What is the Real Consumer Cost of Mandating Animal Welfare?

An Ex Post Analysis of the Effect of California's Proposition 2

Trey Malone and Jayson L. Lusk

Abstract: California voters passed Proposition 2 in 2008, which outlawed the use of battery cages. Subsequent legislation also outlawed the sale of eggs from battery cages in the state. While a number of *ex ante* studies have attempted to project the effects of the housing prohibitions, the ultimate *ex post* effects are unknown, in part because the law was only recently implemented. Using a new price series reported by the USDA Agricultural Marketing Service, we study the movement of daily egg prices in California and the rest of the United States from January 2014 until July 2015. Using two different methods, we calculate difference-in-difference estimates to identify the effect of Proposition 2's implementation on egg prices. Depending on the method and model specification used, we find that Californians now pay $0.48 to $1.08 more for a dozen eggs. The estimates suggest that the laws result in a reduction in consumer surplus of between $400 million and $850 million annually.

Keywords: animal welfare, cage free, egg, organic, Prop 2, time series econometrics

JEL Codes: Q11, Q18

Authors are graduate student and professor in the Department of Agricultural Economics at Oklahoma State University. Contact: Trey Malone, 415 Agricultural Hall, Stillwater, OK, 74078. Phone: 316-990-6182. Email: trey.malone@okstate.edu,

Introduction

Although California's Prevention of Farm Animal Cruelty Act (Proposition 2) passed in 2008, debates about the effects of the measure continue to rage, in part because the law was only recently implemented. After the implementation of the law at the beginning of 2015, media commentators attempted to ascertain the effects. Some claimed that the law's implementation increased egg prices by $2 per dozen or more (Karol, 2015; Wall Street Journal, 2015). One of the challenges with such casual observations is that they ignored the fact that national egg prices were rising at the same time the law went into effect in California (see Figure 1). To add to the inference problem, a number of other events such as the drought in California and the outbreak of avian influenza in the Midwest have led to volatility in egg prices in California and nationwide (Gee 2015; Parsons 2015; USDA/Animal and Plant Health Inspection Service 2015).

Despite these challenges, determining the effect of the implementation of Proposition 2 is of high interest. Several other states have considered adopting laws like that in California, and the European Union already banned conventional batter cages. Michigan and Ohio residents have passed their own restrictions on battery cages, and for a time the United Egg Producers and the Humane Society of the United States worked together to pass federal legislation that would have phased out the use of the smallest battery cages. While such laws may positively affect animal welfare, the effect on food consumers depends on the extent to which egg prices rise. It is typically thought that there are no good demand substitutes for eggs, which implies that demand is highly inelastic. This would imply that even small changes in cost of production could result in large changes in the retail price for eggs. Of particular concern is the effect on lower income consumers who spend a higher share of the income on food. Yet, to date there have has not been a rigorous *ex post* analysis of the effects of such policies on egg prices.

In addition to consumers, egg producers are concerned about the effects of such laws. Although less than 10% of all egg sales were cage free or organic in California before the vote, 63.5% of California voters opted to ban caged eggs (Norwood and Lusk 2011). Thus, although the majority of consumers were seemingly unwilling to pay the premium for cage free and organic in the marketplace, a majority voted to do away with the lesser expensive cage option that is was routinely purchased. Producers were concerned about an “unfunded mandate” by being required to adopt more costly housing systems without the potential for a corresponding increase in demand. Early research forecasted that most consumers would not bare increased production cost; rather, Proposition 2 would nearly eliminate poultry production in the state (Sumner et al, 2008). California producers responded by securing passage of a state law in 2010 that also banned grocery stores from selling eggs that did not meet the new California standard. Several state attorney generals challenged the law, claiming it violated the interstate commerce clause, but their attempts have so far been unsuccessful (Wilson 2014). The law finally went into effect on January 1, 2015.

The primary objective of this study is provide an *ex post* estimate of Proposition 2’s effects on egg prices. We utilize two different approaches to identify the Prop 2’s effect. Both rely on calculating a difference-in-difference. We analyze how the spread between US and California egg prices before January 1, 2015 compares with the same difference after that date. The first approach relies on a straightforward application of an econometric model fit to a reduced form equation for the egg price difference in California and the rest of the United States. The second approach uses a time-series vector autoregressive model fit to data before January 1 to forecast counterfactual California and U.S. egg prices that would have been expected in the absence of the new law. The differences between the observed and counterfactual prices provide an estimate of the policy's impact. Regardless of the approach used, we find the law had a statistically and economically significant impact on California egg prices ranging from about $0.48 to $1.08 per dozen, representing anywhere from a 33% to a 70% price increase.

Background

It is commonplace to calculate the effects of food policies *ex ante* using survey or experimental data. For example, Heng et al. (2013) use an online hypothetical choice experiment to find that consumers perceive the basic living needs of hens to be the most important factor in layers' welfare. Using nationally representative survey data, the study estimated that 85% of consumers were willing to pay about $0.49/dozen more for cage-free eggs. Richards, Allender, and Fang (2013) use non-hypothetical experimental auctions and found a 65% value premium for cage-free eggs, while Norwood and Lusk used a similar approach and found a 70% value premium. Even if consumers are willing to pay a premium for these types of eggs, research suggests that they do not understand standard production practices of the egg industry. Norwood (2012) notes, "if the numbers…are correct, and if they reflect consumer preferences at all times and in all contexts, there would be no need for Proposition 2, as grocery stores would readily sell cage-free eggs…" In fact, one group of consumers believed on average that 37% of eggs come from cage systems even though in reality more than 90% do (Lusk and Norwood 2011). It might be that this lack of knowledge causes nearly 60% of consumers to agree that the government should "pass and enforce anti-cruelty legislation" (Norwood and Lusk 2009).

