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Examining the Economic Basis of Ethical Vegetarianism

Poh Lin Tan

ICPSR
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Poh Lin Tan
ptan@princeton.edu

Princeton University
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ABSTRACT

People who choose to be vegetarian for ethical reasons often believe that their choice has a small but positive impact on the welfare of animals. This paper examines the main economic arguments that are widely used in support of this belief as well as competing theories that claim that ethical vegetarianism in fact leads to *more* animal suffering. Using national chicken and pork production data from the United States Department of Agriculture and household-level expenditure data, I provide some estimates of the elasticity of quantity of each meat type produced to changes in consumer expenditure on it. The data suggest that elasticity of supply is positive and smaller than unity, and that values are larger when the changes in expenditure are negative. On the other hand, there is little evidence to support the rival hypothesis that ethical vegetarianism results in greater animal suffering.

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1. INTRODUCTION

1.1 The Protest Against Intensive Meat Production

The steady climb in Americans' consumption of meat, which reached a height of 200 pounds per capita in 2005 alone (United States Department of Agriculture Economic Research Service), has long been observed with interest by many researchers. Most studies agree that the rise in meat consumption is caused not only by greater consumer demand partly due to higher incomes, more consistent meat quality assured by product grading, persistent meat advertising coupled with increasing dietary preferences for a balanced meat diet, but also influenced by cost-reducing changes in meat production methods that lead to higher output.

Although supply growth typically represents lower prices and hence greater consumer surplus, intensive meat production methods have increasingly come under fire for externalizing some of its costs onto the environment, facilitating the spread of animal diseases as well as sacrificing safe working conditions of laborers and the well-being of animals. These undesirable features of factory farming have become characteristic of many price competitive producers, which have turned to rearing animals in high densities, offering unattractive wages and working conditions to farm and slaughterhouse workers, as well as seeking cheap methods of pollution control and disease prevention in order to minimize costs. For non-intensive meat producers, the price elastic nature of demand for meat from individual producers is a tempting signal from the market that they should follow the same path to stay in the game.

Ethical vegetarianism as a holistic movement argues that these negative externalities have moral costs that are too high to justify current production methods, and hence advocates the boycotting of meat and similarly intensively produced animal foods, including eggs, dairy products and cow leather. Other animal products such as honey and alcoholic drinks are, however, typically kept off this list. It is also worth noting that ethical vegetarians may not necessarily oppose exploitation of animals, as long as it does not involve what may be perceived as excessive cruelty to animals or workers, environmental irresponsibility or other moral concerns of the movement.

Although part of the appeal of ethical vegetarianism may be dissociating oneself as much as possible from a system that one finds odious, the movement seeks most of its justification from economic arguments, one of which is that a fall in demand for products would influence supply, either by reducing quantity supplied or by convincing producers to switch away from intensive to more ethical methods of production. However, if these arguments turn out to be weak, one may contend that an ethical vegetarian has no strong justification to persuade others to join the movement, at least from a consequentialist point of view, even if he or she may derive personal satisfaction from not consuming intensively produced animal products.

1.2 The Economic Basis of Ethical Vegetarianism

In this paper, I examine some of the core economic arguments articulated in the writings of the philosopher Peter Singer, who is considered a central spokesperson for ethical vegetarianism and author of several highly influential books and articles, including *Animal Liberation* (1977), first published in 1975, and, more recently, *The Way We Eat* (2006), the latter of which was coauthored with Jim Mason.

1. ***Ethical vegetarians reduce the quantity of animals produced in factory farms and hence reduce animal suffering.***

Using the example of the playwright George Bernard Shaw, a vegetarian who was convinced that his lifestyle saved many "grateful" animals, Singer (1977) argued that one person's decision to not buy meat leads to a fall in the price of meat and in the profitability of meat production, which causes a fall in supply. In 1980, he abandoned this claim in favor of a more subdued version, which is that one person's decision to not buy meat can *contribute* to a fall in the price of meat and in the profitability of meat production, which leads to a fall in supply, *if* there are enough other people who also choose to change their eating habits (Singer 1980).

2. ***Ethical vegetarians reduce the amount of grains consumed overall, reducing world food prices and hence human suffering due to hunger.***

Singer observed in *Animal Liberation* that since we could derive more nutrition from one pound of corn if we consumed it directly than if we fed the corn to a steer or chicken and then consumed the meat, modern methods of meat production actually reduce the amount of food available in the world. Moreover, according to his argument, the demand for inputs by the meat industry raises the price of grain and hence lowers the quantity that people in third world countries are able to buy (Singer 1977). If there were more vegetarians in America, then the world prices of grain would be more affordable, thereby decreasing the level of global malnutrition. This argument was echoed in another popular book, C. David Coats' *Old MacDonald's Factory Farm* (1989).

The above is not meant to be by any means a comprehensive list, but if the arguments are in fact incorrect, then depriving oneself of animal products or urging other consumers to embrace ethical vegetarianism, which Singer (1977) calls "the most urgent task of the animal liberation movement", may not be justified from a consequentialist view of morality.

Both arguments are empirical claims that can be empirically verified or refuted. Since the problem of malnutrition in the third world is attended by a host of factors strongly influenced by political choices and other non-economic issues, I will confine the paper's discussion to the more plausible first claim dealing with animal welfare, which is also the central claim of the movement.

