Voter and consumer evaluation of restrictions on farm animal management practices

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1 Introduction

In recent years, the treatment of farm animals has attracted much public discussion. The European Union and some states in the United States have adopted regulations directing farm production practices for animals from which food, including eggs, milk, and meat, is derived. Many retailers offer higher-priced animal products marketed as animal-friendly. These products and costly practices may not improve the well-being of animals, but are often perceived by many consumers as doing so.

This paper demonstrates the conditions under which individuals, nearly all of whom regularly consume animal products, may support legislation that requires farm production practices that result in improvements in perceived animal welfare (hereafter, PAW). In many cases, individuals support such legislation even though these PAW production practices increase farm costs and cause higher prices for consumers.

One of the most significant laws mandating PAW production practices in the United States will be implemented in California in 2015. California voters in 2008 passed Proposition 2, which prohibits (conventional) cages for veal calves, egg-laying hens, and pregnant sows that do not allow the animals to "turn around freely, lie down, stand up, and fully extend their limbs" (California Secretary of State, 2008). Very few hogs or veal calves are raised commercially in California, so Proposition 2 applies primarily to the commercial egg industry.

Proposition 2, as passed by voters, deals with how hens were raised but would not have resulted in changes in PAW to the extent that conventional egg production to serve the California market would have shifted to other states (Sumner et al., 2008). The simple economic data and analysis explaining how shipments into Cailfornia would have removed effects of hen housing regulations was evidently not effectively communicated to voters, because the average voter (who supported Proposition 2) did apparently think it would improve PAW. It is unlikely that voters would have anticipated subsequent California legislation, AB 1437, passed in 2010, which requires all eggs *sold* in California be produced by hens raised under the standards required by Proposition 2 (California State Legislature, 2010). When the requirements of Proposition 2 and AB 1437 become effective in 2015, it will raise costs of egg production for suppliers to the California market and thereby raise food prices for most Californians.[1] Throughout the remainder of this article, we refer to individual support or opposition to the joint requirements of Proposition 2 and AB 1437, when appropriate.

Hens living with several other hens in small cages (that is, in conventional housing) have limited movement or access to forage, dustbathing areas, or nests. Hens in a barn or free-range system face higher risk of attack by other hens and frequently lay eggs in chicken feces. Farmers are able to control hen feeding, watering, and egg collection better

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[1] However, we must note that if the Protect Interstate Commerce Act (sponsored by Representative Steve King) is included in the current Farm Bill, AB 1437 would be nullified (King, 2013). Even without that nullification, AB 1437 is likely to face challenge in the courts as a violation of the Interstate Commerce Clause of the Constitution. Without AB 1437 in place, Proposition 2 would have no legal force outside of California.

in a conventional cage system, thereby producing more consistent eggs in terms of nutrition and taste (Mench, Sumner, and Rosen-Molina, 2011). Thus, in several dimensions, a conventional cage production system allows egg farmers better quality control. It has been generally accepted that the currently prevailing conventional cage system does not meet the requirements of Proposition 2, but larger, furnished, cages currently in limited use may also be banned when the regulations are finalized. A more complete discussion of the costs and benefits of each egg production system can be found in Appendix A.

With Proposition 2, a majority of voters supported a ban on a widely available product that nearly all voters consume themselves. When the USDA's Agricultural Marketing Service began reporting specialty egg inventory in January 2010, specialty eggs made up only 3.8% of the shell egg market nationally (USDA–Agricultural Marketing Service, 2010).[2] Sumner et al. (2011) reported that eggs produced in housing systems other than conventional cage systems accounted for a similar share. The decision to switch from conventional animal products to products that carry claims of improved PAW is not trivial. Using scanner data from a national sampling of supermarkets, Chang, Lusk, and Norwood (2010) estimated the retail premium for cage-free white eggs as $1 per dozen, which was a premium of 56% over conventional white eggs in that sample. The European Union instituted a similar ban on conventional hen cages at the beginning of 2012, and average wholesale prices for eggs across all 27 countries (which were already high by U.S. standards) increased by 26% following implementation of that ban (European Commission, 2013). Market data indicate that very few consumers are willing to pay such a premium for eggs with claims of improved PAW (hereafter, PAW eggs), yet most Californians were willing to impose on themselves and other egg consumers a retail price premium for a ban on conventionally

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[2] The Agricultural Marketing Service defines specialty eggs as organic, nutritionally enhanced, cage-free, or vegetarian-fed. We do not have data on the market share for PAW eggs, and use the market share for specialty eggs as a proxy throughout the analysis.

caged hens.