Other *ex ante* studies have used secondary data to estimate changes in consumer and producer surplus resulting from animal welfare policies. Building on the idea that consumers are willing to pay a premium for cage-free eggs, Allender and Richards (2010) use scanner data to estimate the *ex ante* welfare impacts of a change in egg prices due to the policy change. They find that only about 21% of households are willing to pay the premium for cage-free eggs, and they argue that the effect of the policy will be highly regressive. They project that large households with lower incomes will experience the largest welfare loss from the policy change.[1] Norwood and Lusk (2011) used equilibrium displacement models to project the consumer and producer surplus effects of a ban on battery cages. They calculated that converting all cage eggs to cage free in the U.S. would result in a $1.87 billion decline in consumer surplus and a $187 million decline in producer surplus, assuming no consumer demand shift in response to change in type of eggs sold.[2]

Conceptual Framework

The supply of eggs in California is a function of the price of eggs produced, the price of inputs, and other costs of production. The demand for eggs in California is a function of the price of eggs, prices of substitutes, income, and other factors affecting consumer expectations. The passage and implementation of Prop 2 is expected to increase the cost of production (Sumner et al., 2008, 2010, 2011). As shown in Figure 2, the added cost of production shifts the California egg supply curve from *Supply* to *Supply`*. Prices will increase from Cal_t to Cal_t', and quantity demanded will decrease from Q_t to Q_t' causing a decrease in consumer surplus. Assuming consumers do not demand more eggs because of the policy, the change in consumer surplus from the policy change (ΔCS) is

[1] Furthermore, San Francisco consumers do not pay as high a price premium for cage-free and organic eggs as do consumers in the rest of the United States (Chang, Lusk, and Norwood, 2011).
[2] There is limited evidence on the extent to which the passage of such a policy might influence aggregate egg demand. Lusk (2010) showed that the debate leading up to Prop 2 in California caused an increase in demand for cage-free and organic eggs. However, it is unclear how these estimates might correspond to a situation when the policy ultimately goes into effect without the knowledge of many consumers, and where the cage free (or larger cage) eggs are now the commodity egg rather than a premium variety.

(1) $$\Delta CS = [(Cal_t' - Cal_t) \text{ x } Q_t'] + \frac{1}{2}[(Cal_t' - Cal_t) \text{ x } (Q_t - Q_t')].$$

As shown in Figure 2, the intersection of the supply and demand curves results in an equilibrium price, which is a function of the underlying demand and supply variables. We focus on this reduced form equation that determines California egg prices. Likewise, the intersection of aggregate supply and demand curves in the U.S. determines the nationwide price, and a nationwide reduced form price equation can be specified as a function of the underlying supply and demand variables.

However, rather than (at least initially) focusing just on the price that prevails in California, we focus on the spread in prices between California and the rest of the U.S. By focusing on the *difference* in California and U.S. egg prices, we can partially control for any demand or supply shifts that jointly affect demand and supply factors in both locations. The law of one price would suggest that arbitrage opportunities would eliminates price difference between California and other locations except for transfer costs, such as transportation costs and artificial barriers to entry. Most eggs have a shelf life of 3-5 weeks, making the product easy to ship nationally (USDA/Food Safety and Inspection Service, 2011). However, changes in variables that affect arbitrage opportunities (such as transportation cost or the cost of holding inventory) will affect the price spread. Moreover, it might be possible that there are unique demand or supply shifts that occur in California that do not occur in the rest of the U.S., which would increase or decrease the difference in egg prices. The implementation of Proposition 2, for example, would represent a supply shock unique to California. Differential demand shocks would occur if, for example, incomes increased or fell in California more than was the case in the rest of the U.S.

All this suggests that the difference in the price of eggs in California and the rest of the U.S. will be a function of the cost of arbitrage, whether Proposition 2 has been implemented (a unique supply shock to California), and differences in other demand factors (like income) in California compared to the rest of the U.S.

Data and Methods

Data

Our analysis primarily focuses on movements in daily egg prices (cents per dozen) that were obtained from the Agricultural Marketing Service of the USDA from January 2, 2014 until July 30, 2015 (U.S. Department of Agriculture/Agricultural Marketing Service 2015). Around the first of January 2015, the AMS began reporting both US and California Price Series in their online daily National Shell Egg Index Price Report. We contacted the AMS and obtained the data going back to January 2, 2014. Data from January to July 2015 were hand collected from the AMS daily reports. About 93% of California egg production is shell eggs (Sumner et al 2008), so we used California and National weighted average price estimates of white large graded loose shell eggs (GL W L) since these are the eggs most commonly sold in grocery stores). Figure 1 shows the price series for California and for the U.S. The two series tracked each other closely until January 1, 2015 when Prop 2 went into effect.

Variables that could serve as proxies for costs of arbitrage are the cost of fuel, the cost of storage and inventory, and the cost of feed. Nationwide weekly prices for diesel fuel ($/gallon) were obtained from US Department of Energy, Energy Information Administration. Daily values were determined through linear interpolation. Daily data on commercial interest rates (30-Day AA Financial Commercial Paper Interest Rate) were obtained from the Federal Reserve.

We also obtained USDA data on corn prices ($/bushel) from the Livestock Marketing Information Center associated with Chicago export grain bids.

The potential for differential demand shifts were measured by calculating the *difference* in the average hourly earnings of all employees in California and the U.S. as reported by the Bureau of Labor Statistics. In addition, we calculated the *difference* in the unemployment rate in California and the aggregate U.S. using data from the Bureau of Labor Statistics. Data on hourly earnings and unemployment were only available as monthly measures.

Beginning in mid-February 2015, cases of avian influenza began to be reported in chicken flocks. While the outbreak has not affected any egg laying hens in California, the states of Iowa, Minnesota, South Dakota, Wisconsin and Nebraska have lost more than 40 million birds. As a result, data on the number of chickens confirmed with avian influenza were obtained from USDA-APHIS. We deleted all backyard outbreaks and outbreaks associated with turkeys. For each time period, we calculated the cumulative number of birds infected (in millions) up to the date in question.