1.3 Qualifying the Idea of Reducing Suffering

In the first economic argument, Singer implies that a lower level of production would result in a fall in total animal suffering. Since decreasing the quantity of meat produced necessarily means that fewer animals would be brought into being and reared, one may anticipate the objection that it is difficult to say whether the animals themselves would rather have never been born than to be subjected to the kind of conditions found in most factory farms.

Singer defended this assumption by arguing that there could be no moral obligations to beings that are nonexistent and which we do not know will definitely exist in the future; on the other hand, to the animals that do already exist, we are morally obliged to give equal consideration to their interests (Singer 1977), which would require us to produce meat and animal products using morally stringent but costly methods, limiting the quantity produced.

The philosophical point remains contentious and out of the scope of this paper. Nevertheless, one would intuitively imagine that the total happiness of six chickens squeezed by any means into a cage meant for only one chicken would be less than the total happiness of three chickens which are only uncomfortably crowded in the same cage. Therefore, I have adopted Singer's assumption that decreasing the quantity of meat produced by intensive farming methods is equivalent to reducing animal suffering, although readers may certainly choose to take a different view, resulting in a different understanding of the results in this paper.

2. LITERATURE REVIEW

2.1 The Philosophical Basis of Ethical Vegetarianism

Animal Liberation provided ethical vegetarianism with its intellectual footing and vision for altering mainstream behavior, differentiating it from other deviant groups with less coherent ideas. There are two important distinct arguments in the book: the first, which Singer considers "irrefutable", is that it is not *necessary* for humans in developed countries to cause suffering to other animals in order to feed and clothe ourselves; the second is that it is not morally *justified* for humans in developed countries to do so (Singer 1977). If both premises are accepted, then it seems that all moral human agents should choose to become vegetarian.

The first argument is clearly supported by empirical evidence, since there are indeed many people who consume only plant products and lead exceptionally healthy lives even by first world standards. As for using animal skins for clothing or their feathers for bedding, there are certainly enough synthetic materials that would serve as alternatives, and which may very well be cheaper (Singer 1977). Although being compelled to wear plastic shoes instead of leather shoes may represent a huge loss to some people, the point that the choice to use animal materials in this day and age is strictly optional remains correct. However, Singer did not address the environmental costs involved in the manufacture of many synthetic materials that may, in the eyes of environmental vegetarians, outweigh the costs of animal suffering.

The second argument is philosophical in nature and hence considered far more debatable. Singer consistently asserted that he was not claiming that animal lives were as equally valuable as human lives, but rather that their interests, which results from their ability to feel pain and pleasure, deserves "equal *consideration*", if not "equal or identical *treatment*" (Singer 1977, emphasis in text). Therefore, he claims that it is not justified for humans to consume animal flesh and skins since the pleasure that we derive from doing so is far outweighed by the suffering endured by the animals.

While the intention of this paper is not to challenge the philosophical tenets that underlie ethical vegetarianism, which may very well remain intact even if its economic arguments become discredited, it is worth noting that consequentialist arguments using economic evidence have particular force given the nature of these philosophical ideas. Singer himself remarked that "[t]he point of altering one's buying habits is not to keep oneself untouched by evil, but to reduce the economic support for the exploitation of animals, and to persuade others to do the same", and, even more importantly, that "[moral] consistency demands only that we do not contribute *significantly* to the demand for animal products" (Singer 1977, emphasis in text). It is therefore clear that the consequentialist view of morality is critically relevant to Singer's version of ethical vegetarianism.

2.2 An Alternative Theory

In 1978, Philip Devine pointed out that Peter Singer may not be right to assume that lower profits in the meat industry would automatically imply lower levels of production. Instead, he argued that if a small but substantial group of consumers were to withdraw from the market,

causing prices to slip, the majority of consumers which are not vegetarian may respond to the change of price by demanding higher quantities and thus make up the fall in quantity demanded (Devine 1978), depending on the elasticity of demand for meat. This economic argument, while plausible enough in the short run if the fall in demand were considerable and unexpected, should not deter consumers who are determined to stick to a vegetarian diet for a long period of time, since presumably suppliers would be able to respond to the new lower price in the long run by cutting back production. It is possible and even probable that consumers would be unwilling to completely scale down consumption to former levels after the price increases, which would dilute the impact of the original fall in demand, but it is quite unlikely that a sizable proportion of the population would unexpectedly turn vegetarian in the same period, and at any rate production levels would still have declined.

Devine's second argument, which hypothesizes that instead of cutting back production, producers might react to falling profits from sales by "turning to yet more intensive (and thus more painful) forms of meat production" (Devine 1978), or begin producing meat of lower quality in terms of sanitation to recover profits, is more plausible and troubling. Indeed, expected rises in grain prices in 1983, which threatened to lower the profitability of beef production, did lead to predictions that "beef production will become more intensive", and that producers would further attend to "marginal costs and returns to the product" (Bartlett & Cook 1983). The implications are serious not only for animal welfare, but also from the perspective of meatpacking workers, who are estimated by the Bureau of Labor Statistics to be four times as likely as workers in other private industries to become injured or sick due to their jobs (Smil 2002), and whose jobs would likely become more dangerous with increased cost cutting.

