Measuring the Impact of Transitional Certification and Labeling on Organic Conversion Rates and Organic Price Premiums

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0.1 Introduction

Despite industry concerns about the impact of transitional products on the market for organics, a number of agencies have proposed or implemented transitional certification guidelines in recent years, and some have introduced certified transitional labels. In 2016, the first food products marketed as Certified Transitional hit the market. Products with this label are made with certified transitional inputs, which are commodities in the second and third years of the three-year transition period from conventional to organic. The Organic Trade Association (OTA) is concerned that transitional labels could dilute the value of the existing organic label. As a result they worked with the United States Department of Agriculture (USDA) in 2016 to draft plans for the National Certified Transitional Program (NCTP) that include stipulations about the composition and location of such labels. The program is currently on hold due to objections from the Western Organic Dairy Producers (WODPA) who believe that a transitional label will "compromise the integrity of the NOP standards and denigrate the organic label" (Mathews, 2016).

This paper studies how the introduction of certified transitional products and commensurate labeling affect the organic price premium, the return on investment of converting from conventional to organic and, thus, organic conversion rates. To that end, I will construct a model of vertical product differentiation to explore how introducing products with a certified transitional label impacts prices and market shares for conventional, organic, and certified transitional products and, in turn, conversion rates from conventional to organic. In the model, a certified transitional label may dilute the organic premium due to impacting consumers' self-selection constraints by introducing certified transitional products as a relatively close substitute for certified organic products. Thus, farmers contemplating organic conversion may earn higher returns during the conversion period but lower returns post conversion due to competition from transitional organic products produced by farmers who convert later in time.

The model compares the organic price premium and organic market share under a baseline scenario of no transitional certification and labeling to the equilibrium where a certified transitional product is introduced, labeled, and operates as a good of "intermediate" quality between conventional and certified organic. In the latter, organic and transitional products compete directly for sales to consumers who place a high value on goods embodying organic or transitional characteristics. Specifically, the model shows that the impact of introducing transitional certification and labeling on organic conversion depends on consumers' perceived quality of transitional relative to organic and the distribution of consumer preferences for quality attributes embodied in organic or transitional products.

Comparative statics from the model yield insights as to how the introduction of a certified transitional label into the retail space will impact organic conversion for different commodities. Key variables include (i) consumers' perceived quality of the transitional product relative to organic, (ii) distribution of consumer preferences for quality attributes contained in organic and transitional organic products, (iii) farmer discount rates, and (iv) farmers' expected lifespan of their operations. Future empirical work on consumer preferences can help determine appropriate estimates for the former two parameters. I will calibrate the model using organic and conventional production data from the USDA's Agricultural Census, Organic Survey, and other sources.

0.1.1 Background on Organic Industry and Transitional Certification

U.S. demand for organic food products has long eclipsed domestic production of organic commodities and supply of certified organic cropland. Sales of organic products have grown over 700% since the National Organic Program (NOP) was established in 2000, averaging 12.3% growth per year (Delbridge et al. 2017; Silva et al. 2012). During the same period, the amount of domestic certified organic acreage increased by only 200% (Delbridge et al., 2017). In more recent years, the number of certified organic acres in the U.S. has surged, growing 17.4% per year on average between 2014 and 2017. Even so, the U.S. remains a net importer of organic commodities, with value of organic imports reaching $2.1 billion in 2017, an increase of over 20% from the prior year (U.S. Department of Agriculture, 2017).

While organic commodities command a higher price at the farmgate and a premium at retail relative to their conventional counterparts, potentially providing farmers with higher variable profits per hectare compared to conventional crops (Chase et al., 2008), farmers face a number of obstacles when converting from conventional to organic production. One key obstacle often cited by farmers as an impediment to conversion is the transition process. Transitioning to organic is a costly and time-intensive process. Farmers must produce using organic methods for three years before being certified. During this three-year period, referred to as the transition period, farmers often make significant capital investments, experience lower yields, and usually fail to garner price premiums on output.

A variety of federal programs exist to assist with organic production and certification. Under the USDA's Organic Cost Share program, certified organic farmers receive up to $750 per year to cover the cost of organic certification. The USDA further provides financial and technical assistance via the Agriculture Management Assistance (AMA) program in 16 states to farmers who invest in conservation measures to address water management, water quality, erosion control, and other issues. Eligible conservation practices include transitioning to organic farming. Despite this support, the National Sustainable Agriculture Coalition and the Organic Farming Research Foundation say these and other programs could be expanded to better support farmers in the transition process by, for instance, making cost share funds available to farmers in transition and expanding the number of states eligible for AMA (Charney, 2017).

A relatively new approach to easing the financial strain of the transition period is to create a new product category to generate higher returns for farmers in transition. Quality Assurance International (QAI), California Certified Organic Farmers (CCOF), Organic Certifiers (OC), and Ecocert, all accredited certifying agencies (ACAs), have implemented transitional organic certification guidelines and introduced certified transitional labels in recent years for farms in years two and three of the organic conversion process. The most high profile of these efforts is spearheaded by Kashi, who, in 2016, partnered with QIA to set certification standards for transitioning farms and establish a "certified transitional" label. They were the first company to market a product as Certified Transitional at the retail level.

(a) CCOF

(b) Ecocert

(c) QAI

Figure 1: Certified transitional Labels

Such transitional certification programs aim to generate price premiums for transitional crops, thereby motivating a greater number of conventional farmers to convert to organic. Additionally, proponents claim certification will improve access to USDA support services like farm loan products during the transition, facilitate better supply chain management, and establish a market for transitional crops. Despite the purported benefits, the Organic Trade Association (OTA) and other incumbents in the organic industry worry that certification and accompanying labels will weaken the value of organic certification.