The analysis in this paper indicates that such behavior may be entirely explained by straightforward models, depending on how voters and consumers weigh PAW as a public good relative to lower food costs for themselves and other egg consumers[3] and other considerations. Conventional eggs make up such a large share of the market that the average supporter of Proposition 2 must also have been a consumer of conventional eggs. In this paper, we develop a model to characterize the individual benefits obtained by consuming PAW eggs and conventional eggs, and the personal welfare implications of a ban on conventional eggs. We examine how changes in weights of product attributes, cost parameters, and policy outcomes imply changes in the predicted behavior of an individual with respect to egg consumption and support for a ban. In addition, we demonstrate the conditions necessary for an individual to support a ban on conventional eggs. Our analysis shows that, even though a small percentage of Californians consumed specialty eggs in 2008, passage of a law that improves the PAW of hens was almost certainly welfare-enhancing, given the (perhaps faulty) facts base that guided voter support.

We draw on the Cornes and Sandler (1984) model of the demand for a good marketed privately that when consumed also provides broader benefits that are non-rivalrous and non-excludable. Chief among these public benefits of consuming PAW eggs is the gain to *other people* from expecting that the hens laying the PAW eggs live in better conditions. Individuals express demand for the public good characteristics collectively, through organizations seeking to promote PAW (by direct action or lobbying), and individually, by buying products that carry a claim about enhanced PAW, compared with similar products. This characterization of PAW applies equally whether the product in question is eggs, pork, dairy, or lamb. Similarly, individuals may choose to support companies that claim to pro-

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[3] Many have commented that the poor may be especially affected by higher food prices.

mote worker welfare (by buying fair trade coffee or non-sweatshop apparel, for example) by their consumption behavior and by support for regulations.

In addition to the public good characteristics of PAW eggs, private benefits of consuming PAW eggs include the benefits (e.g., nutrition, taste, enjoyment) that accrue regardless of the type of egg consumed. Thus, PAW eggs generate both public and private benefits and meet the description given by Cornes and Sandler (1984).

Implications of our analysis extend beyond the debate over animal welfare. In recent years, several products have been banned because of concerns over their environmental, human health, or ecosystem impacts. Such products include plastic grocery bags, BPA in plastic baby bottles, foie gras and shark fin soup.[4] Our analysis also speaks to the welfare implications of regulation more generally, and especially to regulation of production practices.

In section 2 of this paper, we develop a model of individual preferences for egg consumption, hen PAW, and a proposed ban on conventional eggs. We demonstrate the implications of changing parameter values in a utility-maximization problem, and demonstrate conditions for individual support of and social welfare gain from a ban on conventional eggs. In section 3, we discuss alternative hypotheses for individual support or opposition to such a ban, including differing interpretations of the science of hen welfare, "warm glow" effects, and the costs imposed on other egg consumers. Section 4 concludes.

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[4] California voters recently rejected Proposition 37, mandatory labeling of genetically modified ingredients in food.

2 Modeling individual preferences for egg consumption and perceived hen welfare

In this section, we postulate a utility-maximization problem related to consumption of eggs and a proposed ban on conventional eggs. We show that, under a framework in which individuals gain utility from their own consumption and from the public-good aspects of PAW, legislation to require that eggs be produced in a PAW environment would result in broad public benefits.

We use a primal approach of utility maximization because the dual approach, expenditure minimization, does not allow us to fully characterize the choice between supporting a ban on conventional hen cages and opposing it. Consider an individual who has strong preferences for hen PAW. For such an individual, a ban on conventional cages would achieve such strong benefits, with minimal personal cost, that the outcome is not directly comparable to the non-ban scenario when using expenditure functions. However, using a utility-maximization framework does readily allow this comparison, as we shall soon see.

To simplify language and concepts, for the remainder of the paper, we consider only two types of egg production systems: PAW and conventional.

2.1 A two-player game

First, consider two individuals, John and Dan, who care about their own wealth and the PAW of hens (which each person thinks, perhaps mistakenly, is positively related to cage-free housing). Neither John nor Dan cares about the wealth or welfare of the other person but does care about chickens. Suppose that both John and Dan consume the eggs of one hen per year.[5] If John wishes to improve the PAW of "his" hen, this will come at a personal cost of δ per year. (In the United States, the retail premium for consuming the eggs of one hen per year in 2008 was about \$21 (Chang, Lusk, and Norwood, 2010; USDA–National Agricultural Statistics Service, 2009).) For simplicity, let us ignore any price elasticity of demand for eggs and any effect of a ban on the price of PAW eggs.