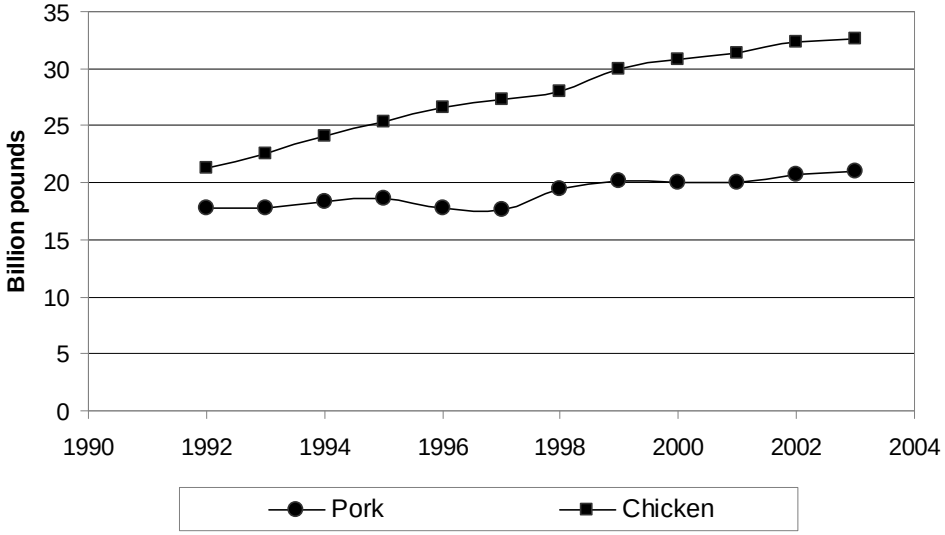
Based on similar lines, David Fraser developed an alternative theory for the historical intensification of meat production, noting that many producers do have "strong animal care values" but find it difficult to act on them because of financial constraints (Fraser 2005). The constraints tighten when profitability falls, and producers react by trying to lower average costs of production by expanding production and spending less on each animal, which necessarily deprives the animals of room and health care, resulting in greater suffering.

Following this reasoning, Fraser predicted that falling profits would *decrease* animal welfare, contrary to the theories of ethical vegetarianism. Therefore, if Fraser's arguments are accepted, becoming vegetarian for the sake of animal welfare achieves the opposite of its goal. The advantage of this alternative interpretation is that it does not require using the controversial assumption that falling production results in less suffering, and instead measures welfare more concretely by the amount of resources devoted to each animal.

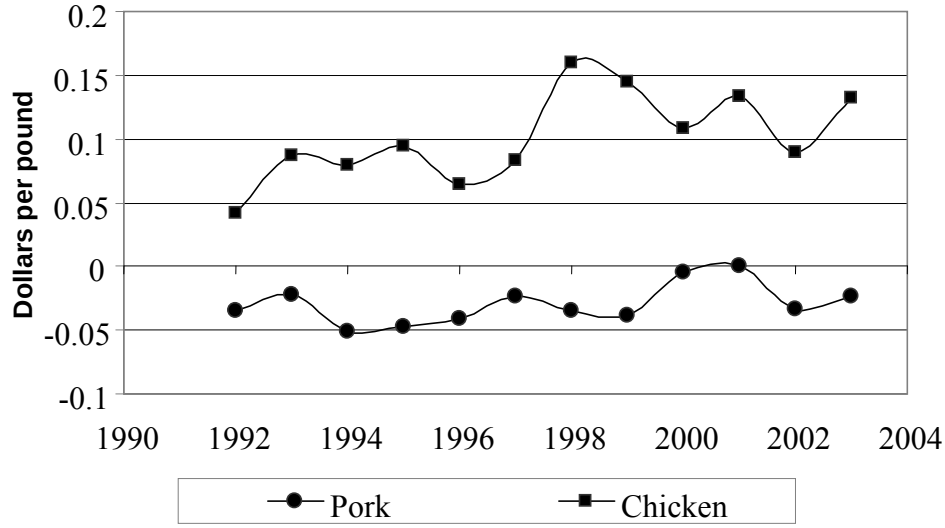
Table 1: Comparing the two theories of intensive animal production

Ethical vegetarianism	Fraser (2005)
Falling profits lead to falling production.	Falling profits lead to increasing production as producers seek to increase profit margins by expanding
Falling profits lead to fewer animals being subjected to mutilation and stress, and hence to less animal suffering.	Falling profits lead to fewer resources to spend on each animal, leading to more animal suffering.

Graph 1: Pork and chicken supply 1992-2003



Graph 2: Net return of pork and chicken production 1992-2003



Graphs 1 and 2 seem to offer some support this alternative hypothesis. Although profits for pork production fell in 2001, production continued to rise in 2002 and 2003. While production seemed to have responded to falling profits from 1993-1997 with lower production from 1996 to 1997, it is likely that industrial adjustments at this time were responsible for the declines due to important technological advances in retailing and meat processing. These tended to favor larger retailers and slaughter plants, creating a more consolidated and exclusive supply chain structure (Barkema et al 2001). Therefore, it is possible that many producers responded to the incentive of lower costs by enlarging operations even as other producers left the industry, stabilizing the level of pork production. A similar strategy may also have been adopted by the chicken industry, with producers responding to erratic profits by pushing down costs through higher production.

3. THE MODEL

3.1 A Model to Test the Economic Arguments of Ethical Vegetarianism

Singer's revised claim that not buying meat can *contribute* to a fall in the price of meat and lower the supply, *if* there are enough other people who are doing the same, is motivated by the fact that each consumer has a negligible impact on the industry. In response, I will seek to estimate proportional rather level effects for chicken and pork.

