Effects of Regulation of Farm Practices on Food Market: California Requirement of Cage-Free Housing Systems for Egg Layers

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I. Introduction

This paper studies the effects of farm practice regulations on food markets. Those farm practices, for example, include farm animal treatment, genetically modification technology, and antibiotics usage in animal agriculture. Often, those farm practice regulations are combined with sale restrictions vertically along the supply chain. That is, if related products are not produced from farms that do not satisfy the corresponding farm practice regulations, those products cannot be sold in the wholesale markets and retail markets within regulated jurisdictions. Combined with such sales regulations, farm practice regulations can affect consumer welfare as well as producer welfare.

Consumers would lose from farm practice regulations through at least two channels. First, farm practice regulations raise production costs of the related food products, and, as a result, consumers must pay more for the consumption of those food products. Second, if some existing food products do not satisfy farm practice regulations, the regulations make those products removed from the corresponding markets, which implies that consumers lose opportunities to buy those products. This paper focuses on the second channel.

The second channel requires the following two conditions: First, consumers can identify, often through labeling, whether certain farm practices are implemented or at least are claimed to be implemented. Second, at least substantial consumers are willing to pay more for those claimed products over the corresponding regular products. Those two conditions often hold in food markets: There are many food labels related to farm practices, including organic claims, cage-free housing claims, and no antibiotics use claims. In the literature on food demand analysis, many studies provide evidence that substantial consumers are willing to pay more for those claimed products than the corresponding regular products (for review papers, for example, see Saitone and Sexton, 2017; Rausser, Sexton, and Zilberman, 2019).

This paper studies the likely effects of California's planned hen housing regulations on the California egg market. We use this case to consider farm practice regulations because it has been of considerable attention in the literature of agricultural policy analysis (for a recent review, for example, see Sumner, 2017). In 2015, California required all eggs sold in California must come from hens raised in a larger cage size in production. After previous increases in cage size, starting in January 2022, California will require that all eggs sold in California must come from hens raised in cage-free housing systems (the cage-free mandate). A series of papers provide evidence on a substantial increase in egg prices because of the restrictive hen housing regulations implemented in 2015 (Sumner et al., 2008, 2010, 2011; Mullally and Lusk, 2018; Carter, Schaefer, and Scheitrum, forthcoming). However, the newly amended hen housing regulations (that is, the cage-free mandate) differs from the previously implemented regulations in the sense that the cage-free mandate will make conventional eggs removed from the California egg market. As a result, consumers would lose opportunities to buy conventional eggs.

To measure the likely effects of the cage-free mandate, we estimate the change in market equilibrium outcomes from the removal of conventional eggs in the California egg market. Because the cage-free mandate is not implemented yet, we attempt to estimate the likely effects of the cage-free mandate indirectly. Specifically, we model the California markets with and without the cage-free mandate. We estimate and compare market equilibrium outcomes between the two markets to measure the likely effects of the cage-free mandate. We expect that our indirect method would present an approximation to the California egg market with the expectation that our simulations would be at least a complementary policy evaluation tool to other methods, including cost analysis.

If conventional eggs are removed from the California egg market, for egg consumption, consumers who used to buy conventional eggs will buy other remaining types of eggs such as cage-free eggs and organic eggs. Hence, the magnitude of the cage-free mandate effect depends in part upon how closely egg products are substituted for each other. That is, to measure the likely effects of the cage-free mandate, it is important to specify an appropriate structure of consumer demand for egg products. To specify the demand, we use the “almost ideal demand system,” developed by Deaton and Muellbauer (1980). The almost ideal demand system is a second-order flexible demand system, in the sense of Diewert (1974), which allows for the demand parameters are unconstrained and determined by data rather than *a priori* assumptions on consumer behaviors or preferences.

The remainder of this paper is organized as follows. Section II provides the background of California hen housing regulations and egg industry. Section III describes the data. Section IV specifies a demand system and estimate demand parameters. Section V provides a simple simulation model. Section VI reports simulation results. Section VII reports conclusions.

II. Background: California Hen Housing Regulations and Egg Industry

In this section, we provide some background of California hen housing regulations and egg industry, which are necessary to understand the California egg market.