Methods

To provide a more robust investigation into the issue, we utilize two different approaches to identify the effect of the implementation of Prop 2 on California egg prices. Both approaches rely on a difference-in-difference estimate to identify the effect.

Approach 1

Approach 1 relies on the reduced form price equations motivated in the conceptual framework. In particular, we consider variations on the following general model:

$$(2)\ P_{CA,t} - P_{US,t}$$

$$= \gamma_0 + \gamma_1 Prop2_t$$

$$+ \gamma_2 pdiesel_t + \gamma_3 ir_t + \gamma_4 pcorn_t + \gamma_5 (w_{CA,t} - w_{US,t}) + \gamma_6 (ur_{CA,t} - ur_{US,t})$$

$$+ \sum_{k=1}^{11} \beta_k m_k + \sum_{j=1}^{4} \alpha_j d_j + \varepsilon_t,$$

where the dependent variable, $P_{CA,t} - P_{US,t}$, is the difference in the price of eggs in the California and the rest of the US in time period t, $Prop2_t$ is a dummy variable that takes the value of 1 after January 1, 2015 and the value of 0 beforehand, $pdiesel_t$, ir_t, and $pcorn_t$ are the prices of diesel fuel, interest, and corn, $w_{CA,t} - w_{US,t}$ is the difference in the hourly wage rate in California and the rest of the US, $ur_{CA,t} - ur_{US,t}$ is the difference in the unemployment rate in in California and the rest of the US, m_k are monthly dummy variables, d_j are dummy variables indicating the day of the week (there are no data on weekends), and the γ's, β's, and α's are parameters to be estimated. Of primary interest is the sign and significance of $\gamma_1$which represents the comparison of the difference in US and California egg prices before and after the implementation of Proposition 2. For robustness and for sensitivity checks, several variations of equation (2) are estimated with one or more of the parameters set to zero.

Approach 2

The reduced form econometric model in (2) estimates the impact of Proposition 2 using a dummy variable identifying the California supply shock while controlling for other possible confounding factors. For a more robust investigation into this issue, we also consider a completely different approach to identify the effect of the implementation of the egg laws. In particular, we estimate vector autoregressive (VAR) models for California and US egg prices using only data *before* Prop 2 went into effect. We then use this model to predict future egg prices – in essence creating a counterfactual scenario that might have occurred had Prop 2 not gone into effect. By comparing the prices that actually transpired with Prop 2 actually in place to those we predict would have occurred in the absence of Prop 2, we can identify the effects of the policy. The advantage of this approach is that it makes no structural assumptions about the avenue through which Prop 2 affects egg prices, relying on reduced-form correlations across time and variables to predict future values.

Ultimately, after some specification testing, the following VAR models were estimated for each location *k* = CA and US:

$$(3)\ \ P_{k,t} = \delta_{k,0} + \sum_{k=1}^{2}\sum_{j=1}^{8} \delta_{k,j} P_{k,t-j} + \delta_{k,9} pdiesel_t + \delta_{k,10} pcorn_t + \sum_{j=1}^{11} \varphi_{k,j} m_j + \epsilon_{k,t},$$

where $P_{k,t}$ is the price of eggs in location *k* (either California or US) in time *t*. Thus, equation (3) models the price of eggs in a location as a function of eight lags of egg prices in that location and eight lags of prices in the other location in addition to the same period prices of diesel and corn and monthly dummy variables. The number of lags were chosen by finding the number of lags that led to the lowest AIC. We checked the model for stationarity by calculating the eigenvalues associated with the 16 lagged price coefficients and we found the modulus of the eigenvalues less than one, indicating the series are stationary.

Equation (3) was estimated only using data before Proposition 2 was implemented (prior to January 1, 2015). Once the estimates were obtained, they were used to forecast daily egg prices going forward from January 1 to July 30, 2015. Let $\hat{P}_{CA,t}$ and $\hat{P}_{US,t}$ be the forecasted prices for California and the US at some period *t* after the policy was in place. Also, let $\bar{P}_{CA,t}$ and

$\bar{P}_{US,t}$ be the actual, realized values observed on date *t*. Now, the projected impact of the policy on date *t* can be calculated as

(4) $Prop\ 2\ Impact_t = (\bar{P}_{CA,t} - \bar{P}_{US,t}) - (\hat{P}_{CA,t} - \hat{P}_{US,t}).$

Equation (4) measures the difference in actual California and National egg prices and the predicted (or counterfactual) difference that would have prevailed in the absence of the implementation of Proposition 2. The mean effect can be determined by calculating (4) for each out-of-sample period in question and averaging across all periods.

Results

All models indicate that the difference between egg prices in California and the United States is at least 48 cents more than it would have otherwise been. Table 2 shows the results from the first approach. The estimates in table 2 suggest that the implementation of Proposition 2 has caused California egg prices to increase by between 53 cents/dozen and 109 cents/dozen compared to the price beforehand. The simplest model that only includes the tie period dummy variable estimates the cost of enforcement to be about 53 cents. Adding parameters that control for other changes in arbitrage possibilities increased the policy's effects. For example, the price of diesel fuel fell at about the same time the policy went into effect. The results in models 3-5 suggest that had changes such as that not occurred, the effect of the implementation of Proposition 2 would have been much larger. Based on adjusted R^2 values, the model in (4) appears to have the best fit, and it estimates Proposition 2's effects to be approximately 97 cents per dozen eggs.

The second approach uses a Vector Auto Regression (VAR) model to forecast what prices might have been without the law's implementation. Table 3 reports the estimates of the VAR model. Using this model, we forecasted a counterfactual scenario predicting what the price difference would be without the law's implementation Figure 3 reports the predicted difference in California and US egg prices that would have prevailed in the absence of the law's implementation (the figure in the appendix shows the underlying predicted prices over time). As shown in figure 3, the predicted counterfactual price difference lies almost exclusively below the actual price difference except for a few days in June. If the predictions were simply inaccurate, we would have expected forecasts above and below the actual, observed values, but because the predicted difference is systematically below the observed differences, we can be reasonably confidence that the effect is due to the implementation of Proposition 2.