The responsiveness of the quantity of each type of meat supplied to a change in expenditure on meat and animal products is estimated using the constant elasticity model below:

$$\ln(Q)_t = ß_0 + ß_1\ln(X_1)_{t-1} + ß_2\ln(X_2)_{t-1} + ß_3\ln(X_3)_t + ß_4\ln(X_4)_t + \varepsilon,$$

where

Q_t = quantity of meat produced domestically and imported
X_1 = real domestic expenditure on meat
X_2 = real retail price per 10 lbs
X_3 = real cost of production per 10 lbs
X_4 = quantity of meat in inventory at beginning of *t*,

Q is measured in pounds and includes imported meat, since presumably ethical vegetarians care about the well-being of pigs raised in Denmark as much as they care about U.S. pigs. Two meats, chicken, which includes meat of layers and other chickens, and pork, have been chosen for comparison, firstly because both groups of animals are typically raised in confinement systems and arguably face the worst abuses of factory farms, and secondly because they have relatively short production cycles compared to beef, which allow for a larger sample size.

X_3 includes all overhead and operating costs as reported by the United States Department of Agriculture Economic Research Service. Both X_2 and X_3 are measured per 10 pounds instead of per pound in order to derive positive values of $\ln(X_2)$ and $\ln(X_3)$ for Box-Cox regressions.

Since rearing animals takes time, producers can only react to expenditure and price changes in *t* by either adding or taking stocks from the inventory, or by importing live animals. To measure the impact on actual new production, a one-period lag is introduced for X_1 and X_2. It is currently unclear how many lags would be optimal to include, which should be determined using either the Bayes or the Akaike information criterion tests. The lags also eliminate the problem of simultaneous causality between the level of expenditure and level of production, as well as for prices and level and production.

The length of each lag, beginning on the 1st of December and the 1st of June of every year, is six months for pigs which are typically slaughtered at 24 weeks of age, and two months for chickens, which are slaughtered at an increasingly young age, from around 72 down to 48 days by 1995 (Smil 2002). A length of two months, beginning from the December of the previous year, therefore seems fairly suitable.

3.2 A Model to Test the Alternative Theory

Here, a second model is used for a different measure of animal suffering.

The responsiveness of the cost of production per 10 lb to a change in expenditure on meat and animal products is estimated using the model below:

$$\ln(C)_t = ß_0 + ß_1\ln(X_1)_{t-1} + ß_2\ln(X_2)_{t-1} + ß_3\ln(X_3)_t + ß_4\ln(X_4)_t + \varepsilon,$$

where

C_t = real cost of production per 10 lb
X_1 = real domestic expenditure on meat
X_2 = real retail price per 10 lbs
X_3 = number of animals in inventory
X_4 = quantity of meat in inventory at beginning of t,

X_3 is included as a direct factor of production costs as well as an indicator of the scale of production, which would affect the cost-saving options available to the producer.

3.3 The Assumption of Constant Elasticity

Elasticities yielded by both models are reliable only if the assumption that they are constant over time. The Box-Cox model, shown below, uses a more general form that avoids this assumption, where the model is linear if $\lambda = 1$, log if $\lambda=0$ and reciprocal if $\lambda = -1$. Chang (1977) found that the measure of fit was better than with either of the stricter forms, with smaller mean square errors and mean square percentage errors.

$$Q^* = ß_0 + ß_1X_1^* + ß_2X_2^* + ß_3X_3^* + ß_4X_4^* + \varepsilon,$$

where

$Q^* = (Q_t^{\lambda} - 1)/\lambda$
$X_1^* = (X_1^{\lambda} - 1)/\lambda$
$X_2^* = (X_2^{\lambda} - 1)/\lambda$
$X_3^* = (X_3^{\lambda} - 1)/\lambda$
$X_4^* = (X_4^{\lambda} - 1)/\lambda$,

λ is a transformation parameter yet to be determined, and elasticity of Q w.r.t X_1,

$E_{QX1} = ß_2X_1^{\lambda} Q_t^{-\lambda}$ (Chang 1977).

Therefore, if the constant elasticity models yield significantly different λ from 0, it should be rejected in favor of the general Box-Cox model.

4. MAIN DATA SOURCES

4.1 United States Department of Agriculture

Most of the required data can be obtained from the Statistics Service or the Economic Research Service of the United States Department of Agriculture (USDA), which collects monthly information on the quantity of red meat, poultry and dairy products produced domestically, imported, exported and stored in inventory. Historical data were found in the Commodity Yearbooks and the Livestock, Dairy and Poultry Outlook tables from the Economic Research Service, while more recent data for 2005 were obtained from the National Agricultural Statistical Services. Only data for commercial production were available, which is not a serious issue since the focus is on intensive producers.

Data limitations stem largely from the fact that only annual data were available for costs of production, where bimonthly and biyearly averages for each *t* were used in place. Moreover, cost data for pigs were available only from 1992, and hence there is only 26 data points from the beginning of 1992 to the first half of 2005. On the other hand, cost data for chicken were available form 1985 but the series were discontinued in 2003, yielding 114 bimonthly points of data. Methods of cost accounting differ among commodities, which should be considered when making direct comparisons of results for costs of chicken and pork.