California hen housing regulations

In 2008, California voters passed California Proposition 2. Proposition 2 required that egg layers must be confined in a manner that they lie down, standing up, and fully extending his or her limbs. Proposition 2 was scheduled to be implemented from January 2015, but people soon realized that those farm-level regulations would not be effective because California egg production would be easily replaced with production outside California (Sumner et al., 2010). In 2013, California enacted another set of regulations (Assembly Bill 1437) on egg sales within California: All eggs sold in California must come from hens raised with a larger cage size (specifically, 116 square inches per hen of usable floor space). In January 2015, those two sets of hen housing regulations (Proposition 2 and Assembly Bill 1437) were implemented at the same time.

In November 2018, California voters decided to reinforce those hen housing regulations through passing Proposition 12. Proposition 12 has two phases. In the first phase (from January 2020 to December 2021), all eggs sold in California must come from hens raised with at least 144 square inches per hen of usable floor space. In the second phase (from January 2022), cage-free housing systems are required in egg production for sales in California. Unlike Proposition 2 in 2008, Proposition 12 in 2018 by itself regulates egg sales as well as farm production practices.

Egg supply and demand in California

In 2019, the U.S. quantity produced of all eggs was about 9,438 million dozen, and California accounted for approximately 3.4% (or 325 million dozen) in the U.S. total production (USDA-NASS, 2020). In terms of production by hen housing systems, given that the total number of layers in the United States is about 400 million, the share of egg layers raised in caged housing systems was about 83.6%, and the share in cage-free housing systems (including organic cage-free housing systems) was about 16.4% (USDA-AMS, 2019). Assuming that the average number of eggs produced per hen is identical across hen housing systems, in terms of the number of eggs produced, the shares of conventional eggs and cage-free eggs would be similar to those shares of layers.

Annual per capita egg disappearance in the United States in 2019 was about 293 eggs (USDA-ERS, 2020). This per capita egg disappearance includes both in-shell consumption and eggs used in processed foods. There is evidence that people in certain racial groups (for example, Hispanic) consume eggs more than other people, and the share of those groups is relatively big in California compared to other regions in the United States. However, we expect that per capita egg disappearance in California would be close to that in the United States because California has relatively higher egg prices than other regions in the United States, which would cancel out the demographics effects. Applying the national estimate of per capita disappearance, about 40 million Californians consume 11,68 million eggs (or 973 million dozen eggs).

III. Data for Estimating the Egg Demand Parameters

We will update this section before the presentation.

IV. Estimating the Egg Demand Parameters

We do simulations for analyzing the likely effects of the cage-free mandate on the California egg market. For the simulations, demand parameters are necessary. In this section, first, we specify the egg demand system. Second, we discuss identification methods for demand parameters. Third, we report the estimation results.

Specification of egg demand system

Our specification of the demand system is the almost ideal demand system, developed by Deaton and Muellbauer (1980). The almost ideal demand system is a second-order flexible demand system, in the sense of Diewert (1974), which allows for the demand parameters are unconstrained and determined by data rather than *a priori* assumptions on consumer behaviors or preferences.

We consider three types of eggs: conventional eggs, cage-free eggs, and organic eggs. For each type of eggs, the demand is specified as follows: For $i = 1, \ldots, 3$, $n = 1, \cdots, N$, and $t = 1, \cdots, T$,

$$(1)\ s_{i,n,t} = \alpha + \beta_i \ln\left(\frac{y_{n,t}}{P_{n,t}}\right) + \sum_{j=1}^{3} \gamma_{i,j} \ln p_{i,n,t} + Z_{n,t}\theta_i + \epsilon_{i,n,t}.$$

The subscript i denotes egg (the subscript 1 denotes conventional eggs, 2 denotes cage-free eggs, and 3 denotes organic eggs). The subscript n denotes counties, and the subscript t denotes monthly periods. The term $s_{i,n,t}$ is the revenue share of the total expenditure of i type eggs in county n in period t. The term $y_{n,t}$ is the overall expenditure of all eggs, and the term $P_{n,t}$ is a price index of all eggs in county n and period t. The term $p_{i,n,t}$ is the price of i type eggs in county n in period t. The term $Z_{n,t}$ is the vector of monthly dummies and state dummies.