Using the data plotted in figure 3, we calculated the difference in difference estimates based on equation (4). As show in table 4, this approach puts the mean estimated effect of Prop 2 to be about 48 cents per dozen from January 1 to July 31, with the largest costs of implementation coming initially after passage in January. These costs are likely highest at the beginning of the law's implementation, as producers had to retrofit their facilities to comply with the new legislation. The lowest difference in prices came in May, which coincides with the onset of the avian influenza; however, prices differences rebounded to more than 30 cents in June and 68 cents in July.

Consumer Surplus Effects

The estimated price effects can be used to calculate changes in consumer surplus given an assumed own-price elasticity of demand. Previous literature estimates own price elasticities of demand for eggs between -0.08 to -0.27 (Kastens and Brester 1996; Andreyeva et al 2010; Okrent and Alston 2011). From equation (1), Q_t and Q_t' are quantities of eggs demanded before and after the policy change. Assuming there are 38,802,500 residents in California (US Census

Bureau, 2015) who consume about 250 eggs per person annually (USDA/Economic Research Service 2015), the quantity of eggs demanded before the policy change (Q_t) is approximately 808 million dozen eggs. To determine the change in quantity demanded, we first estimate the expected price change in a dozen eggs that result from the policy change (this is the estimated effect for γ_1 in equation 2). Average U.S. prices were approximately $1.39 per dozen after January 1, 2015. From the intercept from model 1 in table 1, we calculate California prices to be at least 17 cents higher than the national prices without the implementation of Proposition 2, making Cal_t equal to the sum of the national price and the difference in prices ($1.56). Estimates from table 2 suggest prices have increased by about $0.52 to $1.08 per dozen due to the policy change, making Cal_t' between $2.09 and $2.65. Given that a 1% increase in the price of eggs will lead to a 0.08% to 0.027% decrease in the quantity of eggs demanded, Prop 2 has decreased quantity demanded by between 2.71% and 18.78%. From equation (1), we estimate the dollar loss of consumer surplus to be between $408 million and $853 million (Table 5).

Conclusions

This research used USDA-AMS data to estimate the consumer welfare effects of the price change associated with the implementation of California's Proposition 2. Ballot initiatives that eliminate the use of battery cages may become more common in coming years, suggesting the need for a deeper understanding of the policy's consequences. We find evidence suggesting that forced elimination of battery cages causes a significant increase in the price of eggs, but that the price increase attributed to Proposition 2 is not as high as some popular press articles have suggested.

If more state ballot initiatives pass restrictions on battery cages, Americans in those states can likely expect to see egg prices rise – this study suggests between a 30% and 70% price increase. Given the inelasticity of demand for eggs, such price changes result in a sizable decrease in surplus. While this study does not offer any estimates of the benefits of such animal welfare policies either to consumers or the animals themselves, it does provide an estimate of the potential losses of consumer surplus that could be compared against whatever benefits might arise.

Some economists have argued that animal welfare should be regulated because of various market failures, such as externalities (Harvey and Hubbard 2013). Proposition 2 is, in effect, a command and control policy in that it dictates which production technology cannot be used. However, there may be alternative animal welfare-promoting policies available to state or federal regulators that entail fewer costs while partially mitigating the suggested market failures. Some animal advocacy groups have suggested meat taxes, an idea that may or may not influence the quality of animas' lives (Cowen, 2006). Another alternative proposed by Lusk (2011) is a market for animal welfare de-coupled from animal consumption. He notes consumers absent from the marketplace (such as vegans) who have strong feelings regarding the buying and selling of animal products in general. Giving agricultural producers property rights over "animal well-being units" and allowing these farmers to sell those units independent of the actual product itself could allow passionate animal advocates a direct means to purchase the outcome they desire. Finally, it might be that the marketplace provides avenues for consumers to demand animal welfare-promoting products. As noted in Lusk (2010), increasing information involving animal production correlates with heightened consumer concern for animal welfare in their purchasing decisions. It might be that Veblen's theory of conspicuous consumption also motivates this effect (Bagwell and Bernheim 1996); in some locations, it might be fashionable to buy animal welfare-promoting products in much the same way Sexton and Sexton (2014) suggest conspicuous conservation increased demand for some hybrid automobiles.

It is important to note that this research does not include any analysis of producer welfare impacts. Future research might include the costs borne by producers due to the law's implementation. Moreover, this paper cannot rule out the possibility of consumer demand shifts because of the new regulation. Assuming consumer demand is unchanged, however, we find the cost to consumers to be substantial.

References

Bagwell, Laurie Simon, and B. Douglas Bernheim. 1996. "Veblen Effects in a Theory of Conspicuous Consumption." *American Economic Review* 86(3): 349-373.

Bureau of Economic Analysis. 2015. “Personal Income SQ1.” Last Updated: June 22, 2015. Online.

Chang, Jae Bong, Jayson L. Lusk, and F. Bailey Norwood. 2010. "The Price of Happy Hens: A Hedonic Analysis of Retail Egg Prices." *Journal of Agricultural and Resource Economics*. 35 (3): 406-423.

Cowen, Tyler. 2006. “Market failure for the treatment of animals.” *Society*, 43(2), 39-44.

Gee, Kelsey. 2015. “Egg Prices Jump as Bird Flu Spreads.” *Wall Street Journal*. May 21, 2015.

Harvey, David, and Carmen Hubbard. 2013. “Reconsidering the Political Economy of Farm Animal Welfare: An Anatomy of Market Failure.” *Food Policy*, 38: 105-114.

Heng, Yan, Hikaru Hanawa Peterson, and Xianghong Li. 2013. "Consumer Attitudes toward Farm-Animal Welfare: The Case of Laying Hens." *Journal of Agricultural and Resource Economics* 38(3): 418-434.

