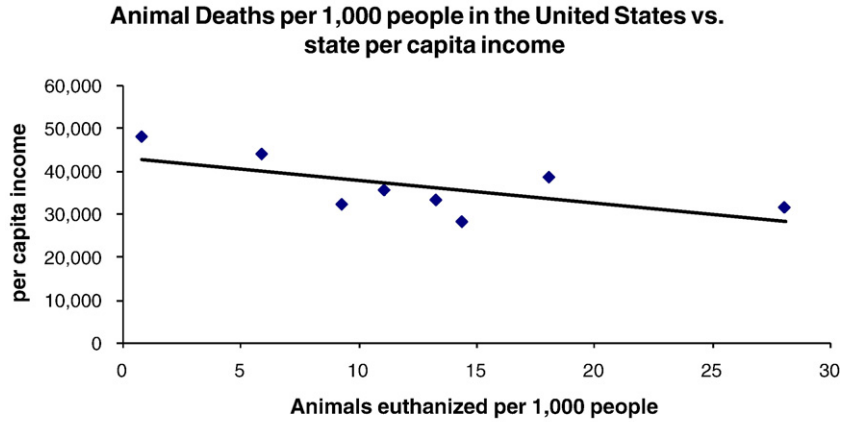
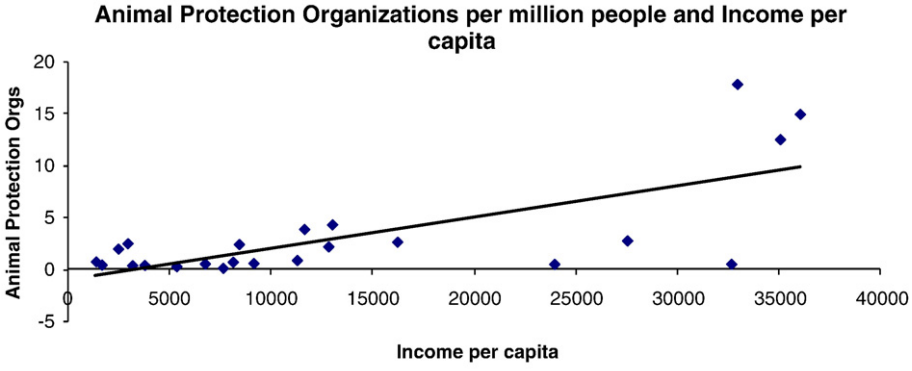


Fig. 6.



Sources: Animal People July/August 2006 and U.S. Census Bureau.

Fig. 7.



Sources: Humane Society of the United States "State of the Animals" (Trent et al., 2005) and International Monetary Fund.

Fig. 8.

forced to enforce the law, the law is changed rather than the policy. Nevertheless, laws passed still can be a valid measure of changing public sentiment, and though there may be considerable institutional drag in enforcement, changing public opinion and laws likely eventually translates into changes in enforcement, at least in some cases.

4. Discussion

The empirical evidence for an animal welfare Kuznets curve is mixed. Some quantitative indicators show sign of a peak, then a decline, while others show continue increasing as the economy grows. Furthermore, in some cases there is a cross-sectional significant relationship between higher income and higher animal welfare across states or countries while in other cases there is no such evidence. The qualitative picture is also mixed in terms of suffering experienced for a typical animal. While concern for animals is generally rising, other trends in industrialization may counter these welfare gains in some industries.

Probably the area in which there is the greatest evidence for an AWKC is for companion animal treatment. If changing levels of public concern is the primary driver of the downward slope of the AWKC, then it makes sense for companion animal welfare to lead other areas. Concern for animals we keep as companions and inevitably form an emotional bond with is likely to come before concern for animals that are removed physically and psychologically from us. Furthermore, most of the goals of the companion animal welfare movement in their broadest sense (i.e. reducing the number of deaths of unwanted animals, minimizing suffering before death) have a broad public consensus. The issue is more "how" to achieve these broad goals than whether to do so. Other issues such as laboratory animal use and animal agriculture, have no such consensus. While people generally agree that harm to animals should be minimized in these settings, what trade-offs and goals should be sought is strongly contested.

In addition to examining some preliminary empirical evidence, the theoretical concept of an animal welfare Kuznets curve was also introduced and explored here. This can be a useful concept for forecasting the future path of change for one important negative side-effect that has resulted from industrialization. Whether the welfare of nonhuman animals will continue to deteriorate or improve with further economic development is still an open question. However, the AWKC provides a more formal and testable statement of what may happen with animal welfare in the future. In the past few decades, there have been a number of challenges presented on environmental, humanitarian, and ethical grounds to the alleged excesses of free market capitalism. The AWKC presents another issue for possible future exploration on this topic. If the welfare of animals is expected to continue to deteriorate indefinitely as income rises, this is another possible challenge to a policy focus on economic growth. On the extreme end, Nibert (2002) argues that capitalism necessarily implies the exploitation of animals. However, if an AWKC exists, then future economic growth need not come at the expense of animal welfare.

While technology itself may address some animal welfare issues, in many cases human action may be necessary. As with the EKC curve, if a declining half of the curve is empirically observed, increased income appears in many cases to lead to increased concern which is a vital mediating factor in leading to welfare improvements. As with the EKC, even if an AWKC does exist, the conclusion that we can ignore these issues and expect to "grow our way out" of them ignores the role of human effort in causing the downward sloping half of such a hypothetical curve.

If an AWKC does exist, then further economic and technological progress may help to improve animal welfare. But either way, such improvement will likely only come through continued public pressure and policy shifts that promote welfare improvements.

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