Supply Response within the Dairy Cow Life Cycle:

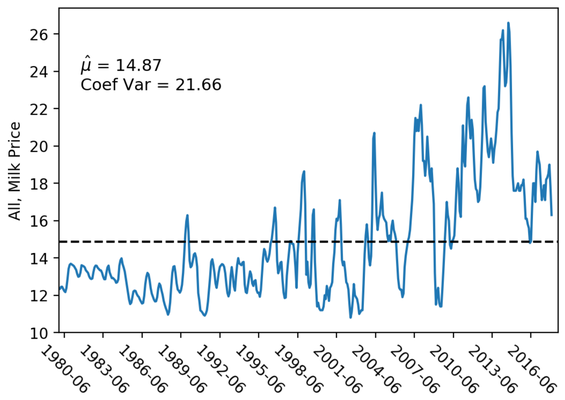
Estimation of Supply Elasticities in DHIA Data

Jared Hutchins and Brent Hueth

Agricultural and Applied Economics, University of Wisconsin – Madison

Introduction

The volatility of milk prices has prompted a discussion on dairy farm supply response: how much do dairy farmers respond to changes in the milk price?



- Literature shows that *extensive* elasticity is bigger than *intensive* elasticity (Chavas and Klemme, 1986; Bozic et al., 2012; Miller, 2015).
- However, aggregate data cannot pick up within lacation changes to milk production.

Data

- Monthly data on individual dairy cows, including age, production, milk quality, and production stage.
- Merged with state level prices for milk, dairy ration, slaughter, and replacement cows.
- Around 2,700 different farms in Wisconsin DHI herds and 1 million different cows from June 2011 to January 2015.
- Total cow-month obs: 11 million

Objectives

Research Question:
Is supply response heterogeneous across the dairy production cycle?

- Incorporation of the biological process into a price response model.
- Isolation of the intensive margin response from the extensive margin response.

Hypotheses

Response to Prices:

Price	Sign	When
Milk Price	+	$d_{it} < 120$
		$\ell_{it} > 1$
Feed Price	-	$d_{it} < 120$
		$\ell_{it} > 1$
Slaughter Price	+/-	$d_{it} > 120$,
		$\ell_{it} > 1$