Karol, Gabrielle. 2015. “Expert says record-high average price for eggs in California is around the corner.” *News 10 Sacramento.* June 12, 2015.

Kastens, Terry L., and Gary W. Brester. 1996 "Model Selection and Forecasting Ability of Theory-Constrained Food Demand Systems." *American Journal of Agricultural Economics*. 78(2): 301-312.

Lusk, Jayson L. 2010. "The Effect of Proposition 2 on the Demand for Eggs in California." *Journal of Agricultural & Food Industrial Organization* (8)1.

Lusk, Jayson L. 2011. “The Market for Animal Welfare.” *Agriculture and Human Values*. *28*(4): 561-575.

Norwood, F. Bailey. 2012. “The Private Provision of Animal-Friendly Eggs and Pork.” *American Journal of Agricultural Economics*. 94(2): 509-514.

Norwood, F. Bailey, and Jayson L. Lusk. 2009. “The Farm Animal Welfare Debate.” *Choices. 24*(3).

Norwood, F. Bailey, and Jayson L. Lusk. 2011. "Compassion, by the Pound: The Economics of Farm Animal Welfare." *OUP Catalogue*.

Okrent, Abigail M., and Julian M. Alston. 2011 "Demand for Food in the United States." *A Review of Literature, Evaluation of Previous Estimates, and Presentation of New Estimates of Demand. Giannini Foundation Monograph* 48.

Parsons, Russ. 2015. “Why eggs have gotten more expensive in California.” *Los Angeles Times*. June 18, 2015.

Richards, T., Allender, W., and Fang, D. 2013. “Media Advertising and Ballot Initiatives: The Case of Animal Welfare Regulation.” *Contemporary Economic Policy*, *31*(1): 145-162.

Sexton, S. E., and Sexton, A. L. 2014. “Conspicuous conservation: The Prius halo and willingness to pay for environmental bona fides.” *Journal of Environmental Economics and Management*, 67(3), 303-317.

Sumner, Daniel A., J. Thomas Rosen-Molina, William A. Matthews, Joy A. Mench, and Kurt R. Richter. 2008. *Economic Effects of Proposed Restrictions on Egg-Laying Hen Housing in California*. University of California Agricultural Issues Center.

Sumner, Daniel A., W.A. Matthews, J.A. Mench., J.T. Rosen-Molina. 2010. "The Economics of Regulations on Hen Housing in California." *Journal of Agricultural and Applied Economics, 42*(3): 429-438.

Sumner, D. A., H. Gow, D. Hayes, W. Matthews, B. Norwood, J. T. Rosen-Molina, and W. Thurman. "Economic and market issues on the sustainability of egg production in the United States: Analysis of alternative production systems." *Poultry science* 90.1 (2011): 241-250.

U.S. Department of Agriculture, Agricultural Marketing Service, Livestock, Poultry, and Grain Market News. 2015. "National Shell Egg Index Price Report." Online.

U.S. Department of Agriculture, Animal and Plant Health Inspection Service. 2015. "Update on Avian Influenza Findings: Poultry Findings Confirmed by USDA's National Veterinary Services Laboratories." Online.

U.S. Department of Agriculture, Economic Research Service. 2015. "Poultry and Eggs: Background." Online.

U.S. Department of Agriculture, Food Safety and Inspection Service. 2011. "Food Safety Information: Shell Eggs from Farm to Table." Online.

Wall Street Journal. 2015. "California's Scrambled Eggs: The state's new chicken-coop law is hitting human beings hard." *Wall Street Journal Online*. January 25, 2015. http://www.wsj.com/articles/californias-scrambled-eggs-1422232494

Wilson, Reid. 2015. "Chickens come before eggs in California case." *The Washington Post*. October 7, 2014.