John will choose to improve the PAW of his hen if and only if the private value of doing so, γ_j, is at least δ per year, the private cost of taking that action. Applying the Cornes and Sandler (1984) model of a privately marketed good that generates broader public benefits, John gains from Dan's consumption of PAW eggs, and Dan gains from John's consumption of PAW eggs. If John values the improved PAW of each hen equally, at γ_j, then a ban on hen cages is worth $2\gamma_j$ to John, but still comes at a personal cost of δ. So, if $\gamma_j > \frac{\delta}{2}$, John prefers to ban non-PAW eggs. If $\delta > \gamma_j > \frac{\delta}{2}$, he would prefer a ban on non-PAW eggs even though he would decline to improve the PAW of his own hen by buying cage-free eggs.

If John and Dan have identical preferences, their combined valuation of a ban on hen cages is $4\gamma_j$, and the cost of the ban is 2δ. Likewise, if John and Dan have identical preferences with $\delta > \gamma_j = \gamma_d > \frac{\delta}{2}$, then they are both better off with a ban on conventional eggs, even though neither would willingly improve the PAW of his own hen. This framework and outcome resemble those of the familiar prisoners' dilemma, in that for each player, the payoffs are highest if they both choose a particular action, yet the outcome of that action is not a Nash equilibrium.[6] See Table 1 for an illustration of the equilibrium concept.

Note that if John or Dan consumes PAW eggs in the absence of a ban (with $\gamma_i > \delta$), he will automatically support a ban on conventional eggs. After the implementation of a ban, he will consume the same number of eggs as he did before the ban, because the price facing

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[5] This is approximately true in the United States, which in May 2013 had 316 million residents and 345 million egg-laying hens (U.S. Census Bureau, 2013b; USDA–National Agricultural Statistics Service, 2013).

[6] See Norwood and Lusk (2011, chap. 10) for a similar discussion.

Table 1: Payoff matrix for Dan and John, with $\delta > \gamma_i > \frac{\delta}{2}$ for each player

		John	
		PAW	non-PAW
Dan	PAW	$2\gamma_j - \delta$ $2\gamma_d - \delta$	$\textcircled{\gamma_j}$ $\gamma_d - \delta$
	non-PAW	$\gamma_j - \delta$ $\textcircled{\gamma_d}$	⓪ ⓪

Given that Dan consumes PAW eggs, payoffs are higher when John consumes non-PAW eggs. Given that Dan consumes non-PAW eggs, payoffs for John are again higher when John consumes non-PAW eggs. Thus, the Nash equilibrium solution in this game is that each consumes non-PAW eggs, even though payoffs to each would be higher if they both consumed PAW eggs. If $\delta > \gamma_i$ for each player, then $2\gamma_i - \delta - \gamma_i < 0 \iff 2\gamma_i - \delta < \gamma_i$. Without coordination, each player will consume non-PAW eggs and lose welfare compared with the scenario where each consumes PAW eggs.

him to consume PAW eggs has not changed. The implications of a proposed ban are that the PAW of hens would improve without any decrease in personal numeraire consumption. The same is true for a vegan, who will not incur any personal cost from implementation of a ban on conventional eggs.

2.2 A many-player game

To generalize the discussion above, let individual i maximize utility according to

$$u^i = u\left(y^i, h^i + \sum_{j \neq i} h^j\right) \tag{1}$$

subject to

$$y^i = w^i - \delta h^i, \tag{2}$$

where y^i is the consumption of all goods other than PAW eggs by individual i, to which we assign a price of unity and denote the *numeraire* good, w^i is the income of individual i, δ is the price premium for PAW eggs and h^i is the PAW egg consumption of individual i. For simplicity of exposition, we continue to let the price of PAW eggs be constant whether the ban is in place or not.[7]

Now, consider a society with N individuals and M hens, with the average individual consuming the eggs of $\frac{M}{N}$ hens. If person i wishes to improve the PAW of "his" hens, this will again come at a personal cost of δh^i per year. Again, it will only be worthwhile for person i to improve the PAW of his hen if the private value of doing so is at least δh^i per year.