To alleviate these concerns and establish uniform certification guidelines, the USDA proposed the National Certified Transitional Program (NCTP) in early 2017. The proposed program utilized standards developed by the OTA, allowed ACAs to certify transitional producers, and established strict labeling guidelines to limit the possibility that consumers would confuse or closely associate transitional and organic products. Goods certified under the program cannot use the word "organic" on any labels and must refrain from including a label on the product's primary panel. Even so, the program was put on hold in 2017, after the Western Organic Dairy Producers Alliance (WODPA) echoed OTA's concerns. WODPA threatened legal action against the USDA if the program came to fruition. Among their grievances is the belief that a transitional label will "compromise the integrity of the NOP standards and denigrate the organic label" (Mathews, 2016).

The rationale behind these concerns is twofold: First, that some consumers may encounter transitional and organic versions of the same product and feel that the transitional product is sufficiently close to organic in quality not to warrant paying the full organic premium. Second, if a label informs consumers of the existence of this transitional period and enables transitional products to capture a premium in the market place, a portion of this premium would then flow to farmers in the form of higher prices paid by processors. Thus, over the long run, a transitional premium could induce conversion of more cropland to certified organic and dilute organic premiums through this supply response.

That is, in the short run, organic premiums may decrease by way of competition with transitional products, and in the long run, they may decrease due to competition with both transitional products and increased organic production. This analysis seeks to address these short- and long-run effects. In this prospectus, I address the former using a static model of vertical differentiation. I then present the framework of a dynamic model of vertical differentiation and organic conversion that I will use to address the latter.

0.2 Literature Review

To my knowledge, the effects of the introduction of certified transitional products, both labeled and unlabeled, on the market for organic food and the decision to transition to certified organic cropland have not yet been studied. Prior to the introduction of goods labeled transitional into the retail space, Williams (2013) estimated willingness to pay for hypothetical transitional produce. Using stated preference methodology, he found a positive willingness to pay for transitional goods. In my empirical work, I will extend this approach by using a mix of stated and revealed preference methodologies in relation to actual commodities and food products certified as transitional.

While not specific to transitional goods, there does exist research on whether foods labeled as GMO-free, a designation available to farms in transition since organic crops must be GMO-free, and organic are substitutes or complements. McFadden and Lusk (2017) explore willingness-to-pay (WTP) for foods that note presence or absence of genetically modified ingredients. Using survey data, they estimate the premium relative to conventional goods that consumers are willing to pay for goods with the organic label, goods with the Non-GMO Project verified label, and goods with both labels. They find that the premium does not increase when both labels are present relative to when only one label is present, indicating that the two labels are viewed as substitutes not complements. They do not hypothesize why this may be the case, though it is possible it is due to consumers associating both labels with “natural” food.

Further, Giannakas (2016) models the coexistence of conventional, genetically modified, and organic goods using a vertical differentiation framework. He concludes that the co-existence of the three quality types in the market depends on market structure, strategic interactions of participants throughout the supply chain, costs associated with supplying the three products, labeling practices, and consumer preferences toward the three quality types.

Marette, Messean, and Millet (2012) estimate willingness to pay for eco-friendly apples when an intermediate quality apple, i.e. an apple labeled "few pesticides", is introduced alongside organic and conventional apples. They find that the average consumers surplus increases with the introduction of this new good, and that willingness to pay for eco-attributes is affected by information provided about environmental processes and attributes of the good in the study.

In relation to farmers’ decisions to convert to organic, Delbridge and King (2016) seek to explain low organic conversion rates by modeling the organic adoption probabilities using net present value (NPV) and options value frameworks. He finds that the adoption probabilities for large farms are especially sensitive to the size of organic premiums. Kuminoff and Wossink (2010) explores how financial compensation can be used to induce conventional farmers to convert their operations to organic. They estimate that the amount of money required to induce a risk-neutral soybean farmer with a 10 percent discount rate is \$311 per acre for ten years. This would cover conversion costs and compensate farmers for higher production costs and increased market risk associated with organic production.

0.3 Static Model

Utilizing the framework developed by Mussa and Rosen (1978) and Saitone and Sexton (2010), I construct a static vertical differentiation model to explore the change in equilibrium price in the markets for conventional and organic products when certified transitional products are introduced into the quality space.

0.3.1 Production

There are N acres of cropland. Each acre produces one unit of output, such that total production is equal to N. I assume supply is inelastic over the period analyzed. I begin with ex ante shares of conventional and transitional production, denoted as S_c and S_{to}, respectively, at $t = 0$ where $0 \leq S_{to} \leq S_c \leq 1$. It follows that the ex ante share of organic production, S_o, is $(1 - S_c - S_{to})$. In the absence of transitional certification and labeling, consumers do not distinguish between conventional and transitional production, so the effective share of conventional production at $t = 0$ is $(S_c + S_{to})$ in this scenario.