4.2 Consumer Expenditure Survey: Diary Survey

The Diary Survey is held nationwide with more than 10000 consumer units participating every year. Respondents are asked to record their purchases daily for a period of two weeks, and these data are collected by the Bureau of Labor Statistics along with other information such as income and family status. In addition, each unit is fitted with weights derived by the Bureau of Labor Statistics such that the weighted sample represents one third of the U.S. population. The data are available by quarter and can be separated into monthly data.

Only completed responses between 1985 and the first half of 2005 were used. Since weekly expenditures are recorded, where the first day could occur on any day of the month, responses that began within the last three days of each month were considered data for the next month.

Ideally, expenditure data for chicken and pork from the Consumer Expenditure Survey should include money spent on each meat at home as well as food in restaurants and elsewhere. Unfortunately, this is impractical, because it is very difficult to assess how much of the expenditure on a chicken sandwich is for chicken only. Therefore, I made the assumption that people consume similar proportions of meat when they dine outdoors as they do at home. Consumers with a preference for lamb should theoretically exhibit the same behavior in grocery stores and restaurants, for example, although this may be violated in practice.

The study is used by the Bureau of Labor Statistics to compute the monthly and annual Consumer Price Index, and inflation data for U.S. urban averages were separately obtained to derive real levels of expenditure, costs and prices.

4.3 Some Summary Statistics

Table 2: Summary Statistics

	Pork			Chicken		
Variables	No. of observations	Mean	Standard deviation	No. of observations	Mean	Standard deviation
Domestic Production (million lb)	27	55600	3770	114	23700	6220
Imports (million lb)	27	2510	591	114	4.337	5.636
Expenditure on meat (million dollars)	27	43200	2580	114	12200	1620
Retail prices ($/lb)	27	1.465	0.052	114	1.003	0.100
Cost of production ($/lb)	27	0.613	0.026	114	0.490	0.111
Meat in inventory (million lb)	27	417	72.4	114	922	474

Table 3 is included to address the issue of multicollinearity between expenditure and retail prices that could lead to biased results. The correlation levels are not alarmingly high, and the reverse signs for each commodity suggest that demand is price inelastic for pork but price elastic for chicken, which, from the point of view of ethical vegetarianism, implies that chicken is a better target for lowering expenditure.

Table 3: Correlation between expenditure and retail price

Pork No. of observations: 27		Chicken No. of observations: 114	
	Retail price		Retail price
Expenditure	0.3444	Expenditure	-0.5387

5. RESULTS AND DISCUSSION

5.1 Expected Results

Theoretically, it is possible to find results that support both theories, with suppliers cutting down both production levels *and* production costs in response to lower expenditures. In this situation, it would be difficult to say whether ethical vegetarianism has a positive impact on animal welfare, since fewer animals would suffer, but the average level of suffering for the remaining animals rise.

This dilemma is not expected to arise, however, because supply is already highly price competitive, and it would be difficult for producers to find ways to further cut costs without beginning to hurt profits, which higher animal death rates due to poorer conditions would cause. It is more likely that higher value per animal would lead to increased production and increased average costs of production, which leads to the opposite dilemma of having more suffering animals with a lower average level of suffering.

I therefore predict that costs of production would react only to *rising* expenditures, and that production levels would react to both increases and falls in expenditure, although they should be more elastic to falling expenditures, since lowering production is generally less costly and risky than expanding it.

5.2 Testing the Economic Arguments of Ethical Vegetarianism

Table 4 shows the outcome of the Akaike and Bayes information criteria tests for the first model, which seeks to find the fewest number of parameters that obtains a minimal level of residual sum of squares. Choosing the smallest values of AIC and BIC, I find that the results coincide for both pork and chicken, with one lag for the former and three for the latter. This is likely to be due to the short production cycle of chickens, allowing producers to take into account relatively recent consumption levels.

Table 4: Choosing number of lags for expenditure using Akaike and Bayes Information Criteria

Lags	Pork No. of observations: 23			Chicken No. of observations: 110		
	degrees of freedom	AIC	BIC	degrees of freedom	AIC	BIC
1	1	-2.674*	-2.575*	1	-1.344	-1.295
2	1	-2.596	-2.448	1	-1.411	-1.338
3	1	-2.509	-2.312	1	-1.689*	-1.590*
4	1	-2.432	-2.185	1	-1.676	-1.553

Table 5: Estimates of elasticities of chicken and pork production w.r.t expenditures in previous *t* using robust regressions

	ln(pork produced and imported) $_t$	ln(chicken produced and imported) $_t$
ln(expenditure) $_{t-1}$	0.174**	0.130*
	(0.059)	(0.057)
ln(expenditure) $_{t-2}$		0.077
		(0.064)
ln(expenditure) $_{t-3}$		0.110
		(0.057)
ln(retail price) $_{t-1}$	-0.357*	0.076
	(0.159)	(0.193)
ln(cost of production) $_t$	-0.479**	-0.461**
	(0.031)	(0.078)
ln(meat in inventory) $_t$	0.041	0.307**
	(0.028)	(0.037)
Constant	18.67	9.696
Adjusted R^2	0.932	0.954
Root MSE	0.019	0.058
No. of observations	26	111

* significant at 5% level
** significant at 1% level

Table 5 shows the first estimates of the responsiveness of the quantity of meat supplied to a change in expenditure. Elasticities for both pork and chicken supply are positive and less than unity, with the supply of chicken being slightly less elastic. The variables seem to account for a large proportion of variation of production, suggesting that omitted variables bias is not a significant problem. The signs for costs of production are positive, as might be expected, while the reverse signs for the coefficients of retail prices affirm that producers respond to levels of actual expenditures rather than to prices, since demand is price elastic for chicken but inelastic for pork.

