Impact of Animal Welfare Policies in California

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Note: All material presented are the researcher(s)' own analyses calculated (or derived) based in part on data from Nielsen Consumer LLC and marketing databases provided through the NielsenIQ Datasets at the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business. The conclusions drawn from the NielsenIQ data are those of the researcher(s) and do not reflect the views of NielsenIQ. NielsenIQ is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein.

Background

- 4 Nov 2008: CA passes Proposition 2: *"Standards for Confining Farm Animals"*
- 1 Jan 2015: Hen-laid eggs from 'battery cages' are not allowed (but larger 'enriched colony cages' still allowed)
- 6 Nov 2018: CA passes Proposition 12 to require higher standards for hens:
  - 1 Jan 2020: at least 1 square feet of floor space per hen
  - 1 Jan 2022: indoors or outdoors cage-free housing must be provided
- **Proposition 12 requires that all eggs consumed in CA be cage-free from 1 Jan 2022** — this also applies to out-of-state suppliers
  - Cage-free eggs have higher costs of production compared to caged production
  - Setting a minimum quality standard will raise the price of eggs in CA

Timeline

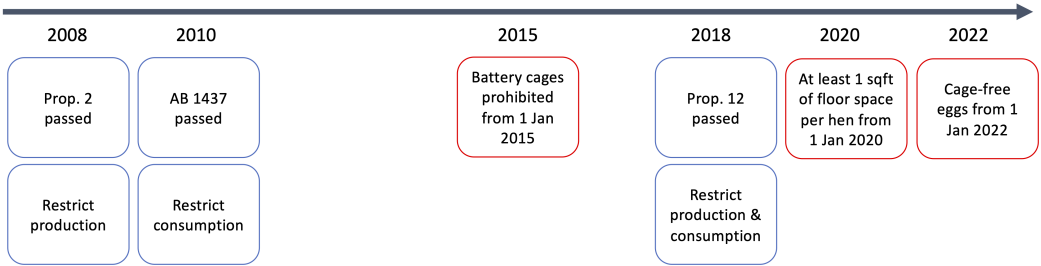


Figure 1: Timeline of Animal Welfare Policies in California

Introduction

Question:

- How do animal welfare (AW) policies affect the welfare of different groups of consumers? Which groups become better/worse off?

Approach:

- Use NielsenIQ datasets and voting data from CA elections to understand consumer preferences and WTP for AW
- Study how egg consumption in California changed after the introduction of AW laws, (i) for different income groups and (ii) across counties in California

Contribution:

- Understand the distributional impact of AW policies in CA and provide a detailed discussion of how consumer welfare was affected

	Battery Cage[1]	Enriched Colony[2]	Aviary (Barn)	Free-range	Pasture-raised
Min. space per hen (sq ft)	0.5	0.8	1	2*	108*
Perching/scratching	×	✓	✓	✓	✓
Access to outdoors	×	×	×	✓	✓
Unit cost[3] ($)	0.670	0.756	0.913		

[1] Banned by Proposition 2 with effect from 1 Jan 2015.

[2] Banned by Proposition 12 with effect from 1 Jan 2022.

[3] Capital and operating costs per dozen eggs (Matthews & Sumner, 2015)

* Refers to outdoor space where hens spend at least 6 hours per day.

Table 1: Key Characteristics of Hen Housing Systems




Clockwise from top left: battery cage, enriched colony, aviary (barn), free-range/pasture-raised

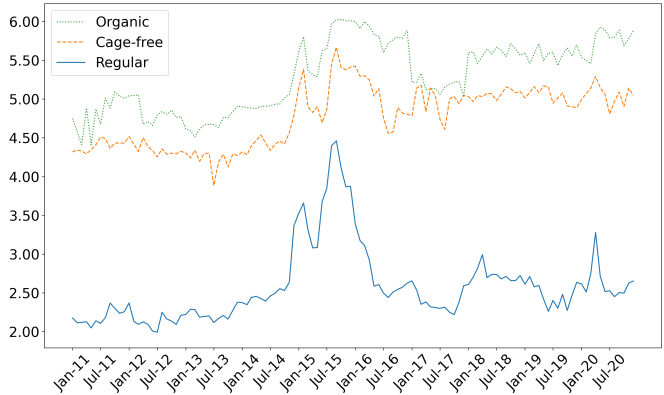


Figure 2: Volume-Weighted Average Store Prices of a Dozen Eggs in California

1. Cage-free eggs refer to products with 'cage-free', 'free-range', or 'pasture-raised' labels.
2. All organic eggs are cage-free by definition.