0.3.2 Consumption

Depending on the policy scenario, the market may consist of conventional (c), transitional organic (to), and organic (o) goods. These goods have homogeneous product attributes (e.g. size, sugar content, etc.) but heterogeneous process attributes (i.e. how they were produced). Consumers agree on the quality ranking of the conventional, transitional, and organic goods and would purchase the organic good if all goods were sold at the same price. Despite this, consumers differ in their valuation of and willingness to pay for the different quality levels. Consumers are indexed by a valuation parameter $\theta \in [\underline{\theta},\overline{\theta}]$ where $\underline{\theta} \geq 0$. I initially assume consumers are uniformly distributed along this space with unit density, which means $\overline{\theta} = \underline{\theta} + 1$. I assume demand for a given commodity exceeds exogenous supply. Since the number of consumers is normalized to one, it follows that $N < 1$, and therefore, N represents the market penetration of the commodity. I further assume consumers purchase no more than one unit of one good in the market (i.e. discrete choice and unit demand), and the purchasing decision is a small portion of budget (i.e. there is no income effect). Given these assumptions, direct utility associated with one unit of good i is

$$U(q_i, x, \theta) = \theta q_i + x, \ \ i = c, to, o$$

where q_i is the exogenous quality of conventional, transitional organic, and organic goods, respectively, and x is expenditure on other outside goods. I normalize the quality of organic goods to 1, so that q_c and q_{to} are the relative qualities of conventional and transitional goods. Consumers face an exogenous budget constraint. $I = x + p_i$, with p_i being the price of conventional, transitional, and organic products, respectively.

Indirect utility is represented as:

$$v(q_i, x, p_i, \theta) = \begin{cases} \theta q_i + I - p_i, & q_i > 0 \\ I, & q_i = 0 \end{cases}$$

0.3.3 Policy 1: No Transitional Certification

All three types of products exist, but in the absence of a transitional certification and labeling, consumers cannot discern between transitional products and conventional goods. It is plausible that many consumers are unaware of the three-year transition period and, thus, the possibility of transitional goods existing in the market. Those who do know must make assumptions about the proportion of conventional and transitional goods in the market to estimate the average quality non-organic goods. Because organic cropland makes up fewer than one percent of all cropland in the U.S., the I assume proportion of unlabeled transitional goods on the market is small enough so as not to alter consumers' expected average quality of conventional goods. Thus, with no transitional labels, transitional goods are sold in conventional markets with expected quality q_c, and consumers are faced with only conventional and organic goods.

The consumer indifferent between consuming an organic or conventional good is located at the point where the indirect utility derived from consuming the two types of goods are equal. Likewise, the consumer indifferent between consuming conventional goods and the outside option is located at the point where indirect utility associated with the two consumption choices are equal.

$$v_o = v_c \implies \theta + I - p_o = \theta q_c + I - p_c \implies \hat{\theta} = \frac{p_o - p_c}{1 - q_c}$$
$$v_c = v_x \implies \theta q_c + I - p_c = I \implies \underline{\theta} < \tilde{\theta} = \frac{p_c}{q_c}$$

The former location is determined by the self-selection constraint, as the consumer is indifferent between the two product types and derives a positive consumer surplus from consuming either type. That is, $v(q_o, p_o, \theta_{oc}) = v(q_c, p_c, \theta_{oc}) > 0$. From this, the demands for conventional and organic goods in time t are as follows:

$$Q_o(p_o, p_c | q_o, q_c) = \overline{\theta} - \hat{\theta} = \overline{\theta} - \frac{p_o - p_c}{1 - q_c}$$
$$Q_c(p_o, p_c | q_o, q_c) = \hat{\theta} - \tilde{\theta} = \frac{p_o - p_c}{1 - q_c} - \frac{p_c}{q_c}$$

I derive inverse demand by inverting these demand functions.

$$p_o = \overline{\theta} - Q_o - Q_c q_c$$
$$p_c = q_c\left(\overline{\theta} - Q_o - Q_c\right)$$

The available production quantities of conventional and organic products, respectively, are

$$Q_o = (1 - S_c - S_{to})N$$
$$Q_c = (S_c + S_{to})N$$

Substituting the available production quantities into the inverse demand functions results in:

$$\begin{aligned} p_o &= \overline{\theta} - (1 - S_c - S_{to})N - q_c(S_c + S_{to})N \\ &= \overline{\theta} - N + N(S_c + S_{to})(1 - q_c) \\ p_c &= q_c(\overline{\theta} - (1 - S_c - S_{to})N - (S_c + S_{to})N) \\ &= q_c(\overline{\theta} - N) \end{aligned}$$

The resulting organic price premium is:

$$p_o - p_c = (\overline{\theta} - NS_o)(1 - q_c)$$

The premium is decreasing in both the ex-ante quantity of organic production and the relative quality of conventional goods.

0.3.4 Policy 2: Transitional Certification and Labeling

Certified transitional goods are labeled and introduced into the market, resulting in the existence of an intermediate-quality product in the quality space. Transitional goods have a quality q_{to}, where $q_c < q_{to} < 1$. Consumers who are indifferent between conventional and transitional goods and those who are indifferent between transitional and organic goods are located as follows:

$$
\begin{aligned}
v_o = v_{to} &\implies \breve{\theta} = \frac{p_o - p_{to}}{1 - q_{to}} \\
v_{to} = v_c &\implies \breve{\theta} = \frac{p_{to} - p_c}{q_{to} - q_c} \\
v_c = v_x &\implies \tilde{\theta} = \frac{p_c}{q_c}
\end{aligned}
$$

This results in the following linear demand functions for conventional, transitional organic, and organic goods:

$$
\begin{aligned}
Q_o(p_o, p_{to}|q_o, q_{to}) &= \overline{\theta} - \breve{\theta} = \overline{\theta} - \frac{p_o - p_{to}}{1 - q_{to}} \\
Q_{to}(p_o, p_{to}, p_c|q_o, q_{to}, q_c) &= \breve{\theta} - \breve{\theta} = \frac{p_o - p_{to}}{1 - q_{to}} - \frac{p_{to} - p_c}{q_{to} - q_c} \\
Q_c(p_{to}, p_c|q_{to}, q_c) &= \breve{\theta} - \tilde{\theta} = \frac{p_{to} - p_c}{q_{to} - q_c} - \frac{p_c}{q_c}
\end{aligned}
$$