To make some brief and imprecise calculations relevant from the point of view of ethical vegetarians, a 1% fall in total expenditure, which involves converting roughly 3 million Americans who are not currently vegetarian to the cause, would result in a fall of 0.174% of pork production and 0.130% of chicken production, which, using production levels for 2003, translates to 0.00174*5497980000 = 9566485.2 pounds of pork and 0.0013*10406627959 = 13528616.3 pounds of chicken, or about 63777 150-pound pigs and 4.5 million 3-pound broilers. The average vegetarian therefore causes a difference to 0.02 pigs and 1.5 chickens every production cycle, or 0.02*2 = 0.04 pigs and 1.5*6 = 9 chickens every year, which is somewhat larger than Singer's noncommittal guess of about 20000 birds for every 10000 vegetarians (Singer 1980).

Table 6: Box-Cox test for model transformation and the assumption of constant elasticity

		Pork		Chicken	
	Implied Model	**Prob>χ^2**	**Decision**	**Prob>χ^2**	**Decision**
H_o: $\lambda = -1$	Reciprocal	0.679	Cannot reject	0.000	Rejected at 5% significance
H_o: $\lambda = 0$	Logarithmic	0.075	Cannot reject	0.474	Cannot reject
H_o: $\lambda = 1$	Linear	0.003	Rejected at 5% significance	0.000	Rejected at 5% significance
No. of observations		26		111	
λ		-1.293 (0.706)		-0.203 (0.269)	
Log likelihood		-168.1		-2286.8	

Table 6 shows the results of the Box-Cox test, which returned a non-significant λ-value of -1.293 for pork and -0.203 for chicken, implying that the constant elasticity assumption for the particular model is not statistically problematic, even though the linear model was rejected for both commodities. On the cautious side, the Prob>χ^2 for pork is fairly small, and the estimates should not be taken as precise values.

Table 7 on the next page distinguishes elasticities of quantity supplied to positive and negative changes in expenditure, and as predicted, the supply of pork is more positive to falls than to increases in expenditure. The coefficient of 0.275 is larger than the previous estimate of 0.174 for pork and is the more useful statistic for ethical vegetarians. Using similar calculations from those performed on the previous page, the true marginal effect is closer to about 0.034 pigs per year per vegetarian, or 1 pig for every 30 vegetarians.

Estimates for either positive and negative changes in expenditure were not significant for chicken, although the *t*-value for ln(expenditure) $_{t-1}$ is substantially better at *t*-1 for negative changes in expenditure than for positive changes, and yields a p-value of 0.074, which can be construed as statistically significant.

Table 7: Comparing elasticity estimates of chicken and pork production w.r.t increased and decreased expenditures in previous *t*

	ln(pork produced and imported) $_t$		ln(chicken produced and imported) $_t$	
	Expenditure in *t*-1> Expenditure in *t*-2	Expenditure in *t*-1< Expenditure in *t*-2	Expenditure in *t*-1> Expenditure in *t*-2	Expenditure in *t*-1< Expenditure in *t*-2
ln(expenditure) $_{t-1}$	0.136	0.275*	0.099	0.284
	(0.145)	(0.115)	(0.108)	(0.155)
ln(expenditure) $_{t-2}$			0.097	-0.062
			(0.110)	(0.115)
ln(expenditure) $_{t-3}$			0.094	0.137
			(0.068)	(0.087)
ln(retail price) $_{t-1}$	-0.167	-0.533**	0.067	0.129
	(0.188)	(0.156)	(0.241)	(0.321)
ln(cost of production) $_t$	-0.475**	-0.442**	-0.458**	-0.521
	(0.059)	(0.057)	(0.097)	(0.137)
ln(meat in inventory) $_t$	0.137	0.036	0.311**	0.291
	(0.069)	(0.036)	(0.043)	(0.075)
Constant	17.54	16.54	10.18	9.126
Adjusted R^2	0.955	0.931	0.958	0.945
Root MSE	0.017	0.018	0.056	0.062
No. of observations	13	13	65	46

* significant at 5% level
** significant at 1% level

On the next page, Tables 8 and 9 shows the impact of proportional changes in expenditure on the quantity of new animals brought into factory farms and on the quantity of animals slaughtered in domestic production. The negative sign for the elasticity of new pig crops to changes in expenditures is the most obvious surprise, given that total quantity of pork decreases to a fall in expenditure. There may be some omitted variable bias in this case, given that only 56.6% of variation is explained. Another possible explanation is that as the value of their meat falls, producers delay the slaughter of female pigs, which are turned over to producing piglets instead. This explanation however does not correspond to the non-significant impact on pigs slaughtered. The third reason, which I think is the most plausible, is that falling expenditures tend to affect mostly pork imports rather than domestic production.

The value of 0.192 for the responsiveness of new chicken crops supplied to a change in expenditure is larger than the value obtained from Table 5, and is probably the more significant value, since it includes the number of animals which were not slaughtered but were lost to disease, shock or other causes. In addition, the third lag is also significant. Using these values, the impact of the average vegetarian is closer to (1.92+1.06)/0.130*9 = 18.5 chickens per year.