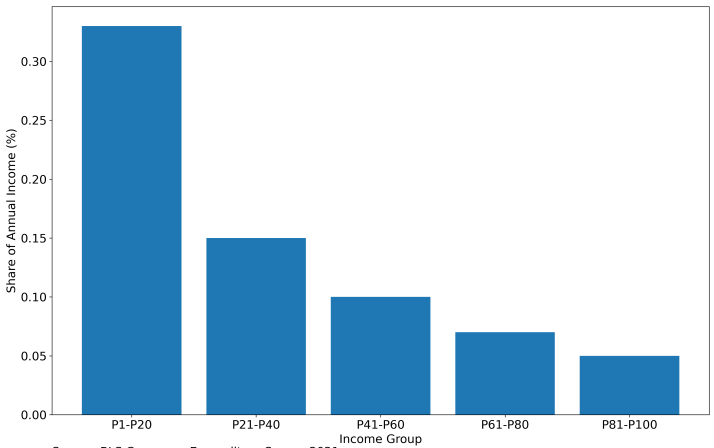
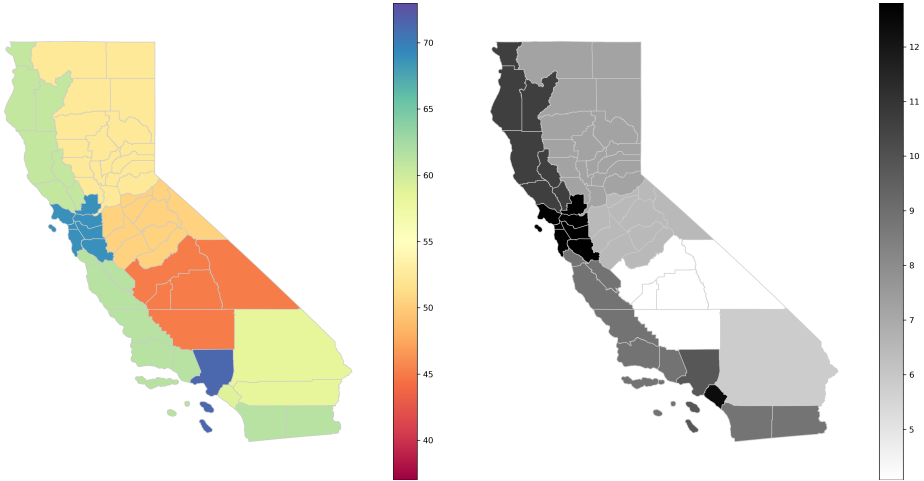


Figure 3: Annual Household Expenditure on Eggs in US



(a) Voted Yes for Prop 12 (%)

(b) Share of Cage-free/Organic Eggs (%)

Figure 4: Spatial Correlation of Prop 12 Vote and Egg Consumption

Related Literature

- **Impact of animal welfare policies on egg prices**
  Allender and Richards (2010), Malone and Lusk (2016), Mullally and Lusk (2017), Carter, Schaefer, and Scheitrum (2021)

- **Consumer preference for egg quality**
  Kotschedoff and Pachali (2020), Oh and Vukina (2021)

- **Consumer demand and policy preferences**
  Deacon and Shapiro (1975), Holian and Kahn (2015), Burkhardt and Chan (2017), Fajgelbaum et al. (2023)

Data

1. **NielsenIQ Consumer Panel Dataset (2004 -)**
   - Household grocery purchases (shopping trips, items purchased, price, quantity, date of purchase, store visited (*subsample*), product characteristics, etc.)
   - Demographics (income, age, education etc.) and location (state, county)
   - *Subsample of consumer data can be matched to retail data with store code and purchase date*
2. **NielsenIQ Retail Scanner Dataset (2006 -)**
   - Weekly prices and quantities of products sold by participating retailers (incl. grocery stores); store location information (state, county, 3-digit zipcode)
3. **UC Berkeley California Statewide Database**
   - Ballot results by voting precinct in California
   - Proposition 2 (2008) and Proposition 12 (2018)

Consumer Data

	Full NielsenIQ sample			Matched to retailer data		
Year	Households	Grocery Trips	Bought Eggs	Households	Grocery Trips	Bought Eggs
2011	5,329	327,490	33,892	3,190	48,563	4,949
2012	5,483	320,162	33,457	3,860	50,736	5,662
2013	5,610	314,206	30,426	4,291	105,374	10,261
2014	5,575	309,991	28,056	4,363	104,103	9,407
2015	5,473	297,950	25,923	4,576	122,989	10,240
2016	5,258	295,617	28,772	4,644	127,637	11,841
2017	5,373	303,818	31,889	4,521	121,987	12,818
2018	5,299	298,229	29,301	4,632	141,672	14,076
2019	5,272	300,697	30,235	4,708	145,876	14,795
2020	4,875	284,693	28,683	4,572	142,283	15,409