Again, recalling the discussion of PAW as a public good, suppose that person i values the improved PAW of all hens equally, at γ_i. Then, to person i, a societal ban on conventional eggs is worth $\gamma_i * M$, but still comes at a personal cost of δh^i.

Similar to the two-player game, if $\gamma_i h^i > \delta h^i$, individual i would consume PAW eggs in the absence of a ban, and would support a ban on conventional eggs because it would improve hen welfare without reducing his numeraire consumption. If $\delta h^i > \gamma_i h^i > \frac{\delta h^i}{M}$, person i prefers to ban conventional eggs even though he would decline to improve the PAW of his own hen. Theorem 1 gives the necessary conditions for individuals and society to benefit from implementation of a ban on conventional eggs.

Theorem 1. *Consider a society with N individuals and M egg-laying hens that provide eggs to those N individuals. Suppose that it costs δh^i to improve the PAW for the hens that lay the eggs consumed by individual i. Let $\gamma_i M$ be the value that individual i places on the improved PAW of all M hens, in aggregate. Let γ_i^{min} be the minimum value of γ_i necessary for individual i to support a ban on conventional hen cages. As the number of hens in society, M, grows, γ_i^{min} approaches zero. On the other hand, let $\bar{\gamma}^{min}$ be the minimum*

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[7] Of course, the effects of an upward-sloping supply curve for PAW eggs would cause the price to increase as quantity demand increases, but marketing margins for PAW eggs may decrease after a ban, offsetting that increase.

average value of γ_i (across all members of society) necessary for society to benefit from a ban on conventional hen cages. As the number of individuals in society, N, grows, $\bar{\gamma}^{min}$ approaches zero.

The proof of Theorem 1 is straightforward, but is included as Appendix B.

2.3 Interpretation and corollaries

To understand the implications of Theorem 1, consider the relevant parameters for California and the United States. In 2008, California had about 37 million residents who consumed the eggs of about 38 million hens, most of which were housed outside of California.[8] The retail price premium to shift consumption from conventional to PAW eggs is about \$1 per dozen, or \$21 per hen per year. Thus, the price premium, $\delta\bar{h}$, facing the average Californian to transform conventional egg consumption to PAW egg consumption was about \$22 per year. Refer to Table 2 for more parameters about the egg market in California and the United States in 2008.

For an individual i, the individual benefits of imposing a ban on conventional egg consumption (that is, the joint requirements of Proposition 2 and AB 1437) would be $\gamma_i M = \gamma_i * 38$ million. Thus, in order for individual i to support a ban on conventional eggs, γ_i would need be only $\frac{\$22}{38 \text{ million}}$, or less than sixty millionths of a penny, assuming average egg consumption. That is, to support a ban on conventional eggs, this individual must value the improved PAW of the average hen at only sixty millionths of a penny, a value too low to even conceptualize. This leads us to Corollaries 1.1 and 1.2.

Corollary 1.1. *In a sufficiently large society, any individual with any notion that the welfare of hens matters and that PAW relates positively to shifting from conventional eggs*

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[8] This approximation assumes that Californians consumed the same number of eggs per capita as other Americans.

Table 2: Egg market parameters for California and United States, 2008

Description	Value
Number of egg-laying hens, United States	339 million
Number of egg-laying hens, California	20 million
Specialty eggs as % of shell egg inventory (January 2010)	3.8%
U.S. population	304 million
California population	37 million
Price of conventional eggs (2010)	\$1.77 per dozen
Retail premium for cage-free eggs (2010)	\$1 per dozen
Annual U.S. egg production per person	21 dozen
Total expenditures on eggs, United States	\$11.6 billion
Total expenditures on eggs, California	\$1.4 billion
Total premium paid for PAW eggs, United States	\$243 million
Total premium paid for PAW eggs, California	\$29 million
Campaign contributions in support of Proposition 2 (2008)	\$10.5 million

Note: Data sources: USDA–National Agricultural Statistics Service (2009); USDA–Agricultural Marketing Service (2010); U.S. Census Bureau (2013a); Chang, Lusk, and Norwood (2010); National Institute on Money in State Politics (2013); authors' calculations.

will support a ban on conventional eggs.

Corollary 1.2. *If individuals j are similar, with $\gamma^j M > \delta h^j$, and perceive that other individuals have similar preferences, a ban on conventional cages will pass.*

Benefits to society are aggregated across individuals, while costs to implement a ban are incurred per hen but not per person. Thus, as N grows, even as M grows proportionately, society becomes more certain to benefit ($\bar{\gamma}^{min}$ approaches zero), as stated in Theorem 1 and shown in Appendix B.

