**Dynamics of Productivity Growth and Markups in the U.S. Dairy Manufacturing Industry**

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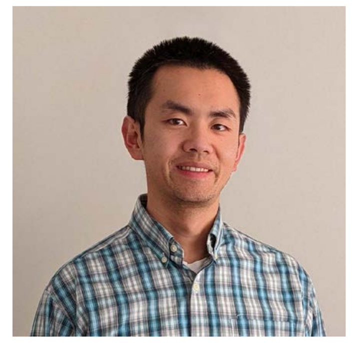

X. Dong

L. Seoane

## Overview

The U.S. dairy manufacturing industry has undergone a major restructuring. Consolidation in fluid milk processing continues at a dramatic pace (**Figure 1**).

As milk processing accounts for most of the cost of dairy manufacturing, the performance of dairy manufacturing is of paramount importance to dairy farmers and consumers alike.

This poster updates productivity growth measures in the dairy manufacturing industries while accounting for Hicks-neutral as well as labor-augmenting technical change.

## Objectives

The main objective is to measure productivity growth in the dairy manufacturing industries while accounting for Hicks-neutral as well as labor-augmenting technical change. Additionally, we estimate markups without a particular specification of technology and demand base, adjusting for economies of scale.

## Methods

To model productivity, we follow Doraszelki and Jaumandreu (2019) by specifying a translog production function that is separable in capital and homogeneous of degree $\nu$ in the variable inputs labor and materials.

We allow for Hicks-neutral productivity $\omega_{Hjt}$ and labor-augmenting productivity $\omega_{Ljt}$ .

$$q_{jt} = \alpha_0 + \alpha_K k_{jt} + \frac{1}{2}\alpha_{KK}k_{jt}^2 + \alpha_L(\omega_{Ljt} + l_{jt}) + \alpha_M m_{jt} - \frac{1}{2}\alpha(mjt - \omega Ljt - ljt)^2 + \omega_{Hjt} + \varepsilon_{jt.} \quad (1)$$

The dependent variable $q$, is the log of output, $k, l$ and $m$ are the logs of capital, labor, and materials, respectively.

From the previous equation (1), we estimate the elasticities of inputs with respect to labor $\beta_L$ and materials $\beta_{M,}$ , and obtain the short-run economies of scale $\nu$ by summing them up.

Using the first order conditions for cost minimization, we substitute for labor-augmenting productivity. At the same time, we control for Hicksian-productivity by assuming that it follows a linear inhomogeneous Markov process, and by pseudo-differentiating the equation, we estimate the resulting specification using nonlinear GMM; and recover estimates $\hat{\omega}_L$and $\hat{\omega}_H$for every industry and year as well as the input elasticities and economies of scale $\nu$.

We then apply Doraszelki and Jaumandreu's (2019) method by starting with the expression for the ratio revenue over variable cost, or price-average variable cost ratio, in terms of the markup. We compute the log of the short-run markup as follows:

$$\ln \hat{\mu}_{jt} = \ln \frac{R_{jt}}{VC_{jt}} + \ln \hat{v}_{jt} + \varepsilon_{jt.} \quad (2)$$

where $R_{jt}$ is observed revenue, $VC_{jt}$ is variable cost, $v_{jt}$ is the short-run elasticity of scale or ratio average variable cost to marginal cost obtained from estimating (1), and $\varepsilon_{jt}$ an error uncorrelated across time and industries for using actual rather than planned output and, therefore, we expect the averages to cancel across industries and time, and, hence, we expect our means to be accurate.