Table 8: Estimates of elasticities of new pig crop and new chicks hatched w.r.t expenditures in previous *t*

	ln(new pig crop) $_t$	ln(new chicks hatched) $_t$
ln(expenditure) $_{t-1}$	-0.148**	0.192**
	(0.051)	(0.045)
ln(expenditure) $_{t-2}$		0.075
		(0.043)
ln(expenditure) $_{t-3}$		0.106*
		(0.043)
ln(retail price) $_{t-1}$	0.217	0.028
	(0.150)	(0.151)
ln(cost of production) $_t$	-0.159*	-0.227**
	(0.060)	(0.059)
ln(meat in inventory) $_t$	-0.003	0.221**
	(0.035)	(0.027)
Constant	21.15	8.817
Adjusted R^2	0.566	0.942
Root MSE	0.020	0.047
No. of observations	26	111

* significant at 5% level
** significant at 1% level

Table 9: Estimates of elasticities of pigs and chickens slaughtered or dead before slaughter w.r.t expenditures in previous *t*

	ln(pigs killed) $_t$	ln(chickens killed) $_t$
ln(expenditure) $_{t-1}$	0.014	0.099*
	(0.042)	(0.044)
ln(expenditure) $_{t-2}$		0.080
		(0.045)
ln(expenditure) $_{t-3}$		0.062
		(0.040)
ln(retail price) $_{t-1}$	-0.279**	0.033
	(0.093)	(0.128)
ln(cost of production) $_t$	-0.325**	-0.272**
	(0.022)	(0.055)
ln(meat in inventory) $_t$	0.039*	0.222**
	(0.016)	(0.026)
Constant	16.98	11.59
Adjusted R^2	0.931	0.944
Root MSE	0.013	0.044
No. of observations	26	111

* significant at 5% level
** significant at 1% level

Table 10: Comparing elasticity estimates of domestically produced and imported chicken and pork

	ln(pork) $_t$		**ln(chicken) $_t$**	
	Domestic production	Imports	Domestic production	Imports
ln(expenditure) $_{t-1}$	0.135*	1.058*	0.130*	1.393*
	(0.051)	(0.491)	(0.057)	(0.674)
ln(expenditure) $_{t-2}$			0.077	1.029
			(0.064)	(0.674)
ln(expenditure) $_{t-3}$			0.110	0.687
			(0.057)	(0.737)
ln(retail price) $_{t-1}$	-0.323*	-1.023	0.077	-8.380*
	(0.142)	(0.871)	(0.193)	(3.618)
ln(cost of production) $_t$	-0.448**	-1.139**	-0.460**	-2.582**
	(0.029)	(0.254)	(0.078)	(0.972)
ln(meat in inventory) $_t$	0.035	0.187	0.307**	0.695*
	(0.025)	(0.245)	(0.037)	(0.338)
Constant	19.61	-6.787	9.694	-44.36
Adjusted R^2	0.930	0.643	0.954	0.692
Root MSE	0.018	0.137	0.058	0.641
No. of observations	26	26	111	75

* significant at 5% level
** significant at 1% level

Table 10 observes the difference on the impact on imported and domestically produced animals, which may be of concern to ethical vegetarians since protection of farm animal interests differ between countries, although factory farming is also employed in Canada, Australia and New Zealand, which are major sources of imports, especially Canada in the case of pork. The tables shows clearly that the signs are of the expected direction, and that the impact on imports is much larger than that on domestic production, which is plausible given that imports constitute a minor part of supply, and a given change would be represent a much bigger proportional difference to exporters.

5.2 Testing the Alternative Theory

Performing a similar test on the second model, I obtained similar results, with one lag recommended for pork and three lags for chicken, which is consistent with the hypothesis that the shorter production cycle of chickens allows producers to use more recent information when making production decisions.

Table 11: Choosing number of lags for expenditure using Akaike and Bayes Information Criteria

Lags	Pork No. of observations: 23			Chicken No. of observations: 110		
	degrees of freedom	AIC	BIC	degrees of freedom	AIC	BIC
1	1	-2.674*	-2.575*	1	-1.344	-1.295
2	1	-2.596	-2.448	1	-1.411	-1.338
3	1	-2.509	-2.312	1	-1.689*	-1.590*
4	1	-2.432	-2.185	1	-1.676	-1.553

Table 12: Estimates of elasticities of production costs w.r.t expenditures in previous *t*

	ln(pork production cost per 10 lb) $_t$	**ln(chicken production cost per 10 lb) $_t$**
ln(expenditure) $_{t-1}$	-0.412	-0.090*
	(0.215)	(0.043)
ln(expenditure) $_{t-2}$		-0.048
		(0.040)
ln(expenditure) $_{t-3}$		-0.031
		(0.042)
ln(retail price) $_{t-1}$	-0.897*	0.239*
	(0.342)	(0.106)
ln(animals in inventory) $_t$	-2.885**	-0.054
	(0.666)	(0.030)
ln(meat in inventory) $_t$	-0.266**	-1.179**
	(0.090)	(0.136)
Constant	67.22	29.90
Adjusted R^2	0.690	0.902
Root MSE	0.077	0.051
No. of observations	26	111

* significant at 5% level
** significant at 1% level

Table 12 shows the first results for responsiveness of the cost of production per 10 lb to a change in expenditure on meat. Firstly, the negative coefficients for ln(animals in inventory)$_t$ and ln(meat in inventory)$_t$ are consistent with findings that larger operations tend to have lower

production costs, which may attract producers to expand production. From the previous regressions (see Table 5), however, the actual production levels do fall rather than rise in response to falling profits, leaving a more consolidated but overall smaller industry.