In the following section, we consider additional factors that may influence an individual's valuation of a ban on conventional eggs, including a "warm glow" feeling from personal contributions to improved PAW, the effects of the ban on (other) egg consumers, and different perceptions about animal welfare.

3 Additional considerations for evaluation and welfare analysis

The analysis above shows that, when considering only the cost of personal egg consumption and one's own valuation of PAW, all individuals with any positive WTP for PAW would support a requirement that hens be raised in a PAW environment. In this light, the fact that 37% of California voters opposed Proposition 2 in 2008 deserves some discussion. In this section, we consider other issues that may have been at stake for voters, in addition to the valuation of hen PAW and the cost of egg consumption.

3.1 The science of animal welfare

First, we must note that, while many voters viewed Proposition 2 as a referendum on standards for animal welfare, science does not support the notion that cage-free housing generally improves the welfare of egg-laying hens. Of course, Proposition 2 itself applied only to eggs produced in California and would have done little to change hen housing, except that the hens would reside outside of California. In addition, voters could not have known which production systems would be authorized under the requirements of Proposition 2. If voters perceived that the requirements of Proposition 2 would decrease hen welfare or have a neutral effect on it, the main results of Proposition 2 (and the subsequent California legislation that applied the standards to all eggs sold in the state) would have been increased prices for egg consumers and reduced (or left unchanged) hen PAW. Unlike the individuals characterized by our model in Section 2, these voters would have been likely to oppose Proposition 2 because they did not view the change in PAW brought by Proposition 2 as beneficial.

3.2 "Warm glow" effects

Andreoni (1989) characterized the "warm glow" effect as a private, selfish benefit distinct from the benefit an altruist gains by donating to a charity and increasing the availability of the public good. Consumers of PAW eggs may obtain some warm-glow sensation from the expectation that "their" hens have improved PAW, and value more highly the PAW of "their" hens than that of other hens. If consumers obtain this warm glow from the act of *improving* PAW through their unusual consumption behavior, rather than from the act of consumption itself, then the requirements of Proposition 2 and AB 1437 eliminate the opportunity to obtain a warm glow from choosing to consume PAW eggs, and causes a potential reduction in individual welfare along this dimension.[9]

Although it may be true that individuals obtain a selfish, private benefit from personal contributions to PAW, it seems unlikely that this benefit would exceed the benefit from an alternative requirement that all hens be raised in a PAW environment. Thus, for the voters who believed that Proposition 2 would improve PAW for hens, we conclude that any warm glow effect that may have been important for the consumption decision was largely irrelevant to the decision whether to support or oppose Proposition 2.

Note that individuals may obtain a warm glow from *voting* in favor of a ban on conventional eggs, but the sign of the effect (that is, whether it is a warm glow or a "cold prickle") depends on the calculated change in welfare from other components of the utility function. That is, *any* vote (whether for or against) carries with it the potential for a private, warm glow, benefit as long as it is the *right* decision in the mind of the voter. A voter may gain a warm glow from voting in favor of a measure that has substantial private costs even if, or especially if, they expect the measure to be defeated by the votes of others who consider

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[9] If individuals contribute to animal-welfare lobbying organizations, a warm-glow effect may accompany those donations and would also disappear with the implementation of Proposition 2.

the costs. In this paper, we generally avoid discussing mechanisms or incentives to vote at all, but this clarifying point is useful within our discussion of warm-glow effects.

3.3 The value of donations to animal-welfare lobbying organizations

One approach to evaluating the public and private benefits from the passage of Proposition 2 is to examine the contributions made to the campaigns in favor of and opposed to the measure.

As shown in Table 2, the total value of registered contributions to the campaign in support of Proposition 2 was \$10.5 million. The largest contribution from a single individual was \$500,000. The campaign drew national attention, and most of the campaign contributions came from consumers and activists outside of California (National Institute on Money in State Politics, 2013). Contributions to the campaign opposing Proposition 2 totaled almost \$9 million. If the donors to the campaign expected that passage of Proposition 2 would improve the PAW of all 19 million caged egg-laying hens in California, they may have seen the cost of improving hen PAW through lobbying as extremely low: around \$0.55 per hen.