Table 2: Summary Statistics: Grocery Trips in California

Retailer Data

Year	Number of grocery stores	Stores that sell all types of eggs	Matched to consumer data
2011	1,365	543	517
2012	1,335	984	924
2013	1,302	1,037	978
2014	1,177	1,085	1,026
2015	1,140	1,099	1,019
2016	1,122	1,085	997
2017	1,113	988	876
2018	1,677	1,298	1,117
2019	1,788	1,406	1,203
2020	1,779	1,427	1,205

Table 3: Summary Statistics: Grocery Retailers in California

Matched Sample Covers All Regions in California

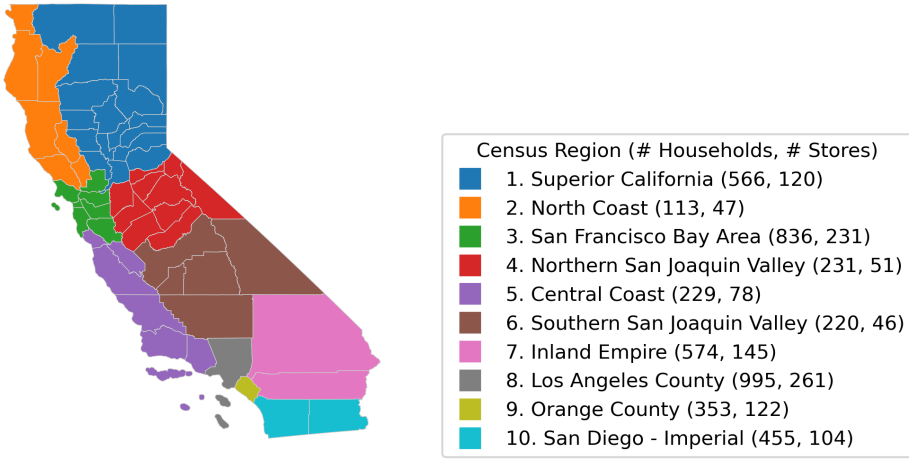


Figure 5: Matched Households and Stores in 2020 Counties

Egg Consumption Trends

Year	Avg. Cons. (dozens)	Market Share (%)			Price per Dozen ($)		
		Regular	*Cage-free*	*Organic*	*Regular*	*Cage-free*	*Organic*
2011	24.1	97.5	0.8	1.7	2.18	4.39	4.81
2012	23.2	97.4	1.0	1.6	2.14	4.35	4.83
2013	21.9	96.0	2.1	1.9	2.23	4.23	4.70
2014	19.2	94.0	2.8	3.2	2.53	4.47	4.97
2015	18.3	91.6	4.6	3.8	3.75	5.19	5.74
2016	21.6	93.6	3.5	2.9	2.78	4.99	5.84
2017	24.4	92.5	4.6	2.9	2.39	4.95	5.16
2018	22.6	90.4	6.0	3.5	2.73	5.06	5.60
2019	24.2	90.3	5.6	4.1	2.48	5.03	5.58
2020	23.2	90.0	6.5	3.5	2.64	5.05	5.74

Table 4: Consumption, Market Shares and Prices of Eggs in California

Consumer Heterogeneity

	Avg. Cons. (dozens/year)	Market Share (%) *Regular*	*Cage-free*	*Organic*
Less than $25,000	18.09	96.26	2.01	1.73
$25,000 to $49,999	20.03	96.38	2.12	1.50
$50,000 to $69,999	19.93	94.58	3.37	2.05
$70,000 to $99,999	19.74	92.25	4.69	3.06
$100,000 and above	20.84	89.11	5.61	5.28
34 and below	16.64	90.28	5.24	4.48
35 to 64	20.55	93.22	3.71	3.06
65 and above	19.69	93.81	3.58	2.61
High school and below	24.42	96.48	2.00	1.52
College and above	21.63	92.27	4.36	3.37

Table 5: Summary Statistics of Egg Consumers in California (2011-2020)

Model

- Consumers have preference for the outside good Y_{it}^0 and taste for egg quality Y_{it}^1
- Grocery stores offer three types of eggs:
  regular (rg), cage-free (cf), organic (og); + outside option (0)
- $(Y_{it}^0, Y_{it}^1) \implies$ whether to consume eggs, and if so, what quality to consume
- Y_{it}^* is observed choice of i from a store trip t

$$Y_{it}^* = \begin{cases} 0 & \text{if } \gamma Y_{it}^0 > Y_{it}^1, \theta_{it}^{rg} > Y_{it}^1 \\ rg & \text{if } \gamma Y_{it}^0 \leq Y_{it}^1, \theta_{it}^{rg} \leq Y_{it}^1 < \theta_{it}^{cf} \\ cf & \text{if } \gamma Y_{it}^0 \leq Y_{it}^1, \theta_{it}^{cf} \leq Y_{it}^1 < \theta_{it}^{og} \\ og & \text{if } \gamma Y_{it}^0 \leq Y_{it}^1, \theta_{it}^{og} \leq Y_{it}^1 \end{cases}, \quad \gamma \geq 0$$