Results

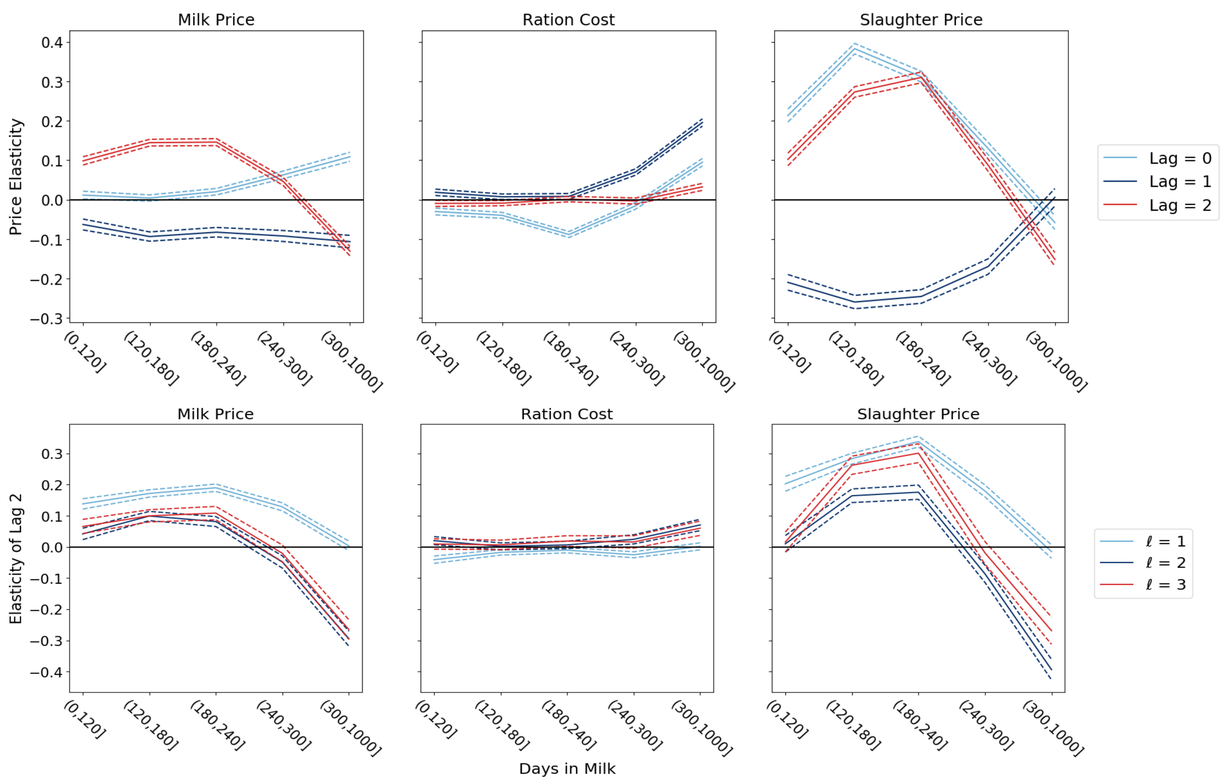


Figure 1: Standard errors clustered at the cow-herd level.
Covariates: calving month, month of the year, milked 3x, time trend.

Empirical Model

The modified Wood (1980) lactation curve is:

$$y_{it} = a d_{it}^{b} e^{c d_{it}} e^{\gamma X_{it} + \epsilon_{it}}$$

$$\ln(y_{it}) = \ln(a) + b \ln(d_{it}) + c d_{it} + \gamma X_{it} + \epsilon_{it}$$

where y_{it} is observed output, d_{it} is days in milk, ℓ_{it} is lactation number, and X_{it} is some vector of environmental characteristics.

Production stage $s_{it} = (d_{it}, \ell_{it})$ interacted with prices, dynamic panel model following Arellano and Bond (1991):

$$\Delta \ln(y_{it}) = \alpha + \Delta \ln f(s_{it}|\theta) + \gamma \Delta X_{it} + \rho \Delta \ln(y_{i,t-1}) + \sum_{j=1}^{S} \sum_{m=0}^{L} \eta_{jm} \Delta \ln(P_{t-m}) \times \mathbb{1}\{s_{it} = s_j\} + \Delta \epsilon_{it}$$

- y_{it}: Milk production (ECM) of cow i at time t.
- f: modified Wood curve
  $\ln f(s_{it}|\theta) = a_1 \ell_{it} + b_0 \ln d_{it} + c_0 d_{it} + b_1 \ln d_{it} \times \ell_{it} + c_1 d_{it} \times \ell_{it}$
- P_{t-m}: Price vector at lag m.
- X_{it}: Time variant cow covariates.
- $\Delta y_{i,t-1}$ instrumented with $y_{i,t-2}$

Conclusions

- Supply response is heterogeneous across production stage, most of the time consistent with dairy science predictions.
- Milk supply response is stronger to milk prices two months out than current milk prices.
- Feed prices have almost no effect, slaughter price has relatively large effect.
- Behavioral model of price response not immediately clear (future research).

References

Bozic, M., C. A. Kanter, and B. W. Gould (2012). Tracing the Evolution of the Aggregate U.S. Milk Supply Elasticity Using a Herd Dynamics Model. *Agricultural Economics 43* (5), 515–530.
Chavas, J.-P. and R. M. Klemme (1986). Aggregate Milk Supply Response and Investment Behavior on U.S. Dairy Farms. *American Journal of Agricultural Economics 68* (1), 55–66.
Miller, M. (2015). *Regional Differences in Dairy Supply Response to Price and Policy.* Ph.D., The University of Texas at Dallas, United States – Texas.
Wood, P. D. P. (1980). Breed Variations in the Shape of the Lactation Curve of Cattle and Their Implications for Efficiency. *Animal Science 31* (2), 133–141.

Contact Info
Jared Hutchins: jhutchins@wisc.edu
Brent Hueth: hueth@wisc.edu