However, this approach to understanding WTP for PAW is fundamentally flawed for three reasons. First, the (marginal) effect of increased campaign contributions on voting cannot be assessed; perhaps Proposition 2 would have passed regardless of the amount of advertising in favor of the campaign, or regardless of the balance between contributions in support of and opposed to the measure. Second, even if campaign contributions and the election outcome were perfectly correlated, the marginal value of an additional vote is zero except when the election is otherwise tied. Finally, of course, the correct interpretation of

Proposition 2 was that the voters were not deciding whether to improve the PAW of hens, but whether to (effectively) move most of California's egg farms to other states (Sumner et al., 2008). Many supporters of hen welfare who believed that eliminating conventional cages would improve PAW may have avoided donating to the campaign for this reason. These factors mean that we cannot confidently infer the public or private valuation of hen PAW using the value of campaign contributions.

3.4 The cost imposed on egg consumers

In Section 2, we demonstrated how any voter who cares about hen PAW and their own consumption would support a measure to require improved hen PAW, given a reasonably large number of hens and sufficiently low cost of improved PAW. Next we consider how an individual's support for the ban may change when accounting for the effects of the ban on the cost of egg consumption for other people.

First, consider the total cost of requiring that all eggs sold in California be PAW eggs.[10] Californians consumed about 777 million dozen eggs in 2008, given an estimate of 21 dozen per person. Based on a retail price premium of $1 per dozen (Chang, Lusk, and Norwood, 2010), a shift to cage-free egg consumption would cost $777 million if the quantity of eggs consumed did not change as a result of the price increase. Using a demand system for 43 different food products and data from individual food expenditure diaries, Okrent and Alston (2012) estimated the own-price elasticity of demand for eggs as $\eta = -0.24$. Using this elasticity estimate, we compute the new quantity of eggs consumed in California after a rise of $1, or 56%, as 673 million.

Thus, consumption of goods other than eggs would fall by $673 million after a ban

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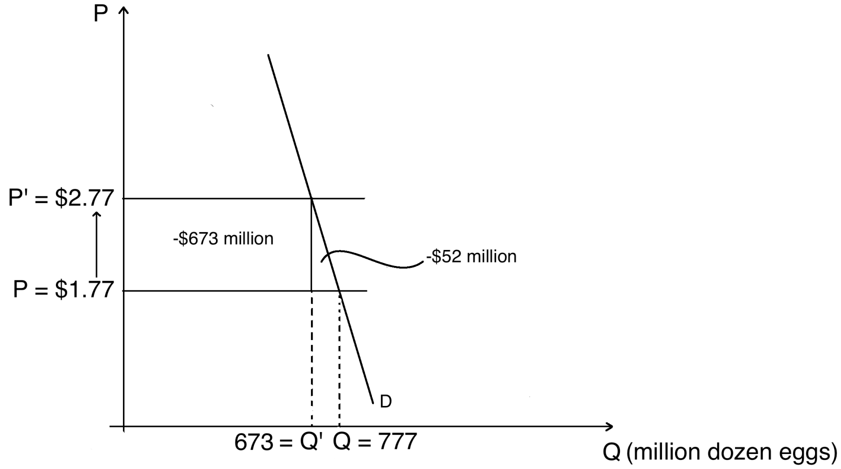
[10] Again, Proposition 2 did not mandate any particular production system such as cage-free, and did not require that all eggs sold in California meet any set of requirements. AB 1437, however, extended the requirements of Proposition 2 to cover all eggs sold in California, effective 2015.

on conventional eggs, and in addition, consumers would lose utility because they do not consume as many eggs. The public welfare loss from a requirement that eggs be raised cage-free is thus at most \$725 million (\$673 million in consumption of other goods and foregone consumption of 104 million dozen eggs). See Figure 1 for an illustration of this welfare change.

Figure 1: Maximum public welfare loss from passage of Proposition 2 and AB 1437



Suppose that individual i obtains private benefits from a ban on conventional eggs, but believes that the public benefits from a ban on conventional eggs are small. Let him perceive that the welfare effects of a ban on other individuals is $\sum_{j \neq i} \Delta \tilde{u}_j < 0$. Despite that individual i obtains private benefits from the ban, he may oppose the ban because of the costs he perceives that it imposes on others. For individual i, let the private benefits of a ban on conventional eggs be those given in the previous section: $\Delta u_i = \gamma_i M - \delta h^i$, where $\gamma_i M$ is individual i's WTP for the improved PAW of all hens. If individual i perceives that the net effect of the ban on other people's welfare is negative, imposing a welfare loss of $\sum_{j \neq i} \Delta \tilde{u}_j$, then individual i's private benefits must outweigh $\sum_{j \neq i} \Delta \tilde{u}_j$ in order for individual i to support a ban on conventional hen housing.