- γ is importance of animal welfare: $\uparrow \gamma \implies \uparrow$ value of outside option

Heterogeneous Consumers

- Preferences depend on demographic characteristics, Z_i (income, age and education) and unobserved taste shocks $(\varepsilon_{it}^0, \varepsilon_{it}^1)$

$$Y_{it}^0 = Z_i'\beta^0 + \varepsilon_{it}^0$$
$$Y_{it}^1 = Z_i'\beta^1 + \varepsilon_{it}^1$$

- (β^0, β^1) can be extended to random coefficients
- Covariance parameter σ captures the correlation of preference for no consumption of eggs with preference for higher quality eggs

$$\begin{pmatrix} \varepsilon_{it}^0 \\ \varepsilon_{it}^1 \end{pmatrix} \sim \mathcal{N}(0, \Sigma) \quad , \quad \Sigma = \begin{bmatrix} 1 & \sigma \\ \sigma & 1 \end{bmatrix}$$

Index Cutoffs

- Consumer's cutoffs depend on prices

$$\theta_{it}^{rg} = \theta^{rg} + \alpha P_{it}^{rg}$$
$$\theta_{it}^{cf} = \theta^{cf} + \alpha\left(P_{it}^{cf} - P_{it}^{rg}\right)$$
$$\theta_{it}^{og} = \theta^{og} + \alpha\left(P_{it}^{og} - P_{it}^{cf}\right)$$

- $(\theta^{rg}, \theta^{cf}, \theta^{og})$ denotes average preference for each type; can later allow for market-specific FEs
- $(P_{it}^{rg}, P_{it}^{cf}, P_{it}^{og})$ are store-level price indices for each type of egg at trip t
- α is average marginal utility of income

Graphical Example 1: $\sigma > 0, \gamma = 0$

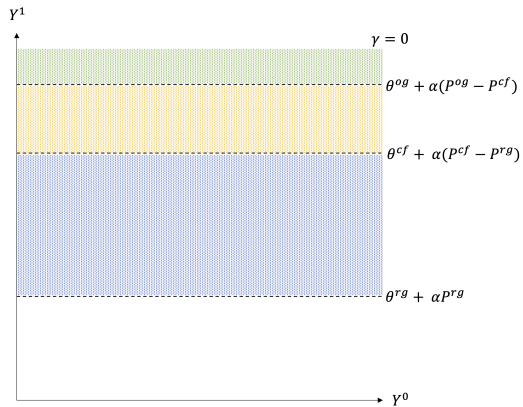


Figure 6: Choosing Egg Quality Without Outside Good Preference

Graphical Example 2: $\sigma > 0, \gamma = 1$

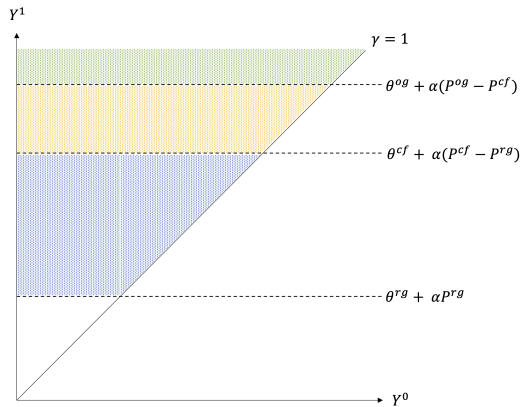


Figure 7: Choosing Egg Quality With Outside Good Preference

Example 1: No Purchase

- The probability of choosing no purchase is:

$$\begin{aligned}
&\Pr\left(\gamma Y_{it}^0 > Y_{it}^1\ ,\ \theta_{it}^{rg} > Y_{it}^1\right) \\
=&\Pr\left(Z_i'\beta^0\gamma + \varepsilon_{it}^0\gamma > Z_i'\beta^1 + \varepsilon_{it}^1\ ,\ \theta^{rg} + \alpha P_{it}^{rg} > Z_i'\beta^1 + \varepsilon_{it}^1\right) \\
=&\Pr\left(\varepsilon_{it}^1 - \varepsilon_{it}^0\gamma < Z_i'(\beta^0\gamma - \beta^1)\ ,\ \varepsilon_{it}^1 < \theta^{rg} + \alpha P_{it}^{rg} - Z_i'\beta^1\right)
\end{aligned}$$

- If $\gamma = 0$, and if we assume $\theta^{rg} > 0, \alpha > 0$, we get

$$\Pr\left(\varepsilon_{it}^1 < -Z_i'\beta^1\ ,\ \varepsilon_{it}^1 < \theta^{rg} + \alpha P_{it}^{rg} - Z_i'\beta^1\right) = \Pr\left(\varepsilon_{it}^1 < \theta^{rg} + \alpha P_{it}^{rg} - Z_i'\beta^1\right)$$