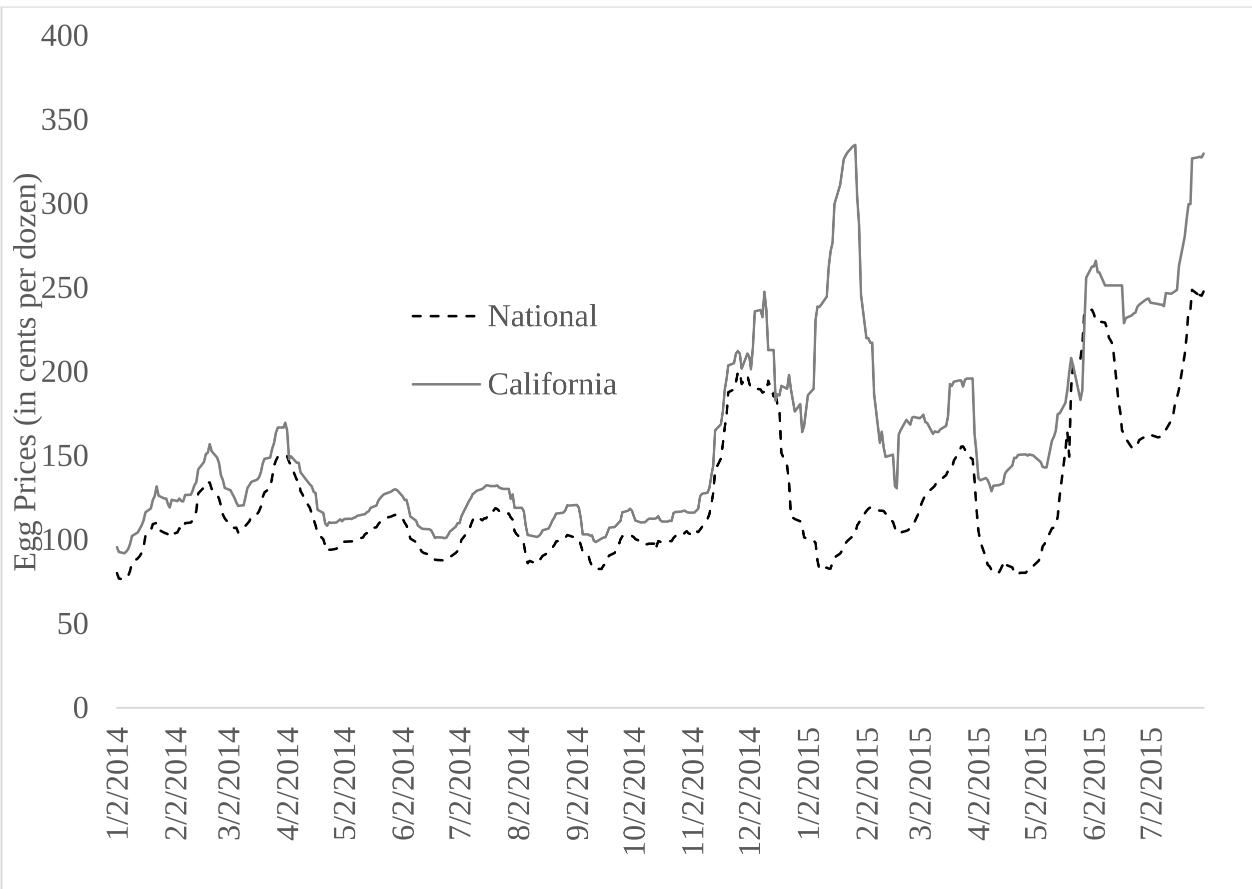

Figure 1. National and California Prices of White Large Graded Loose Shell Eggs (in cents)
(source: USDA AMS National Shell Egg Index Price Report)