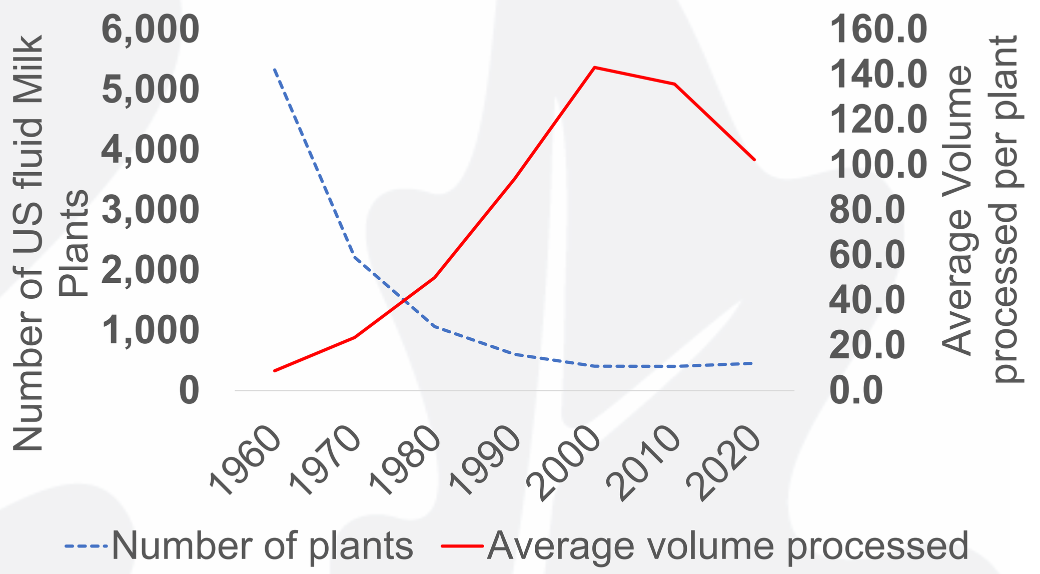


**Figure 1: Number and average size of U.S. fluid milk product plants**

## Data & Estimations

We estimate productivity and markups using the latest update of the NBER-CES Manufacturing Industry Dataset (2021).

The industries of interest are fluid milk manufacturing (NAICS=311511), cheese manufacturing (311513), dry, condensed, and evaporated dairy products (311514), and ice cream and frozen desserts (311520).

We collect annual data for 1958-2018 on sales, employment, payroll, cost of materials, and real fixed capital assets. Using industry-specific price indexes, we deflate the dollar values to obtain quantity indexes for outputs and inputs. Since we omit 1958 due to lags, we utilize 240 observations for estimation (60x4).

**Table 1: Translog Production Function with Labor-augmenting and Hicksian Productivity 1958-2018**

| Production function params. (Std. dev.) | | | | |
|---|---|---|---|---|
| time | $\beta_K$ | $\nu$ | α | ρ |
| 0.001<br>(0.000) | 0.010<br>(0.061) | 0.981<br>(0.022) | 0.044<br>(0.024) | 0.962<br>(0.020) |

| Dispersion and growth of productivity (Std. dev.) | | | |
|---|---|---|---|
| Output effect $\beta_L$ ωL | | $\omega_H$ | |
| Cross-s. std. dev. | Mean growth | Cross-s. std. dev. | Mean growth |
| 0.191 | 0.028<br>(0.218 ) | 0.217 | 0.002<br>(0.049) |