  Which is the choice probability in a model of vertically differentiated products

- $\beta^0\gamma$ is an identification problem — may have to assume γ or restrict $\beta^0 = \beta^1$

Example 2: Cage-Free Eggs

- The probability of choosing cage-free eggs is:

$$
\begin{aligned}
&\Pr\left(\gamma Y_{it}^0 \leq Y_{it}^1\ ,\ \theta_{it}^{cf} \leq Y_{it}^1 < \theta_{it}^{og}\right) \\
=&\Pr\left(\gamma Y_{it}^0 \leq Y_{it}^1\ ,\ \theta^{cf} + \alpha\left(P_{it}^{cf} - P_{it}^{rg}\right) \leq Z_i'\beta + \varepsilon_{it}^1 < \theta^{og} + \alpha\left(P_{it}^{og} - P_{it}^{cf}\right)\right) \\
=&\Pr\left(\varepsilon_{it}^1 - \varepsilon_{it}^0\gamma \geq Z_i'(\beta^0\gamma - \beta^1)\ ,\right. \\
&\left.\theta^{cf} + \alpha\left(P_{it}^{cf} - P_{it}^{rg}\right) - Z_i'\beta^1 \leq \varepsilon_{it}^1 < \theta^{og} + \alpha\left(P_{it}^{og} - P_{it}^{cf}\right) - Z_i'\beta^1\right)
\end{aligned}
$$

- $\uparrow P_{it}^{cf} \implies \downarrow$ purchases for cage-free eggs (own-price effect)
- $\uparrow P_{it}^{rg}/P_{it}^{og} \implies \uparrow$ purchases for cage-free eggs (cross-price effect)
- Choice depends on prices $P_{it}^{rg}, P_{it}^{cf}, P_{it}^{og}$, demographics Z_i and tastes $\varepsilon_{it}^0, \varepsilon_{it}^1$
- Similar intuition applies for regular and organic eggs

Next Steps

1. Design and implement an estimation procedure for the model
2. Model the supply-side to predict prices after Proposition 12
3. Calculate the change in consumer welfare; across income-groups and household profiles
4. Discuss whether the Proposition 12 election results can be rationalized by welfare changes

End

Appendix A

Proposition 12

'Cage-free housing system' means an indoor or outdoor controlled environment for egg-laying hens within which hens are free to roam unrestricted; are provided enrichments that allow them to exhibit natural behaviors, including, at a minimum, scratch areas, perches, nest boxes, and dust bathing areas; and within which farm employees can provide care while standing within the hens' usable floorspace. Cage-free housing systems include, to the extent they comply with the requirements of this subdivision, the following:

(1) *Multitiered aviaries, in which hens have access to multiple elevated platforms that provide hens with usable floorspace both on top of and underneath the platforms.*

(2) *Partially slatted systems, in which hens have access to elevated flat platforms under which manure drops through the flooring to a pit or litter removal belt below.*

(3) *Single-level all-litter floor systems bedded with litter, in which hens have limited or no access to elevated flat platforms.*

(4) *Any future systems that comply with the requirements of this subdivision.*

Table 3. Land and facility capital costs by housing system.

Item	Conventional[1]	Aviary	Enriched
Capital outlay ($ million)			
Land	0.02	0.01	0.01
House construction	0.99	1.22	0.86
Equipment	1.96	0.73	0.62
Total	2.97	1.96	1.49
Annualized cost of capital outlays at constant interest plus depreciation (%)			
5% (interest + depreciation)	148,500	98,000	74,500
10% (interest + depreciation)	297,000	196,000	149,000
Average eggs per year at an average of 51 wk of laying (dozen eggs)			
Eggs for 51 wk production	5,079,500	1,212,900	1,243,500
Annualized cost of capital outlays per dozen eggs (%)			
5% (interest + depreciation)	0.029	0.081	0.060
10% (interest + depreciation)	0.058	0.162	0.120

[1]The conventional house was built in 2004. We adjusted land, construction, and equipment costs for price changes to their equivalent 2011 values using national producer price index for building construction and farm equipment and local price data for changes in land value.