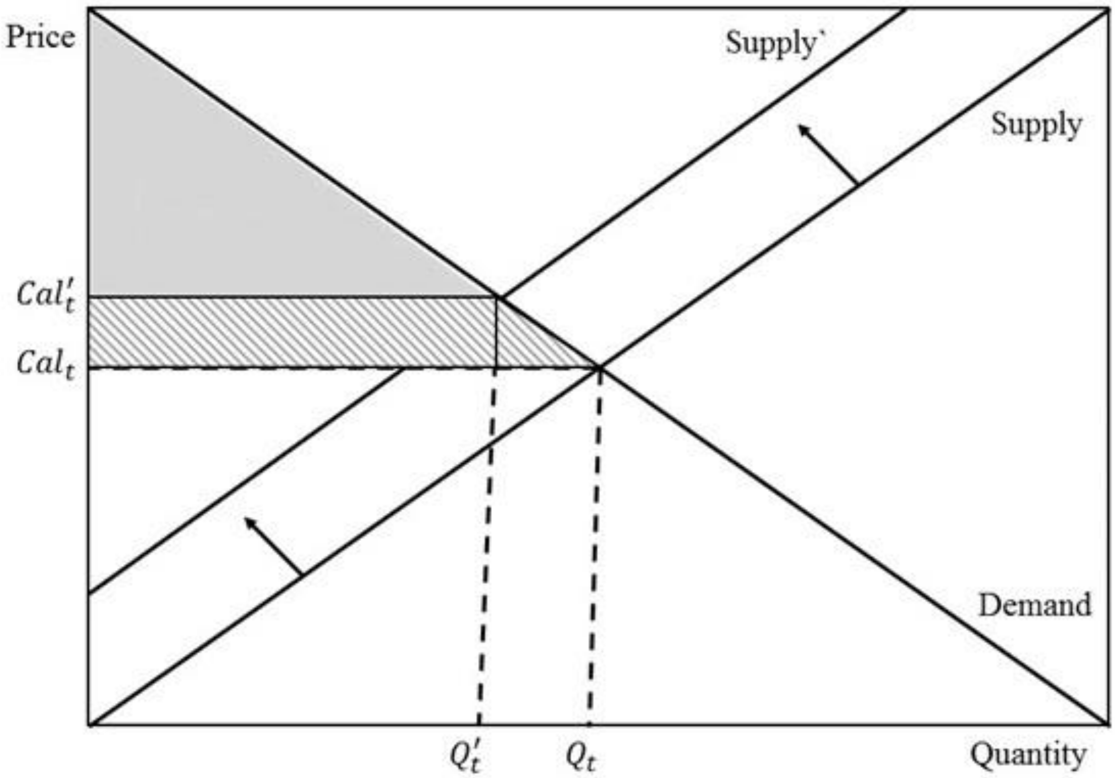

Figure 2. Effects of a Supply Shift Caused by Implementation of Proposition 2

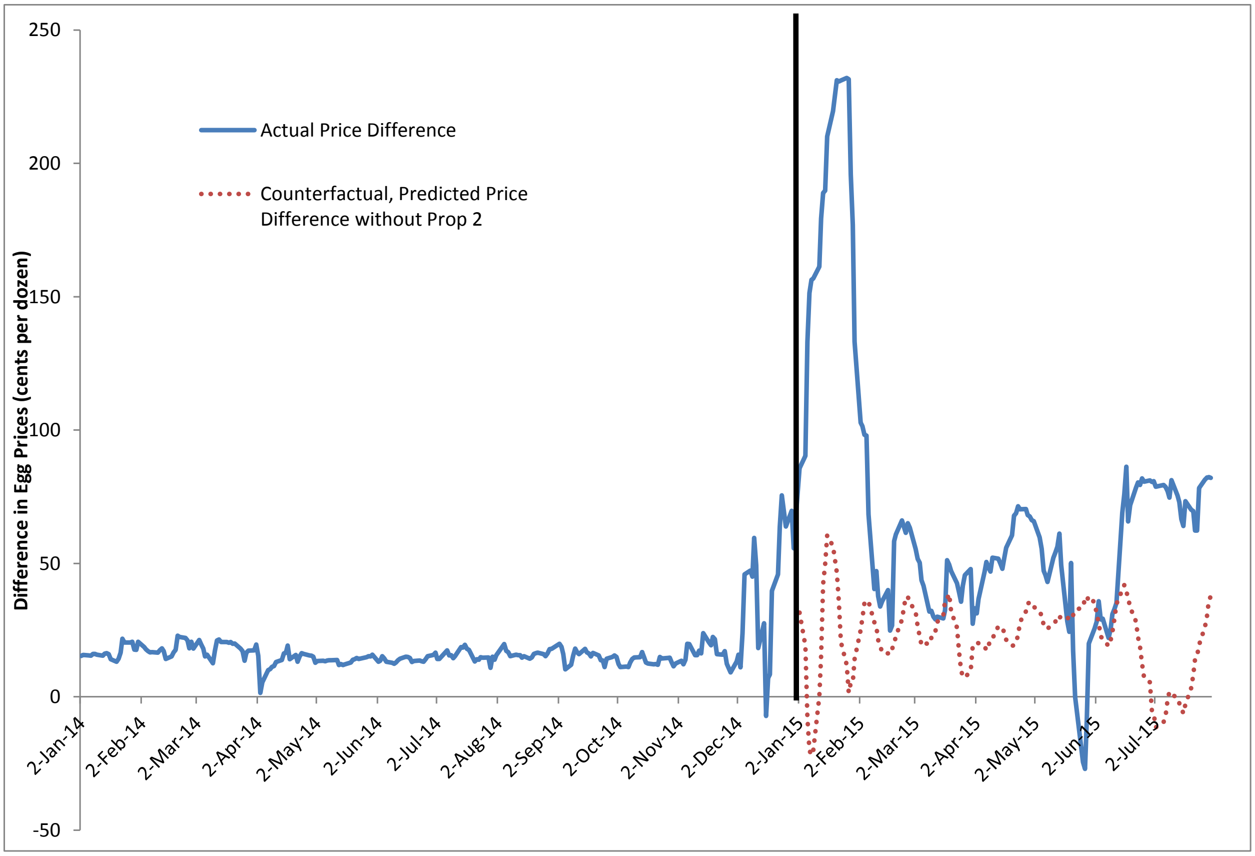

Figure 3. Difference in Actual California and National Egg Prices and the Predicted (or Counterfactual) Difference that would have Prevailed in the Absence of the Implementation of Proposition 2 (in cents per dozen)

Table 1. Descriptive Statistics for National and California Large Graded Loose Shell Eggs for Before and After Implementation of Proposition 2 (in cents per dozen)

	Before Implementation			After Implementation		
	Mean (Std. Dev)	Min	Max	Average (Std. Dev)	Min	Max
National	113.51 (27.64)	76.51	199.98	138.59 (49.7)	79.08	248.8
California	131.05 (31.17)	92.04	247.70	209.0 (57.33)	129.01	335.17
Price Difference	17.54 (9.82)	-7.17	75.52	70.41 (51.03)	-27.03	232.05

Number of observations before and after implementation 256 and 147, respectively.

Table 2. Factors Affecting the Difference in California and National Egg Prices (January 1, 2014 to July 30, 2015)

Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Intercept[a]	17.536*[b] (1.992)[c]	16.560* (6.117)	-203.88* (82.281)	1624.914* (134.557)	1694.502* (151.179)
Prop 2 Enforced	52.869* (3.299)	55.435* (2.962)	108.612* (24.483)	96.789* (18.905)	92.891* (19.295)
Diesel price	---	---	30.700 (22.053)	-77.923* (17.294)	-80.39* (17.465)
Interest rate	---	---	83.292 (77.132)	-22.707 (57.047)	-26.173 (57.149)
Corn price			30.788* (4.930)	-13.587* (5.149)	-17.267* (6.308)
Wage difference	---	---	---	-97.248* (5.893)	-100.631* (6.779)
Unemployment rate difference	---	---	---	221.035* (18.352)	225.459* (18.868)
Cumulative bird flu cases	---	---	---	---	0.099 (0.098)
Day of the week effects	No	Yes	Yes	Yes	Yes
Month effects	No	Yes	Yes	Yes	Yes
Number of Parameters	2	17	20	22	23
Number of Observations	402	402	402	402	402
R^2	0.390	0.626	0.667	0.821	0.822
Adjusted R^2	0.386	0.608	0.649	0.810	0.810

[a]The intercept reflects the pre-Prop 2 price difference,, and except for Model 1, on Wednesday in September when other explanatory variables are zero.
[b]One asterisk represents statistical significance at the 0.05 level or lower
[c]Numbers in parentheses are standard errors

Table 3. Vector Auto Regression fit to Data Prior to Implementation of Prop 2 (January 1, 2014 to December 31, 2014)

Variable	US Price	CA Price
Intercept	-40.022* (19.219)	101.348* (30.486)
$PriceCA_{t-1}$	0.131* (0.047)	0.735* (0.075)
$PriceCA_{t-2}$	-0.087 (0.056)	0.163 (0.089)
$PriceCA_{t-3}$	0.044 (0.057)	-0.062 (0.090)
$PriceCA_{t-4}$	0.003 (0.055)	-0.298* (0.087)
$PriceCA_{t-5}$	0.126* (0.055)	-0.158 (0.088)
$PriceCA_{t-6}$	-0.005 (0.057)	0.035 (0.09)
$PriceCA_{t-7}$	-0.281* (0.056)	0.075 (0.089)
$PriceCA_{t-8}$	0.149* (0.052)	-0.172* (0.083)
$PriceUS_{t-1}$	0.906* (0.070)	0.484* (0.111)
$PriceUS_{t-2}$	0.390* (0.087)	-0.349* (0.138)
$PriceUS_{t-3}$	-0.079 (0.095)	0.501* (0.151)
$PriceUS_{t-4}$	-0.202* (0.094)	-0.075 (0.150)
$PriceUS_{t-5}$	-0.450* (0.101)	-0.354* (0.161)
$PriceUS_{t-6}$	0.113 (0.104)	0.108 (0.165)
$PriceUS_{t-7}$	0.391* (0.097)	0.235 (0.154)
$PriceUS_{t-8}$	-0.224* (0.082)	0.049 (0.130)
Corn Price	-0.980 (1.309)	0.868 (2.076)
Diesel	15.581* (4.942)	-20.188* (7.838)
January	-10.954* (2.723)	-6.098 (4.319)
February	-10.807* (2.973)	-2.497 (4.716)
March	-9.445* (3.158)	-1.258 (5.009)
April	-9.087* (3.021)	-6.660 (4.793)
May	-9.933* (3.021)	-7.634 (4.793)
June	-10.146* (2.685)	-8.822* (4.259)
July	-10.329* (2.421)	-6.612 (3.841)
August	-9.922* (2.334)	-7.825* (3.702)
September	-10.120* (2.370)	-9.021* (3.760)
October	-7.760* (2.013)	-12.356* (3.193)
November	-3.892* (1.608)	-6.861* (2.551)
R^2	0.993	0.987