I derive the following inverse demand functions:

$$
\begin{aligned}
p_o &= \overline{\theta} - Q_o - Q_{to}q_{to} - Q_c q_c \\
p_{to} &= q_{to}(\overline{\theta} - Q_o - Q_{to}) - Q_c q_c \\
p_c &= q_c(\overline{\theta} - Q_o - Q_{to} - Q_c)
\end{aligned}
$$

In any period t, the available production quantities of organic, transitional, and conventional products, respectively, are as follows:

$$Q_o = (1 - S_c - S_{to})N$$
$$Q_{to} = S_{to}N$$
$$Q_c = S_cN$$

I plug these production quantities into the inverse demand functions to derive price as a function of production shares, and taste and quality parameters.

$$\begin{aligned}
p_o &= \overline{\theta} - (1 - S_c - S_{to})N - S_{to}Nq_{to} - S_cNq_c \\
&= \overline{\theta} - N(1 - S_c(1 - q_c) - S_{to}(1 - q_{to})) \\
p_{to} &= q_{to}(\overline{\theta} - (1 - S_c - S_{to})N - S_{to}N) - S_cNq_c \\
&= q_{to}(\overline{\theta} - N) + S_cN(q_{to} - q_c) \\
p_c &= q_c(\overline{\theta} - (1 - S_c - S_{to})N - S_{to}N - S_cN) \\
&= q_c(\overline{\theta} - N)
\end{aligned}$$

The quality of transitional crops can be denoted as a linear combination of q_o and q_c such that $q_{to} = \alpha + (1 - \alpha)q_c$ and $\alpha \in (0, 1)$. Here, α can be interpreted as the substitutability of transitional and organic goods, where α approaching one indicates consumers view transitional and organic goods as near-perfect substitutes, and α approaching zero indicates transitional and conventional are near-perfect substitutes. I substitute the function for q_{to} into p_o and p_{to}.

$$\begin{aligned}
p_o &= \overline{\theta} - N\Big(1 - \big(S_c + S_{to}(1 - \alpha)\big)(1 - q_c)\Big) \\
p_{to} &= (\overline{\theta} - N)\big(\alpha + q_c(1 - \alpha)\big) + \alpha S_cN(1 - q_c)
\end{aligned}$$

Proposition 1. *The introduction of certified transitional certification and labeling decreases the price of organic goods.*

The change in the price of organic goods induced by the introduction of transitional organic certification and labeling (Δp_o) is as follows:

$$\begin{aligned}\Delta p_o = p_o^{p2} - p_o^{p1} &= \overline{\theta} - N\Big(1 - \big(S_c - S_{to}(1-\alpha)\big)(1-q_c)\Big) - \overline{\theta} + N - N(S_c + S_{to})(1-q_c) \\ &= -S_{to}N\alpha(1-q_c)\end{aligned}$$

Because $q_c < 1$, the sign of Δp_o is negative. The magnitude of the reduction in price is determined by the volume of transitional production, the relative quality of conventional goods, and the degree to which consumers believe transitional and organic goods are substitutes. The magnitude is increasing in $S_{to}N$ and α and decreasing in q_c. I calibrate the ex ante shares of organic and transitional goods using total U.S. farmland acreage as well as organic and transitional cropland acreage as reported in the USDA's Agricultural Census and Organic Survey. The 2014 Organic Survey reports 137,561 acres of transitional cropland and 2,409,869 acres of organic cropland.[1] In 2012, there were 389,690,414 acres of cropland in the U.S. (U.S. Department of Agriculture, 2012). This results in $S_c = 99.35$ percent, $S_t = 0.04$ percent and $S_o = (1 - S_c - S_t) = 0.62$ percent.

Using these shares, I simulate the percentage change in p_o by setting N to 0.9, simulating α in intervals of 0.1 to 0.9, and simulating q_c in intervals of 0.4 from 0.1 to 0.9. Additionally, I set the shares of transitional and conventional production to one percent and 98.35 percent, respectively, (holding S_o constant) to show how policy two might affect the price of organic if the share of transitional cropland were much higher than the current value. The percentage change in price ranges from -0.002 percent to -0.806 percent. The small magnitude of the decrease is due in large part to the small share of transitional production. This share is likely to remain small due to the fact that goods are only transitional for a finite period before

[1] Transitional acreage is comprised of 24,550 from non-organic farms and 113,011 from certified and exempt farms.

becoming organic. That is, the share of transitional production can be thought of as a flow rather than a stock that accumulates over time.

Table 1: Percentage Change in the Price of Organic Under Policy 2

	$S_t = 0.04\%$			$S_t = 1.0\%$		
α	$q_c = 0.1$	$q_c = 0.4$	$q_c = 0.9$	$q_c = 0.1$	$q_c = 0.5$	$q_c = 0.9$
0.1	-0.003%	-0.003%	-0.002%	-0.090%	-0.082%	-0.048%
0.2	-0.006%	-0.006%	-0.003%	-0.179%	-0.165%	-0.095%
0.3	-0.009%	-0.009%	-0.005%	-0.269%	-0.247%	-0.143%
0.4	-0.013%	-0.012%	-0.007%	-0.358%	-0.329%	-0.190%
0.5	-0.016%	-0.015%	-0.008%	-0.448%	-0.411%	-0.238%
0.6	-0.019%	-0.017%	-0.010%	-0.537%	-0.494%	-0.285%
0.7	-0.022%	-0.020%	-0.012%	-0.627%	-0.576%	-0.333%
0.8	-0.025%	-0.023%	-0.013%	-0.716%	-0.658%	-0.380%
0.9	-0.028%	-0.026%	-0.015%	-0.806%	-0.740%	-0.428%

Proposition 2. *The introduction of certified transitional certification and labeling does not alter the price of conventional goods.*

Under both policies, the price of conventional goods is equal to $q_c(\overline{\theta} - N)$, which is not dependent on the share and substitutability of transitional goods.

