Economics of By-Product Use in Dairy Feed Rations Including Resource Consequences

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RESEARCH QUESTIONS

1. What shares of almond, canola, and cotton industry revenues are from by-products sold to dairies? (Table 1)
2. To what extent does dairy demand for by-product feeds affect crop resource use? (Equation 1 & Table 2)
3. To what extent do by-product feeds reduce the footprint of dairy feed production? (Table 2)

Data

We collected price, production, and disappearance quantity data from government, industry, and academic sources. This poster uses dairy by-product feed use data supplied by a broad national sample of nutritionists and feed merchants, **representing 35.7% of U.S. milk production** (de Ondarza and Tricarico 2021). Data is representative of markets in 2019.

REVENUE FROM BY-PRODUCTS SOLD TO DAIRIES

By-product use is a source of revenue for crop industries and dairies feed a significant share of by-products. The resource use of dairy by-product feeds depends on the share of the crop industry revenue from by-products sold to dairies and supply and demand elasticities.

Almond hulls are 4.1% of almond industry revenue and dairies in the Central Valley of California use 96% of the almond hulls. **If local dairies use less, the almond industry faces further transportation costs to ship hulls out of state.**

The North America canola industry crush 53% of canola and export 47%. Canola meal is 20% of revenue from canola meal, oil, and canola exports. U.S. dairies use 55% of canola meal. Canola meal sold to U.S. dairies is 11% of canola revenue. **Transport costs are small relative to the price of meal**, so absent dairies, more will be exported and fed to other livestock. Cotton by-products are 13.6% of cotton revenue and **dairies use 39% of cottonseed, mainly in the South and West close to production**, and 30% is crushed.

Table 1. U.S. Dairy By-Product Feed Share of Listed Industry Revenue

Industry	By-product as a share of revenue	Dairy use share of by-product	Dairy use share of revenue
Almond	4.1%	96%	3.9%
Canola	20%	55%	11%
Cotton	Cottonseed=9.7%, meal=2.5%, hulls=1.4%	Cottonseed=39%, meal=20%, hulls=8%	4.4%

***Industry revenue is the sum of revenue from products (like canola oil and meal) and other crop uses (like canola exports). By-products fed to dairy cattle include almond hulls, canola meal, cottonseed, cottonseed meal, and hulls.**

DAIRY BY-PRODUCT DEMAND AND CROP SUPPLY

We show that the supply and demand elasticities are crucial to understanding the extent to which dairy demand for hulls affects almond resource use. Similar models apply to canola and cotton. Producers use resources in proportion to the quantity of almonds. The percentage change in the quantity of almonds relative to a percentage change in dairy demand for hulls is given by:

$$\frac{\%\,\Delta Q_{almonds}}{\%\Delta Dairy\ demand\ for\ hulls} = \frac{R_{hulls}\times S}{\theta} \quad (1)$$

$$where\ \theta = \left[\frac{R_{almonds}}{\eta_{almonds}} + \frac{R_{hulls}}{\eta_{hulls}} - \frac{1}{\varepsilon}\right]\times\eta_{hulls}$$

On the right-hand side is the almond hull share of revenue (R_{hulls}) times the dairy use share of hulls (S).

The expression θ captures the supply and demand elasticities. **We show the extent to which θ matters.**

The other parameters are the share of industry revenue from almonds ($R_{almonds}$), the price elasticity of supply of almonds (ε), and the price elasticity of demand for almonds ($\eta_{almonds}$). Lastly, the price elasticity of demand for hulls (η_{hulls}) is the share weighted sum of dairies and other users' elasticities of demand for hulls.

To illustrate that θ matters in relevant scenarios, consider the percentage change in the quantity of almonds produced in three years in response to a change in the expected price of hulls and almonds. In this case, ε will be very small, therefore θ will be large, and a change in almond resource use relative to a change in dairy demand will be negligible.