Figure A1: Capital Costs (Matthews & Sumner, 2015)

Table 4. Average operating and capital costs per dozen eggs for each housing system

Item	Conventional	Aviary	Enriched
Feed cost ($)	0.425	0.436	0.417
Pullet cost ($)	0.148	0.221	0.143
Labor cost ($)	0.019	0.074	0.056
Energy cost ($)	0.014	0.015	0.014
Miscellaneous cost ($)	0.005	0.005	0.005
Sum of operating costs ($)	0.612	0.751	0.636
Percentage higher operating costs compared with conventional	—	23	4
Capital costs (at 10%; $)	0.058	0.162	0.120
Capital + operating ($)	0.670	0.913	0.756
Percentage higher costs compared with conventional	—	36	13

Figure A2: Average Unit Costs (Matthews & Sumner, 2015)

Product Heterogeneity

	UPCs	Mean	S.D.	Min.	Med.	Max.
Price (All)	442	3.69	1.37	1.50	3.65	6.99
Price (Regular)	305	3.14	1.07	1.50	3.02	6.98
Price (Cage-free)	59	4.40	1.00	1.67	4.47	6.99
Price (Organic)	79	5.27	1.17	1.99	5.47	6.93
Regular	442	0.69	0.46	0	1	1
Cage-free	442	0.13	0.34	0	0	1
Organic	442	0.18	0.38	0	0	1
Brown	442	0.48	0.50	0	0	1
Omega 3	442	0.08	0.27	0	0	1
USDA Grade (A/AA)	442	0.94	0.24	0	1	1
XL / Jumbo	442	0.22	0.41	0	0	1
Pack	442	14.39	9.01	6	12	60

Table A1: Summary Statistics of Egg UPCs in California (2011-2020)

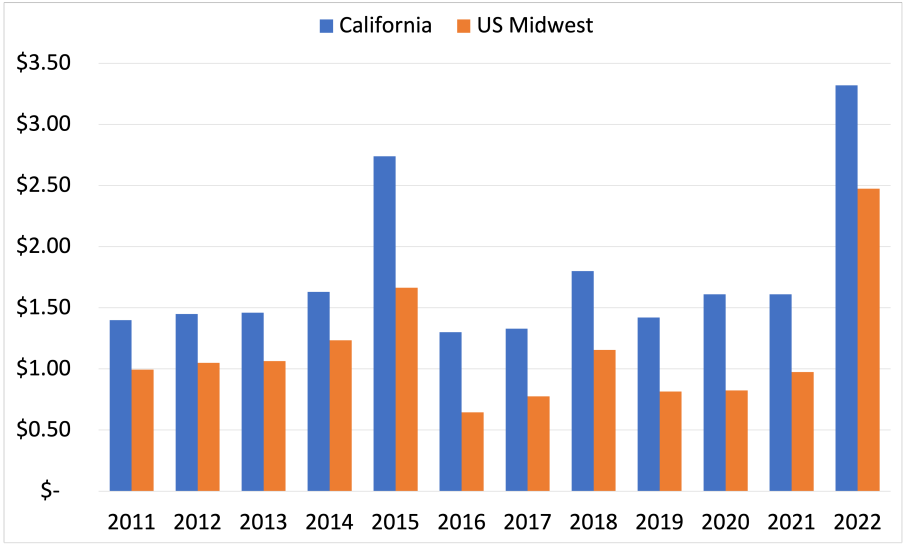


Figure A3: Median Wholesale Price of Dozen Large White Eggs (Source: USDA)

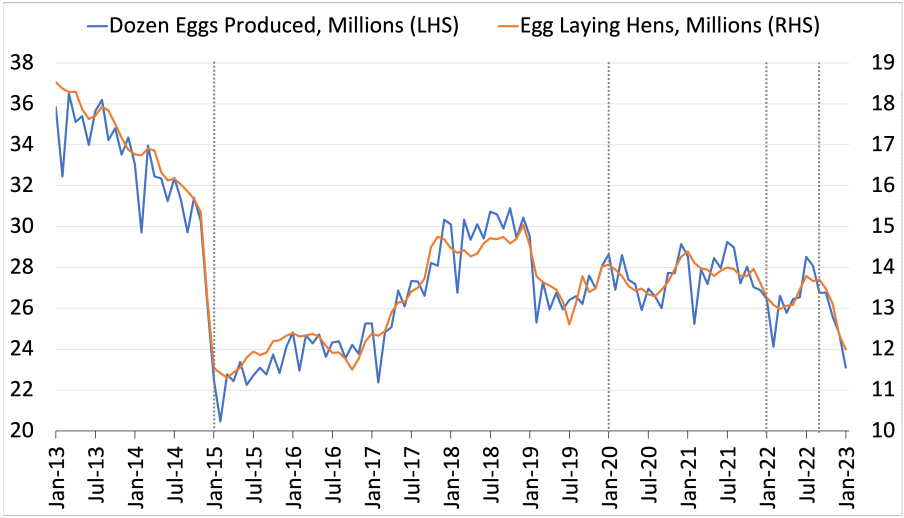


Figure A4: Egg Production in California (Source: USDA)