Proposition 3. *It follows from propositions 1 and 2 that the introduction of certified transitional certification and labeling reduces the organic premium by the same amount as the reduction in the price of organic.*

The change in price premiums is equal to $(p_o^{P2} - p_c^{P2}) - (p_o^{P1} - p_c^{P1})$. Because $P2_c = P1_c$, the change in premiums is equal to $p_o^{p2} - p_o^{p1}$ or Δp_o.

Proposition 4. *The price of transitional goods is increasing in the degree to which consumers believe transitional and organic goods are substitutes.*

The derivative of p_{to} with respect to α is

$$\frac{\partial p_{to}}{\partial \alpha} = (\overline{\theta} - N + S_c N)(1 - q_c)$$

As $N < \overline{\theta}$, the sign of the derivative is positive.

Proposition 5. *Transitional goods are sold at a premium relative to conventional goods.* The difference between the price of transitional conventional goods is

$$\begin{aligned} p_{to} - p_c &= (\overline{\theta} - N)\big(\alpha + q_c(1-\alpha)\big) + \alpha S_c N(1 - q_c) - q_c(\overline{\theta} - N) \\ &= \alpha \underbrace{(\overline{\theta} - N)}_{(+)} \underbrace{(1 - q_c)}_{(+)} + \alpha S_c N \underbrace{(1 - q_c)}_{(+)} \\ &> 0 \end{aligned}$$

This is positive for all $\alpha > 0$, which indicates transitional certification will allow farmers to obtain higher prices during the transition period than they would in the absence of transitional certification and labeling.

In total, the introduction of transitional certification and labeling causes a decrease in organic prices and premiums in the short run. This effect, however, is small in magnitude given the limited amount of production that will be certified transitional at an given time. Transitional products garner a positive premium over conventional goods, which may encourage producers to convert more acres from conventional to organic. Over time, this may further reduce the organic premium due to competition with increased organic production.

0.4 Dynamic Model

To determine long-run price impacts and how the change in price caused by the introduction of transitional certification affects organic conversion rates, I will develop a dynamic vertical differentiation model. The underlying assumptions about consumption are the same as in the static model, but production differs. The basic framework of the model is developed in the following sections.

0.4.1 Production

I, again, assume total output equal to N and the same ex-ante shares of organic, transitional, organic output. Conventional producers may now choose to adopt organic production practices and convert output from conventional to organic. Producers undergo conversion at increasing marginal cost. This reflects the fact that some farmland is more suitable to organic conversion leading farmers to face heterogeneous conversion costs. I use the following quadratic transition cost function utilized by Saitone and Sexton (2010):

$$C(T) = 0.5\beta T^2$$

where $T \in [0, N]$ is the number of conventional acres (and, therefore, the quantity of output) that have transitioned or are in the process of transitioning to organic, and $\beta \in (0, \infty)$ is used to calibrate the marginal cost of transitioning from conventional to organic.

I measure time so that the transition to organic production takes one period. Let τ_t be the number of acres that transition and are, thus, eligible for transitional certification in a given period t. I denote T_0 as the number of acres that have ex ante completed or are in the midst of the transition process. That is, $T_0 = (1 - S_c)N$. In period $t \geq 1$ the total number of acres that are in the midst of or have completed the transition process is

$$T_t = \underbrace{(1 - S_c)N}_{\text{ex-ante o + to}} + \overbrace{\sum_{n=1}^{t} \tau_n}^{\text{ex-post to}}$$

Acres that transition in year t become eligible for organic certification in period $t + 1$, such that the total number of organic acres in year $t \geq 1$ is $(1 - S_c - S_{to})N + \sum_{n=0}^{t-1} \tau_n$. I further assume conversion is an irreversible process. That is, organic and transitional acreage cannot be converted back to conventional.

0.4.2 Policy 1: No Transitional Certification

All three types of products exist, but transitional goods are marketed and sold as conventional. The consumer indifferent between consuming an organic or conventional good and the consumer indifferent between consuming conventional goods and outside goods are located as follows:

$$v_{o,t} = v_{c,t} \implies \theta + I - p_{o,t} = \theta q_c + I - p_{c,t} \implies \hat{\theta}_t = \frac{p_{o,t} - p_{c,t}}{1 - q_c}$$
$$v_{c,t} = v_{x,t} \implies \theta q_c + I - p_{c,t} = I \implies \underline{\theta} < \tilde{\theta}_t = \frac{p_{c,t}}{q_c}$$

From this, I derive demands for conventional and organic goods in period t:

$$Q_{o,t}(p_{o,t}, p_{c,t}|q_o, q_c) = \overline{\theta} - \hat{\theta}_t = \overline{\theta} - \frac{p_{o,t} - p_{c,t}}{1 - q_c}$$
$$Q_{c,t}(p_{o,t}, p_{c,t}|q_o, q_c) = \hat{\theta}_t - \tilde{\theta}_t = \frac{p_{o,t} - p_{c,t}}{1 - q_c} - \frac{p_{c,t}}{q_c}$$