Let a be the relative value that individual i places on his own welfare, and let $(1-a)$ be the relative value he places on others welfare (Andreoni and Miller, 2002). Then, in order for individual i to support a ban, it must be that $a\left(\gamma_i M - \delta h^i\right) > (1-a)\left(\sum_{j \neq i} \Delta\tilde{u}_j\right)$. That is, $\gamma_i M + \frac{1-a}{a}\sum_{j \neq i} \Delta\tilde{u}_j > \delta h^i$. If individual i perceives that for all other Californians, $\gamma = 0$, then $\sum_{j \neq i} \Delta\tilde{u}_j \approx -\$725$ million per year. Thus, for individual i to support a ban on conventional hen cages despite believing that no other Californians valued PAW, the necessary condition for support of the ban is that $\gamma_i M - \delta h^i > \frac{1-a}{a} * \$725$ million. Individual i would have to have very high WTP for hen PAW and very high selfishness parameter a in order to *support* such a ban. Theorem 2 states this result more generally.

Theorem 2. *If individual i cares about the costs facing (other) egg consumers and perceives that for enough members of society $j \neq i$, $\gamma_j M < \delta h^j$, individual i may vote against a ban on conventional hen cages. This may occur even if individual i perceives that eliminating conventional cages improves hen PAW and cares about the welfare of hens.*

We do not propose to estimate voters' perceptions about the effects of Proposition 2 and AB 1437 on other voters, or to make any claims about the selfishness of voters who supported Proposition 2. Instead, the discussion here is merely intended to illustrate another of the issues that faced voters considering Proposition 2, in addition to personal welfare and hen PAW.

3.5 Various alternative explanations for support of a ban on conventional eggs

In addition to the alternative hypotheses discussed above, supporters of the ban on conventional eggs may have had an implicit model of egg marketing such that market power of PAW egg suppliers would decline once conventional eggs were removed from the competition. On the other hand, they may have expected that the opportunity for price discrimination—steep marketing margins for PAW eggs but not for conventional eggs—would end after implementation of a ban on conventional eggs. Another possibility is that people may be inherently selfish in considering income and consumption issues (Andreoni and Miller, 2002) and more empathetic (even about other species) when considering physical discomfort (Rae Westbury and Neumann, 2008).

None of these alternative explanations is intuitively satisfying by itself. Some combination of them may apply, and given the importance of animal practice regulations and buyer restrictions, would be useful to empirically measure the importance of each factor discussed here and in our main analysis in determining individuals' support for laws that require specific farm production practices to improve PAW. An economic experiment may help to evaluate the relative weights given by voters to these considerations. Analysis of local ballot results and demographic data may help identify the economic and social characteristics of supporters of such laws. To better understand the welfare effects of issues such as restrictions on hen housing and increased egg prices, it would be useful to estimate demand for both conventional and PAW eggs over a full range of retail prices, rather than over the bimodal distribution of prices commonly found within a given retailer. Estimating the producer pass-through of costs to consumers in the egg market would also be instrumental.

4 Conclusion

In this paper, we developed approaches to characterize individual benefits and costs incurred from a ban on conventional housing for egg-laying hens. We demonstrated that, under some plausible conditions, as the number of hens affected by a ban grows, the necessary condition for an individual to support the ban becomes trivially satisfied. We discuss alternative hypotheses for individual support or opposition to the regulation of hen housing, including differing interpretations of the science of hen welfare, “warm glow” effects, and the costs imposed on other egg consumers. Our basic conclusion remains that even voters who regularly consume conventional eggs were better off voting in favor or Proposition 2 if they perceived (rightly or wrongly) that Proposition 2 would improve the welfare of egg-laying hens.

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Appendix A: Evidence on animal welfare in different production systems

We are participants in a research project in which inputs and outputs for three different egg production technologies are carefully measured and compared. One technology used in the project is conventional cages, in which six hens are placed in a 4 square-foot cage, giving each hen 80 square inches. The project also uses an enriched cage system, in which 60 hens are placed in a much larger cage, giving each hen 116 square inches. The enriched cage system also provides perches, a nest area, and a scratch pad. The third system is an aviary system, in which hens are placed in an open barn with a perch, a nest area, and litter access. The aviary system provides 144 square inches (1 square foot) per hen.