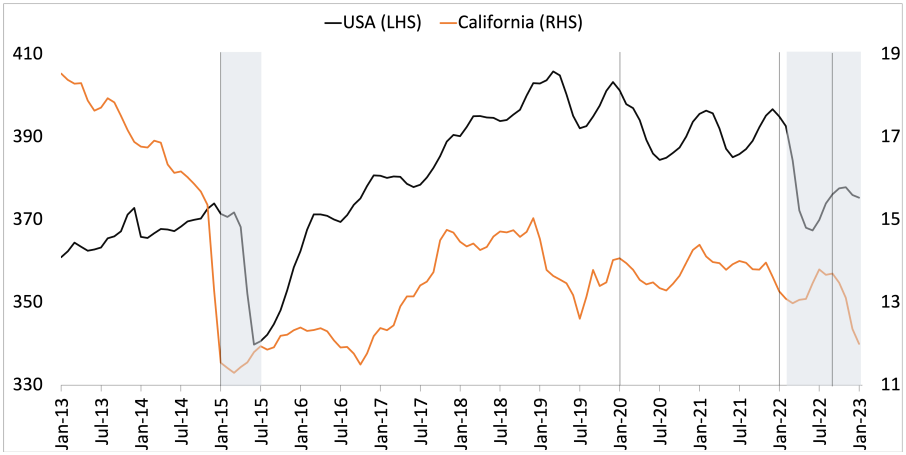
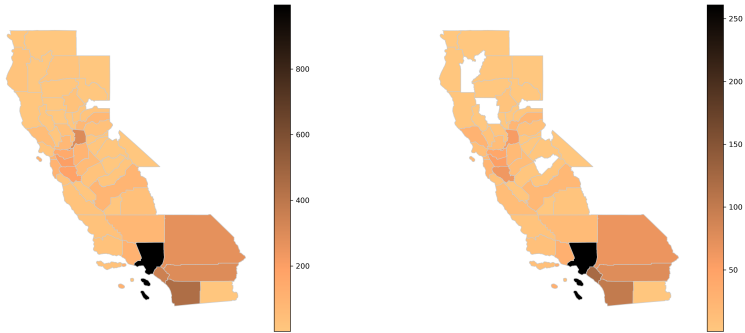


Figure A5: Number (in millions) of Egg-laying Hens (Source: USDA)[1]

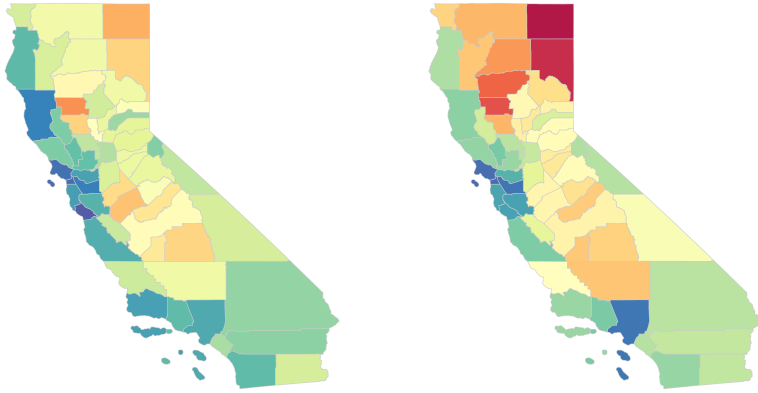
[1]Vertical lines show CA policy changes; Shaded regions show bird flu events

Back



(a) Matched Households (2020) (b) Matched Stores (2020)

Figure A6: Matched Households and Stores in 2020 (Counties)



(a) Proposition 2 (2008) (b) Proposition 12 (2018)

Figure A7: % voted Yes for Animal Welfare Propositions in CA

Appendix B

Reduced-Form

- For this analysis I use a subsample of 94,386 egg purchases made by 5,866 households in California from 2016 to 2017 in the Nielsen Consumer Panel
- Assume that the observed choice Y_{it}^* is a function of the latent variable Y_{it}:

$$Y_{it}^* = \begin{cases} Regular & \text{if } Y_{it} < \theta_1 \\ Cagefree & \text{if } \theta_1 \leq Y_{it} < \theta_2 \\ Organic & \text{if } Y_{it} \geq \theta_2 \end{cases}$$

$$Y_{it} = X_i'\beta + \delta_t + \varepsilon_{it} \ , \ \varepsilon \sim Logistic$$