RESOURCE CONSEQUENCES OF DAIRY DEMAND FOR BY-PRODUCTS

Table 2. Estimated Effect of a 10% Reduction in the Quantity of Each Listed By-Product from an Exogenous Shift in U.S. Dairy Demand for the Listed By-Product

By-Product	Reduction in listed by-product dry matter tons fed to dairy cattle	Reduction in almonds, canola & cotton acres (% reduction in parenthesis)	Replacement feed example: Corn silage acres *
Almond hulls	170,000	3,000 (0.25%)	18,000
Canola meal	400,000	44,000 (0.19%)	48,000
Cottonseed, meal & hulls	230,000	29,000 (0.21%)	32,000

***Silage acres needed to replace dry matter from by-product holding milk constant. We are not claiming this is what farmers would do. Corn silage is high-yielding and low in protein relative to canola meal and cottonseed, so this is a lower bound.**

When dairies use fewer almond hulls, growers still produce almonds and find other uses for hulls. The same point applies to canola meal and cottonseed.

We model responses to relative prices over a ten-year horizon, simulate an exogenous shift back in the dairy demand for by-products and present the results in Table 2.

California dairies use 1.7 million tons of almond hull dry matter. When dairies use 10% fewer hulls, the price of hulls decreases and other users buy more. We estimate that almond growers respond to the change in relative prices by growing 3,000 fewer acres of almonds, equivalent to a 0.25% reduction in almond acres. Other almond resources, like irrigation water, will decrease by 0.25%. The dairy demand effects on resource use (-0.25%) is smaller than the revenue from 170 thousand tons of hulls (0.39%).

U.S. dairies use about 4 million tons of canola meal dry matter. When dairies use fewer tons of meal, the price of meal decreases, other users feed more and more canola and canola meal are exported. Furthermore, canola is an integral part of crop rotations in Prairie provinces, and growers do not change acreage much in response to a relative price change (supply is inelastic). Therefore, canola producers respond to the change in relative prices by growing 44,000 fewer acres (0.19% reduction in North America canola acres).

Dairies feed 2.3 million tons of dry matter from cottonseed plus cottonseed meal plus cottonseed hulls. When dairies use less, the prices of cotton by-products decrease, and other users buy more. Furthermore, cotton supply is inelastic, reflecting difficulties in adjusting cotton acres in response to a price change. Therefore, cotton producers respond to the change in relative prices by growing 29,000 fewer acres of cotton (0.21% reduction in cotton area).

Feeding almond hulls, canola meal, and cotton by-products reduce the resource footprint of milk production. We focus on land, but similar arguments apply to other resources.

A reduction in dairy by-product demand, keeping milk production constant, could occur if dairies faced mandates on ingredient mixes. To meet cattle nutritional needs, dairies would use other feeds. We use one example where dairies use more corn silage.

In the case of **almond hulls**, we estimate Central Valley dairies would use 18 thousand additional acres of corn silage to replace the dry matter from hulls. Corn silage is grown close to dairies because of high transportation costs. Therefore, dairy's share of local silage revenue is 100%, and dairies use all the resources in silage production.

The implication of almond hull use is reduced resource use per pound of milk.

Feeding **canola meal** also saves some land if dairies feed more corn silage. In practice, some of the nutrition in canola meal would be replaced with legume crops (like alfalfa hay) that produce less dry matter per acre. Therefore, more additional acres of non-by-product feeds would be used compared to silage alone. Similar points apply to cotton by-products.

Alfalfa hay is relatively cheap to transport and has a national market. All alfalfa revenue is from hay, and dairy is a large share of alfalfa hay use. Therefore, dairy's share of alfalfa revenue is high. When dairies increase their demand for alfalfa, growers plant more alfalfa, and other users might use slightly less. Therefore, the percentage change in resources used in alfalfa production divided by the percentage change in dairy demand for alfalfa is high.

de Ondarza, M.B., and J.M. Tricarico. 2021a. "Nutritional contributions and non-CO2 greenhouse gas emissions from human-inedible by-product feeds consumed by dairy cows in the United States." *Journal of Cleaner Production.* 315, 128125. doi.org/10.1016/j.jclepro.2021.128125