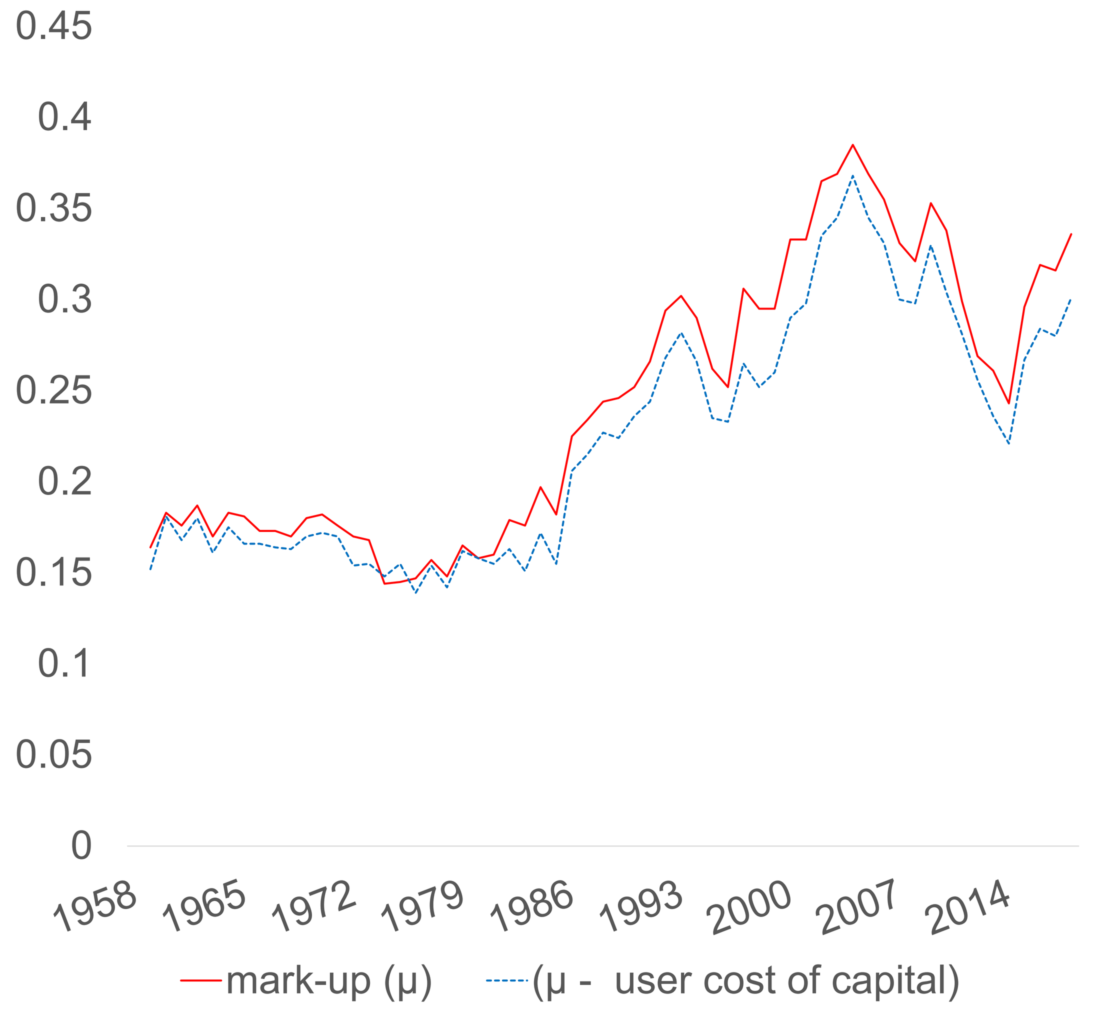


**Figure 2: Evolution Mark-up 1959-2018c**

## Results

### Productivity (Table 1)

- The estimated short-run elasticity of scale $\nu$ (labor + materials) is 0.981, while the elasticity of capital is 0.010 (noisy); the sums of both elasticities imply constant returns to scale.
- The mean of total growth productivity is 3% over the years.
- Increase in productivity is due mainly to labor augmenting productivity (2.8%), while Hicksian productivity growth has been slow (0.2%).

### Mark-ups (Figure 2)

- The short-run elasticity of scale indicates that the marginal cost exceeds the average variable cost by around 2% (ln0.981 ≃ -0.0161) and does not have a significant impact in the reduction of the value of the ln(R/VC).
- The mean mark-up (μ) for the whole period is around 22%. This markup has been adjusted by the cost of capital (-1.8%).
- Mark-ups are stable from 1959 to 1985. From this point onwards, mark-ups increased significantly, reaching a maximum of 36% (2004), after which they decrease and stabilize at around 30% in the later period.
- We are likely missing significant parts of the variable costs centralized in non-manufacturing establishments, such as logistics and maintenance. Accounting for these, ln(R/VC) will decrease by around 15 points, yielding a final mark-up of around 8%, which seems to be a reasonable value.

## Conclusions

- The estimated production function shows a significant increase in productivity driven by labor augmenting productivity. Our estimates of short-run elasticity of scale and capital make it plausible to think about increasing returns to scale in the long run. These increasing returns to scale are likely the driver of the concentration observed in the milk manufacturing industry.
- Mark-ups increased from 1985 to 2005 and at around 30% thereafter. These higher mark-ups could be due to missing information in the accounting data linked to the transference of some services to non-manufacturing establishments, that also produced the apparent rises in markups from 1985-1990.

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