$$X_i = \left(income_i, age_i, college_i, married_i, female_i\right)'$$

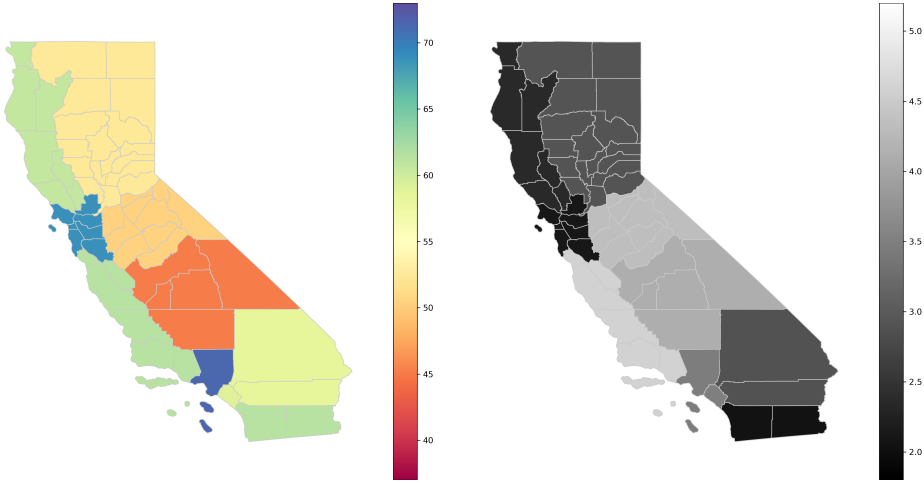
$$\delta_t = \text{ year and month dummies for trip } t$$

- Consumer preference for egg quality is (θ_1, θ_2)

Results

	MLE	Std. Error.	Odds Ratio
β: \$25,000 to \$49,999	0.095*	0.054	1.099
β: \$50,000 to \$69,999	0.259***	0.058	1.295
β: \$70,000 to \$99,999	0.590***	0.056	1.804
β: \$100,000 and above	0.932***	0.051	2.534
β: Age 35 to 64	-0.212***	0.042	0.809
β: Age 65 and above	-0.543***	0.055	0.581
β: College and above	0.623***	0.040	1.864
β: Married	0.049	0.030	1.050
β: Female head	0.258***	0.061	1.294
θ_1	2.687***	0.082	
θ_2	3.448***	0.084	
Observations	94,386		

Standard errors are bootstrapped with 50 replications
*** p<0.01, ** p<0.05, * p<0.1



(a) Voted Yes for Prop 12 (%)

(b) Estimate of θ_1 by Region

Figure A8: Spatial Correlation of Prop 12 Vote and Estimated Cutoffs

Reduced-Form (Part 2)

- Observed price depends on consumer choice: $P(Y_{it}^*)$
- In this alternate specification I use a 2-step approach to account for price effects in consumer choice (Oh & Vukina, 2021)
- Step 1: Regress price on a constant, observed product characteristics $Z(Y_{it}^*)$ and demand shifters (*Easter* and *Christmas* dummies) to predict residual price π_{it}

$$P(Y_{it}^*) = \gamma_0 + Z(Y_{it}^*)'\gamma + \delta_1 Easter + \delta_2 Christmas + \pi_{it} + \nu_{it}$$

- Step 2: Use predicted residual price $\hat{\pi}_{it}$ to account for price effects:

$$Y_{it} = X_i'\beta + \delta_t + \rho\hat{\pi}_{it} + \varepsilon_{it}$$

Step 1

	Coefficient	Std. Error.
Cagefree	0.723***	0.015
Organic	0.960***	0.016
XL / Jumbo	0.242***	0.008
USDA Grade (A/AA)	0.215***	0.008
Brown	1.442***	0.012
Omega-3	1.165***	0.016
Easter	0.192***	0.014
Christmas	0.074***	0.014
Constant	1.678***	0.008
Observations	94,386	
R^2	0.433	

*** p<0.01, ** p<0.05, * p<0.1

Step 2

	MLE	Std. Error.	Odds Ratio
ρ	-0.068***	0.017	0.935
β: \$25,000 to \$49,999	0.098**	0.048	1.103
β: \$50,000 to \$69,999	0.266***	0.045	1.305
β: \$70,000 to \$99,999	0.598***	0.048	1.819
β: \$100,000 and above	0.947***	0.049	2.579
β: Age 35 to 64	-0.220***	0.044	0.803
β: Age 65 and above	-0.547***	0.052	0.579
β: College and above	0.627***	0.040	1.872
β: Married	0.060**	0.029	1.062
β: Female head	0.247***	0.061	1.280
θ_1	2.657***	0.070	
θ_2	3.418***	0.068	
Observations	94,386		

Standard errors are bootstrapped with 50 replications
*** p<0.01, ** p<0.05, * p<0.1

Results

	MLE	MLE (Alt.)
ρ		-0.068***
β: \$25,000 to \$49,999	0.095*	0.098**
β: \$50,000 to \$69,999	0.259***	0.266***
β: \$70,000 to \$99,999	0.590***	0.598***
β: \$100,000 and above	0.932***	0.947***
β: Age 35 to 64	-0.212***	-0.220***
β: Age 65 and above	-0.543***	-0.547***
β: College and above	0.623***	0.627***
β: Married	0.049	0.060**
β: Female head	0.258***	0.247***
θ_1	2.687***	2.657***
θ_2	3.448***	3.418***
Observations	94,386	

Standard errors are bootstrapped with 50 replications
*** p<0.01, ** p<0.05, * p<0.1

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