The term $P_{n,t}$ is a price index for all eggs, and we use the Stone index:

$$(2)\ \ln P_{n,t} = \sum_{i=1}^{3} w_{i,n} \cdot \ln p_{i,n,t}.$$

The term $w_{i,n}$ is the weight for i type in county n and is the average of the expenditure share of i type in county n.

Under the specified demand system, the revenue share of product i includes three main terms. The first term is based on own- and cross-prices of egg types. The second term is based on the real expenditure for egg consumption, $y_{n,t}/P_{n,t}$. The revenue share of i type increases as the real expenditure for egg consumption increases if the coefficient of the real expenditure, β_i, is positive. The third term is based on the monthly fixed effects and the state fixed effects. Given everything else equal, i type would have higher revenue shares than other egg types as a result of different consumer preferences for egg types over months and across states.

Identification of price coefficients

We use instrumental variable techniques to account for the potential simultaneity problem. That is, we consider the potential case when there are some factors unobserved to the researchers that affect both quantity demanded and prices.

We do not use cost shifters, although cost shifters are potentially appropriate instruments. To be useful instruments, those cost shifters would have to be measured separately for individual types, counties, and periods. However, to our knowledge, there is no available data that is appropriate for our research purpose.

Instead, to obtain instruments, we attempt to use the panel structure of our data, following the approach of Hausman and Taylor (1981), Hausman (1996), and Nevo (2001). Specifically, for the price of a type of eggs in a county, we use the prices of the same type of eggs from neighbored counties as instruments. The intuition of the instruments is that the prices of individual egg types in each county in each period reflect both product costs and county-specific factors. To illustrate county-specific factors, consider that local grocery stores run promotions on a particular type of eggs in a certain period.

Elasticity estimates

We will update this subsection before the presentation.

IV. A Simple Simulation Model to Analyze the Likely Effects of the Cage-Free Mandate

The absence of conventional eggs means that the quantity demanded of conventional eggs is zero. Let us assume that consumers prefer cage-free eggs and organic eggs to conventional eggs, given the same prices. Under this assumption, conventional eggs would be removed from the market when the price of conventional eggs rises up to the price of cage-free eggs. Because of substitution in demand, there are also changes in the quantity demanded of cage-free eggs and the quantity demanded of organic eggs.

Formally, let us consider the following system of log-transformed egg demand functions:

$$(4)\ d\ln q_1 = \epsilon_{11} \cdot d\ln p_1 + \epsilon_{12} \cdot d\ln p_2 + \epsilon_{13} \cdot d\ln p_3,$$

$$(5)\ d\ln q_2 = \epsilon_{21} \cdot d\ln p_1 + \epsilon_{22} \cdot d\ln p_2 + \epsilon_{23} \cdot d\ln p_3,$$

$$(6)\ d\ln q_3 = \epsilon_{31} \cdot d\ln p_1 + \epsilon_{32} \cdot d\ln p_2 + \epsilon_{33} \cdot d\ln p_3.$$

The subscript 1 denotes conventional eggs, 2 denotes cage-free eggs, and 3 denotes organic eggs. The term q is the quantity demanded, and the term p is the price. The term $\epsilon_{i,j}$ is the price elasticity of product i in response to a price change in product j, for $i, j = 1,2,3$. The demand elasticities summarize the extent of how closely egg products are substituted for each other.

Notice that, under perfect competition assumption, there is no change in the prices of cage-free eggs and organic eggs by the cage-free mandate. That is, in simulations, $d\ln p_2 = d\ln p_3 = 0$. Given the price change in conventional eggs, we can simulate the changes in the quantity of cage-free eggs and the quantity of organic eggs. Among consumers who used to buy conventional eggs, one group would buy cage-free eggs, and the other group would buy organic eggs when conventional eggs are removed from the market, given the price difference between cage-free eggs and organic eggs. For convenience, we assume that the shares of those two groups can be represented by the observed shares of cage-free eggs and organic eggs.

IV. Simulation Results

We will update this section before the presentation.

V. Conclusions

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