Number of observations in each regression = 248

Table 4. Difference in Difference Estimate of Effect of Implementation of Proposition 2 using Predictions from Vector Auto Regression (cents per dozen eggs)

Time Frame	Mean Estimated Effect of Prop 2[a]	Lower 95% CI	Upper 95% CI
January 1 to July 31	48.43	39.56	57.29
January	161.95	142.74	181.15
February	32.89	23.80	41.97
March	17.18	12.17	22.18
April	31.09	26.67	35.50
May	2.55	-10.98	16.08
June	30.82	18.30	43.33
July	68.15	61.74	74.57

[a]Calculated as the difference in the observed difference in California and National egg prices and the predicted (or counterfactual) difference in California and National egg prices that would have prevailed in the absence of the implementation of Proposition 2.

Table 5. Change in Consumer Surplus due to Implementation of Proposition 2 under Different Demand Elasticity Assumptions

Price Elasticity of Demand	Change in consumer surplus when $\gamma_1 = 0.52$	Change in consumer surplus when $\gamma_1 = 1.08$
-0.08 (Kastens and Brester 1996)	-421,596,261	-853,571,578
-0.18 (Okrent and Alston 2011)	-414,359,979	-823,031,590
-0.27 (Andreyeva et al 2010)	-407,847,326	-795,545,600

Appendix

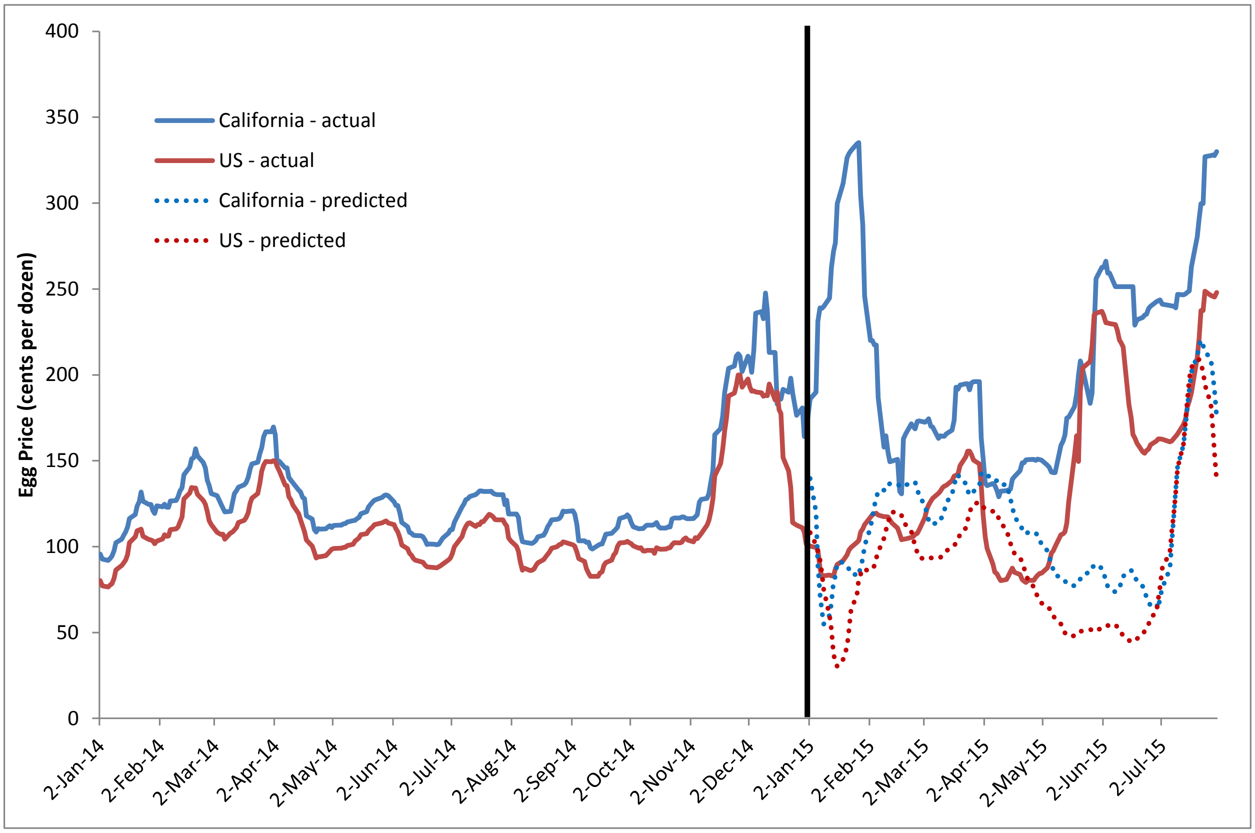

Figure A.1 Actual Prices and Predicted Prices from VAR model shown in table 3