The results from the first set of flocks—nearly 300 thousand birds producing eggs over a 60-week period—indicate that the cost of producing eggs using enriched cages ($0.597/dozen) is similar to the cost when using conventional cages ($0.583/dozen). Egg production per hen is also nearly identical in each system. Cumulative mortality rates are also comparable in these two systems: 4.77% in the conventional system and 5.21% in the enriched cage system. An aviary system, by contrast, underperforms: total cost of production is around $0.668/dozen, while cumulative mortality is about 11.74%. On the basis of mortality alone—there are many other dimensions—hen welfare is much better in the two cage systems than in the cage-free aviary system.

There is an extensive scientific literature on the benefits and disadvantages of various egg production systems for hen welfare. Savory (2004) found that hens in conventional cages face reduced risk of aggression, cannibalism, parasites, and smothering, and lower mortality. Free-range systems, on the other hand, allow hens to behave in other natural ways that appear to be welfare-enhancing, such as exercising, dust bathing, foraging, nesting, and perching (Savory, 2004; Lay et al., 2011). Enriched cages provide hens with some of the advantages of the other two systems, but also some drawbacks (Lay et al., 2011; Mench, Sumner, and Rosen-Molina, 2011).

The scientific evidence does not clearly support the notion that banning conventional cages for laying hens will result in improvements in animal welfare. Some consumers may strongly support improved farm animal welfare, but be opposed to banning conventional hen cages or gestation crates for sows because they believe that these systems improve the welfare of farm animals. Several newspaper editorials ahead of the vote on Proposition 2 argued that hens were better off in conventional cages, citing sanitary issues. They argued that the passage of Proposition 2 would result in the egg industry shifting out of the state, where conditions for animal welfare and food safety may have been even worse (*San Francisco Chronicle*, 2008; *Los Angeles Times*, 2008). The *San Jose Mercury News* (2008) editorial staff noted that cages prevent the birds from attacking one another, but still supported the ban. The American Veterinary Medical Association opposed the ban, citing increased risk of injury and disease for hens in cage-free systems (Nelson, 2008).

Because the relative well-being of hens in each production system is uncertain, we avoid assigning the label "welfare-improving" to any production system, and instead refer only to "perceived animal welfare," or PAW.

Appendix B: Proof of Proposition 1

Proposition 1. *Consider a society with* N *individuals and* M *egg-laying hens. Suppose that it costs* δh^i *to improve the PAW for the hens that lay the eggs consumed by individual* i*. Let* $\gamma_i M$ *be the value that individual* i *places on the improved PAW of all* M *hens, in aggregate. Let* γ_i^{min} *be the minimum value of* γ_i *necessary for individual* i *to support a ban* *on conventional hen cages. As the number of hens in society, M, grows, γ_i^{min} approaches zero. On the other hand, let $\bar{\gamma}^{min}$ be the minimum average value of $\bar{\gamma}$ necessary for society to benefit from a ban on conventional hen cages. As the number of individuals in society, N, grows, $\bar{\gamma}^{min}$ approaches zero.*

Proof. First, consider an individual in this society for whom $u^i = u\left(y^i, h^i + \sum_{j \neq i} h^j\right)$. Individual i will choose to consume PAW eggs if the private value of improving the PAW of the hens that produce the eggs he consumes exceeds the private value of doing so. Using the notation from Section 2, the necessary condition for individual i to consume PAW eggs is that $\gamma_i h^i > \delta h^i$.

If individual i values the improved PAW of *all* hens at $\gamma_i M$, then the necessary condition for individual i to support a ban on conventional eggs is merely that $\gamma_i M > \delta h^i$. As M grows, the minimum value of γ_i necessary for this relationship to hold, γ_i^{min}, approaches zero.

To determine whether society benefits from a ban on conventional eggs, we simply aggregate benefits and costs across individuals. The gross benefits to society are $\sum_{i=1}^{N} \gamma_i M = \bar{\gamma} N M$, and the gross costs of the ban are $\sum_{i=1}^{N} \delta h^i = \delta \bar{h} N$. Thus, society benefits if $\bar{\gamma} N M > \delta \bar{h} N \iff \bar{\gamma} M > \delta \bar{h} = \delta \frac{M}{N} \iff \bar{\gamma} N > \delta$.

Thus, as N grows, the minimum value of $\bar{\gamma}$ necessary for this relationship to hold and for society to benefit from a ban, $\bar{\gamma}^{min}$, approaches zero.

$\square$