I invert these demand functions to find inverse demands:

$$p_{o,t} = \overline{\theta} - Q_{o,t} - Q_{c,t} q_c$$
$$p_{c,t} = q_c \left(\overline{\theta} - Q_{o,t} - Q_{c,t}\right)$$

The available production quantities of conventional and organic products, respectively, in period $t \geq 1$ are

$$Q_{c,t} = (S_c + S_{to})N - \sum_{n=0}^{t-1} \tau_n = N - T_{t-1}$$
$$Q_{o,t} = (1 - S_c - S_{to})N + \sum_{n=0}^{t-1} \tau_n = T_{t-1}$$

Inserting these values into the inverse demand functions results in:

$$p_{o,t} = (\overline{\theta} - T_{t-1}) - q_c(N - T_{t-1})$$
$$= \overline{\theta} - Nq_c - T_{t-1}(1 - q_c)$$
$$p_{c,t} = q_c(\overline{\theta} - N)$$

The price of organic goods is decreasing in T_{t-1}, meaning the price of organic decreases as more acres convert.

The marginal cost of transitioning to organic in period $t \geq 1$ is $MC(T_t) = \beta T_t$ when not accounting for opportunity cost. Producers who transition forgo selling those goods as conventional goods once they have completed the conversion process, so the full marginal cost when accounting for opportunity costs is

$$MC_t = \beta T_t + \sum_{n=1}^{l} \delta^n p_{c,t+n}$$
$$= \beta T_t + \sum_{n=1}^{l} \delta^n q_c(\overline{\theta} - N)$$

Here, l is the lifespan of the organic operation, and δ is the discount factor equal to $(1+r)^{-1}$. That is, the marginal cost of transitioning in period t is the sum of βT_t and the net present value (NPV) of the conventional price beginning in the first period in which the producers who begin transitioning in period t no longer sell their output in the conventional market $(t + 1)$ through the final year of the useful life for the recently converted cropland $(t + l)$. Producers who begin the transition process in year t receive p_c that year, just as they do if they do not transition, and p_o for every year thereafter through $t + l$. Thus, the marginal benefit of converting is

$$
\begin{aligned}
MB_t &= \sum_{n=1}^{l} \delta^n p_{o,t+n} \\
&= \sum_{n=1}^{l} \delta^n \big(\overline{\theta} - Nq_c - T_{t+n-1}(1-q_c)\big)
\end{aligned}
$$

Marginal benefit is decreasing in the number of acres who convert.

Equilibrium in each period occurs when the marginal cost of conversion equals the marginal benefit. I assume production is in equilibrium in period $t = 0$. As there is no policy change in period $t = 1$ (or any other time) under this scenario, the marginal cost and benefit functions are static over time. These functions are increasing in T and decreasing in T, respectively, so additional conversion beyond ex-ante levels will increase marginal cost, decrease marginal benefits, and throw production out of equilibrium. It follows that, in equilibrium, producers do not convert additional acres to organic in periods $t \geq 1$, i.e. $\tau_1, ..., \tau_n = 0$, and the steady-state level of conversion is $T_{ss} = T_0 = (1 - S_c)N$. The steady-state price for organic products under this scenario is

$$p_{o,ss} = p_{o,1} = \overline{\theta} - N + S_c N(1 - q_c)$$

and the organic premium is

$$p_{o,ss} - p_{c,ss} = (1 - q_c)(\overline{\theta} - N(1 - S_c))$$

The premium is decreasing in the relative quality of conventional goods and increasing in the quantity of conventional production.

0.4.3 Policy 2: Transitional Certification and Labeling

Upon the introduction of transitional certification and labeling in period $t = 1$, there is a new good of "intermediate" quality q_{to} in the product space, where $q_c < q_{to} < 1$ and $q_{to} = \alpha + (1-\alpha)q_c$. There now exist consumers who are indifferent between organic and transitional goods and those who are indifferent between transitional and conventional goods at locations $\breve{\theta}$ and $\check{\theta}$.

$$\begin{aligned} v_{o,t} = v_{to,t} &\implies \breve{\theta}_t = \frac{p_{o,t+n} - p_{to,t}}{1 - q_{to}} \\ v_{to,t} = v_{c,t} &\implies \check{\theta}_t = \frac{p_{to,t} - p_{c,t}}{q_{to} - q_c} \\ v_{c,t} = v_x &\implies \tilde{\theta}_t = \frac{p_{c,t}}{q_c} \end{aligned}$$

This results in the following linear demand functions for for conventional, transitional, and organic goods:

$$\begin{aligned} Q_{o,t}(p_o, p_{to}|q_o, q_{to}) &= \overline{\theta} - \breve{\theta}_t = \overline{\theta} - \frac{p_{o,t} - p_{to,t}}{1 - q_{to}} \\ Q_{to,t}(p_o, p_{to}, p_c|q_o, q_{to}, q_c) &= \breve{\theta}_t - \check{\theta}_t = \frac{p_{o,t} - p_{to,t}}{1 - q_{to}} - \frac{p_{to,t} - p_{c,t}}{q_{to} - q_c} \\ Q_{c,t}(p_{to}, p_c|q_{to}, q_c) &= \check{\theta}_t - \tilde{\theta}_t = \frac{p_{to,t} - p_{c,t}}{q_{to} - q_c} - \frac{p_{c,t}}{q_c} \end{aligned}$$

I rearrange these to find inverse demands.

$$\begin{aligned} p_{o,t} &= \overline{\theta} - Q_{o,t} - Q_{to,t}q_{to} - Q_{c,t}q_c \\ p_{to,t} &= q_{to}(\overline{\theta} - Q_{o,t} - Q_{to,t}) - Q_{c,t}q_c \\ p_{c,t} &= q_c(\overline{\theta} - Q_{o,t} - Q_{to,t} - Q_{c,t}) \end{aligned}$$

