Expansion of plant-based milk and substitutability between cow's milk and plant-based milk

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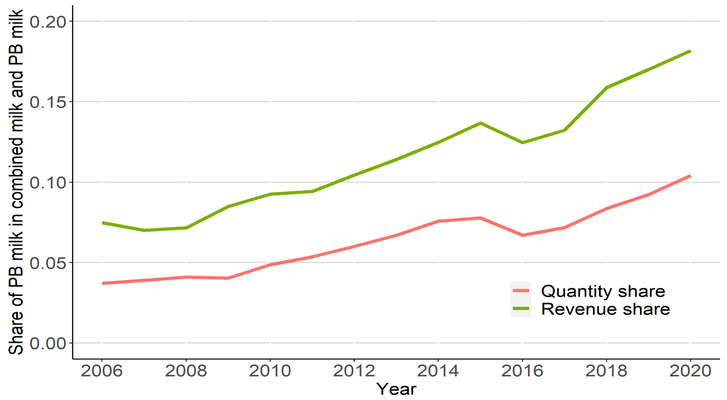
Background

- Plant-based milk has been on the rise for more than a decade. Plant-based milk substitutes accounted for 3.1% of the quantity of combined cow's milk and non-dairy substitutes in 2006 and reached 10.5% in 2020, a 300% expansion.
- In contrast, U.S. cow's milk consumption has declined for many decades, and the rate of decline has accelerated in recent years. According to USDA Estimated Fluid Milk Sales, the average annual rate of decline was 0.2% from 2000 to 2010, while it was 1.6% from 2010 to 2020.
- As more plant-based alternatives become widely available in grocery stores and restaurants, it is important to understand the substitution pattern between animal-based products and plant-based alternatives and measure the impact of the new products on the animal-based products.

Objective

- Estimate the substitutability patterns between liquid retail cow's milk products and plant-based milk products.
- Quantify the effect of expansion of plant-based milk on cow's milk price and quantity



Data

- Combination of two data sets: Nielsen Homescan Consumer Panel (HMS) and Retail Measurement Services (RMS)
- Nielsen's HMS contains nationally representative consumers and records their grocery purchases of 60,000 households
- Nielsen's RMS contains weekly quantities and sales of unique items
- Nielsens' RMS is used to recover information of products not chosen in each panelist's shopping trip.

Demand model: Random coefficient logit model

$$U_{ijt} = -(\bar{\alpha} + \sigma_\alpha u_i^p)P_{jt} + \sum_{k=1}^{K} X_{jt}^k(\overline{\beta_k} + Z_i'\gamma_k + \sigma_k u_i^k) + \lambda\widehat{v_{jt}} + \xi_{ib(j)} + \epsilon_{ijt}$$

- Index consumer by i, product by j, and choice occasion by t
- P_{jt}: price of product j at time t
- X_{jt}: product attribute (plant-based dummy, organic, fat, pack size, lactose-free)
- Z_i: consumer characteristics (age, income, education, household size)
- $\xi_{ib(j)}$: brand-specific dummies
- $\widehat{v_{jt}}$: residual from first stage regression of price on instrument and other product characteristics

Table 1: Demand Estimation – Main attributes

Variable	Moment	Estimate	Standard Error
Price	Mean	0.701	0.011
	SD	0.282	0.004
Fat content	Mean	0.518	0.032
	SD	0.749	0.009
Organic	Mean	-3.888	0.227
	SD	2.810	0.059

Table 2: Demand Estimation – Demographic interaction

Variable	Mid-income	High-income	Mid-age	Old-age	Household size	College
Plant-based	0.010 (0.056)	0.140 (0.056)	-0.349 (0.068)	-0.470 (0.073)		-0.416 (0.068)
Fat content	0.035 (0.018)	0.145 (0.022)	-0.010 (0.025)	-0.081 (0.024)		-0.390 (0.025)
Organic	1.043 (0.116)	1.211 (0.112)	0.082 (0.094)	-0.703 (0.105)		1.665 (0.184)
Quarter gal					-0.419 (0.030)	
Half gal					-0.391 (0.014)	

Table 3: Substitution patterns among cow's and plant-based milk

Variable	Effect of 1 percent increase on:				
		Cross demand for:			
	Own demand	Cow conven	Cow organic	Cow LC-free	Plant-based
Cow conventional	-0.686		1.206	1.599	1.406
Cow organic	-2.452	0.241		0.303	0.519
Cow lactose-free	-3.152	0.393	0.362		0.454

Conclusion

- Plant-based milk alternatives are more substitutable to organic cow milk and lactose-free cow's milk than to conventional cow's milk
- Higher-income and younger households tend to prefer plant-based product, which is similar pattern for the organic attribute.