However, it is the negative signs of the coefficients for $\ln(\text{expenditure})_{t-1}$ is the most interesting result, since it is the opposite of what was predicted by Fraser (2005). The coefficient for pork, -0.412, has a p-value of 0.060, which is fairly significant. These values do not offer any evidence that animal welfare is compromised by ethical vegetarianism, since it would not lead to lower average costs.

The coefficients for $\ln(\text{retail price})_{t-1}$ are equally puzzling. Assuming that demand for chicken is price elastic and for pork price inelastic (see Table 3 and the discussion on page 12), a rise in prices should lead to higher profitability for pork and lower profitability for chicken. Under Fraser, this should mean that the coefficient should be positive for pork and negative for chicken, since producers should increase expenditure on each pig and lower expenditure on each chicken. The results, on the other hand, show that the coefficient is negative for pork and positive for chicken.

To verify that the problem is not an issue of functional forms, a Box-Cox test was used. Table 13 shows that the logarithmic form is acceptable for the model and that Prob>χ^2 are quite far from critical values.

Table 13: Box-Cox test for model transformation and the assumption of constant elasticity

		Pork		Chicken	
	Implied Model	**Prob>χ^2**	**Decision**	**Prob>χ^2**	**Decision**
H_o: λ = -1	Reciprocal	0.056	Cannot reject	0.463	Cannot reject
H_o: λ = 0	Logarithmic	0.378	Cannot reject	0.723	Cannot reject
H_o: λ = 1	Linear	0.867	Cannot reject	0.151	Cannot reject
No. of observations		26		111	
λ		-0.842 (0.946)		-0.326 (0.919)	
Log likelihood		32.71		177.9	

Table 14: Comparing elasticity estimates of chicken and pork production w.r.t increased and decreased expenditures in previous *t*

	ln(pork production cost per 10 lb) $_t$		**ln(chicken production cost per 10 lb) $_t$**	
	Expenditure in *t*-1> Expenditure in *t*-2	Expenditure in *t*-1< Expenditure in *t*-2	Expenditure in *t*-1> Expenditure in *t*-2	Expenditure in *t*-1> Expenditure in *t*-2
ln(expenditure) $_{t-1}$	-1.232 (0.564)	-0.465 (0.477)	0.071 (0.109)	-0.132 (0.117)
ln(expenditure) $_{t-2}$			-0.243 (0.123)	-0.011 (0.104)
ln(expenditure) $_{t-3}$			-0.045 (0.062)	-0.021 (0.099)
ln(retail price) $_{t-1}$	-0.053 (0.744)	-1.204** (0.383)	0.065 (0.157)	0.428 (0.214)
ln(animals in inventory) $_t$	-2.876* (1.034)	-2.768** (0.661)	-0.055 (0.038)	-0.026 (0.053)
ln(animals in inventory) $_t$	-0.581** (0.152)	-0.229* (0.083)	-1.320** (0.187)	-1.157** (0.226)
Constant	91.62	65.72	34.19	28.34
Adjusted R^2	0.698	0.755	0.904	0.894
Root MSE	0.079	0.067	0.051	0.052
No. of observations	13	13	65	46

* significant at 5% level
** significant at 1% level

Table 14 distinguishes between effects of falling and rising expenditures on average costs of production. Again, coefficients for ln(expenditure)$_{t-2}$ are negative for both meats. The values are also insignificant at 5% level, although the coefficient for ln(expenditure)$_{t-2}$ on chicken when expenditure $_t$ represents an increase in expenditure, -0.243, has a fairly small p-value of 0.053. The signs of the coefficients for ln(retail price)$_{t-1}$ continue to be incorrect.

The model therefore does not support Fraser's claims that "the problem has not been excessive profit-taking by large corporations, but low and unpredictable profits and the constraints these place on producers" (Fraser 2005).

6. CONCLUSION

The findings from this paper generally support the economic arguments for ethical vegetarianism in the case of chicken and pork, although results may differ for other meats and animal products. On the other hand, there is little evidence to show that ethical vegetarianism is actually counterproductive, unless further studies show that animal welfare is improved at the expense of farm and slaughterhouse workers or the environment. In addition, one may conclude that vegetarianism decreases animal suffering only if one also accepts that less animal suffering occurs when there are fewer animals being brought into being and reared on factory farms, returning the debate on the ethical vegetarianism to philosophical grounds.

In the economic realm, however, there is certainly avenue for further research. The current models suffer from relatively small sample sizes, and results may change with the inclusion of new theoretically relevant explanatory variables such as retail prices of other meats. It may also be appropriate to study the impact of changes in expenditures before and after the mid-1990s, which may display different behavior in production decision-making. Furthermore, instead of comparing the effect of increasing and decreasing expenditure on cost of production, the effect of increasing and decreasing profits or production levels could be used. In particular, a direct test of the theories in Table 1 would make the conclusion more convincing. On the microeconomic level, individual firm studies would provide a stronger insight into the choice of variables and length of lag, as well as the impact of average costs on animal welfare. For consumer studies, the assumption that people spend the same proportions of money on similar foods is important to the results, and would be in its own right an interesting question to answer.

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