In period $t \geq 1$, the available production quantities of organic, transitional, and conventional products, respectively, are:

$$Q_{o,t} = (1 - S_c - S_t)N + \sum_{n=0}^{t-1} \tau_n = T_{t-1}$$

$$Q_{to,t} = \tau_t$$

$$Q_{c,t} = (S_c + S_t)N - \sum_{n=0}^{t} \tau_n = N - T_t$$

I plug these production quantities into the inverse demand functions.

$$\begin{aligned}
p_{o,t} &= (\overline{\theta} - T_{t-1}) - q_{to}\tau_t - q_c(N - T_t) \\
p_{to,t} &= q_{to}(\overline{\theta} - T_{t-1} - \tau_t) - q_c(N - T_t) \\
&= q_{to}(\overline{\theta} - T_t) - q_c(N - T_t) \\
p_{c,t} &= q_c(\overline{\theta} - T_{t-1} - \tau_t - (N - T_t)) \\
&= q_c\left(\overline{\theta} - N\right)
\end{aligned}$$

Again, the price of conventional goods is constant over time under present assumptions. I then substitute q_{to} as a linear combination of q_o and q_c into the inverse demand equations for organic and transitional products.

$$\begin{aligned}
p_{o,t} &= \overline{\theta} - Nq_c - (T_{t-1} + \alpha\tau_t)(1 - q_c) \\
p_{to,t} &= \alpha(q_c - 1)(T_t - \overline{\theta}) + q_c(\overline{\theta} - N)
\end{aligned}$$

As with policy 1, the marginal cost of transitioning when not accounting for opportunity costs is βT_t, though the opportunity cost differs. Producers who transition forgo selling those goods as conventional goods once they begin the transition process, so the full marginal cost in the presence of transitional certification is

$$\begin{aligned}
MC_t &= \beta T_t + \sum_{n=0}^{l} \delta^n p_c \\
&= \beta T_t + \sum_{n=0}^{l} \delta^n q_c(\overline{\theta} - N) \\
&= \beta T_t + q_c(\overline{\theta} - N)(1 + \sum_{n=1}^{l} \delta^n)
\end{aligned}$$

Producers who begin the transition process in year t receive p_{to} in year t and p_o for every year thereafter through $t + l$. Thus, the marginal benefit of converting is

$$\begin{aligned}
MB_t &= p_{to,t} + \sum_{n=1}^{l} \delta^n p_{o,t+n} \\
&= \alpha(q_c - 1)(T_t - \overline{\theta}) + q_c(\overline{\theta} - N) \\
&+ \sum_{n=1}^{l} \delta^n \bigg((\overline{\theta} - Nq_c - (T_{t-1} + \alpha\tau_t)(1 - q_c) \bigg)
\end{aligned}$$

Prior to introduction of the certification and labeling policy in period one, production is in equilibrium, and the marginal cost and marginal benefit functions are equal to those presented under the no-labeling scenario (policy one). Once certification is introduced, the marginal cost and benefit functions are altered to those presented above. Here, producers have the same knowledge of future prices and the same net discounted benefit from conversion in each period. A producer who delays conversion in the first period foregoes earning the transitional premium in that period, which is valuable because it is not discounted, and the organic premium in the next period. I assume there are no further policy changes that would unexpectedly alter price, cost, and benefit functions. It follows, then, that conventional producers for whom the introduction of transitional certification has now made it beneficial to convert, will do so all at once. The level of organic conversion, thus, begins in a steady state and immediately moves to a new steady state when transitional certification and labeling is introduced in period one (i.e. the policy change causes the steady state to move from T_0 to T_1).

I find the steady-state level of conversion, T_{ss} by equating MC_1 and MB_1 and solving for T_1

$$\begin{aligned} T_1 = T_{ss} &= \frac{p_{to,1} - p_c + \sum_{n=1}^{l} \delta^n (p_{o,2} - p_c)}{\beta} \\ &= \frac{\overline{\theta}(\alpha + \sum_{n=1}^{l} \delta^n)(1 - q_c)}{\beta + (\alpha + \sum_{n=1}^{l} \delta^n)(1 - q_c)} \end{aligned}$$

The assumption that production is ex ante in equilibrium allows me to calibrate conversion costs and solve for β. This results in

$$\beta = \frac{\sum_{n=1}^{l} \delta^n (1 - q_c)(\overline{\theta} - (1 - S_c)N)}{(1 - S_c)N}$$

I plug this into the steady-state level of conversion, T_{ss}, to get

$$T_{ss} = \frac{\overline{\theta}N(1 - S_c)(\alpha + \sum_{n=1}^{l} \delta^n)}{\alpha N(1 - S_c) + \sum_{n=1}^{l} \delta^n \overline{\theta}}$$

Because the price of organic in a given year is a function of the number of acres who enter the transition process that year, the price of organic does not reach a steady state until period two. Thus, there are two different prices for organic goods beyond the ex-ante price. The first occurs in period one when organic and transitional goods coexist and compete against one another, and the second occurs in period two and beyond, when there are no longer transitional goods in the market.

$$\begin{aligned} p_{o,1} &= \overline{\theta} - Nq_c - (T_o + \alpha\tau_1)(1 - q_c) \\ p_{o,ss} = p_{o,2} &= \overline{\theta} - Nq_c - T_{ss}(1 - q_c) \end{aligned}$$

Proposition 6. *The introduction of transitional certification and labeling increases the* *numbers of acres converted to organic.*

$$\Delta T_{ss} = T_{ss}^{P2} - T_{ss}^{P1} = \frac{\overbrace{(1-S_c)}^{(+)}\alpha N \overbrace{(N - NS_c - \overline{\theta})}^{(-)}}{\underbrace{\alpha N(S_c - 1) - \sum_{n=1}^{l} \delta^n \overline{\theta}}_{(-)}}$$

$$> 0$$

Substituting $(1-(1+r)^{-l})/r$ for $\sum_{n=1}^{l} \delta^n$ allows this to be expressed directly in terms of the interest rate and lifespan of the organic operation.[2]

$$\Delta T_{ss} = \frac{\alpha N r(S_c - 1)(1+r)^l(\theta + N(S_c - 1))}{\theta + \alpha N r(S_c - 1)(1+r)^l - \theta(1+r)^l}$$

The steady-state level of T is greater under policy two than under policy one. The difference between the two is increasing in r and decreasing in l. Since the steady-state value of T under policy one is independent of r and l, it follows that the steady-state level of T under policy 2 is also increasing in r and decreasing in l. I simulate the percentage increase in acres converted to organic using many of the same values used to simulate price changes in the static model. Namely, I set $S_c = 99.35$ percent, $N = 0.9$, $\overline{\theta} = 1$, $l = 20$, simulate discount rates in intervals of 0.3 from 0.2 to 0.8, and simulate α in intervals of 0.1 from 0.1 to 0.9. The percentage increase in the number of acres converted to organic in the presence of transitional certification and labeling ranges from 0.67 to 9.11 percent depending on the discount rate and the substituability of transitional and organic products.

[2] $(1-(1+r)^{-l})/r$ is the present value of a constant annuity paid over l periods and is equal to $\sum_{n=1}^{l} \delta^n$.

Table 2: Percentage Change in Number of Acres Converted to Organic Under Policy 2

α	r=0.03	r=0.05	r=0.08
0.1	0.67%	0.80%	1.01%
0.2	1.34%	1.60%	2.02%
0.3	2.00%	2.39%	3.04%
0.4	2.67%	3.19%	4.05%
0.5	3.34%	3.99%	5.06%
0.6	4.01%	4.78%	6.07%
0.7	4.68%	5.58%	7.08%
0.8	5.34%	6.38%	8.10%
0.9	6.01%	7.18%	9.11%

Proposition 7. *The introduction of transitional certification and labeling decreases the price of organic in all periods relative to the no-certification scenario.*

In period one, $\tau_1 = \Delta T_{ss} > 0$, so transitional goods are present and compete with organic goods. The difference in the price of organic goods in period one under policy two relative to the steady-state price of organic under policy one is as follows and is negative.

$$p_{o,1}^{P2} - p_{o,ss}^{P1} = \alpha\tau_1 \underbrace{(q_c - 1)}_{\text{(-)}}$$
$$< 0$$

Beyond period one, there are no transitional goods on the market under each policy, but the number of organic goods is greater under policy two than under policy 1. Comparing the steady-state price of organic goods under each policy shows how increased organic production resulting from transitional certification and labeling affects the price of organic goods.

$$p_{o,ss}^{P2} - p_{o,ss}^{P1} = \tau_1 \underbrace{(q_c - 1)}_{\text{(-)}}$$
$$< 0$$

As in the static model, the price change is small as there are so few acres in transition at any given time. It ranges from -0.006% when $S_c = 99.35$ percent, $N = 0.9$, $\overline{\theta} = 1$, the discount rate is 0.8, $q_c = 0.1$, and $\alpha = .1$ to -.053% when alpha is increased to 0.9.[3]

Proposition 8. *Increased organic production reduces the price of organic more than the presence of transitional products.*

Under policy two, the steady-state price of organic goods is smaller than the price of organic goods in period one.

$$p_{o,ss}^{P2} - p_{o,1}^{P2} = \tau_1 \underbrace{(1-\alpha)}_{(+)} \underbrace{(q_c - 1)}_{\text{(-)}}$$
$$< 0$$

That is, competition with τ_1 acres of organic output reduces the price of organic more than competition with τ_1 acres of transitional output decrease the price of organic, which is intuitive because transitional products are of lower quality than organic.

In summary, I find that in exchange for small reductions in organic price premiums, the introduction of transitional certification and labeling generates transitional premiums that cause farmers to convert a greater number of acres than they would in absence of transitional certification policies.

[3] I chose a discount rate of 0.8 and set $q_c = .1$ as the magnitude of the price difference is increasing in the discount rate and decreasing in q_c. As such, these values create a sort of upper bound on the price decrease for each α.

0.5 Conclusion

While both the static and dynamic models show that transitional organic certification and labeling decrease the price of organic products, the magnitude of the effect in a given period is dependent on the share of transitional production in that period. Currently, the share of transitional cropland is negligible, fewer than one tenth of a percent. While transitional labeling will induce more acres to convert, as shown in the dynamic model, the number of acres converting in any given period is likely to remain relatively low compared to the number of organic acres. This is because acres can only be certified transitional for a finite period before being certified as organic. Consequently, the number of organic acres will continue to increase as more acres convert, while the number of transitional acres do not accumulate over time.

While the effects of transitional labeling on the price of organic are small, there is potential for transitional certification and labeling to have substantial impacts on the number of acres that convert to organic. By simulating a multitude of price and conversion outcomes, I show that premiums generated by transitional labeling result in a nearly ten percent increase number of acres of organic cropland, all the while decreasing prices of organic output by fewer than one percent.

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