Efficiency and Regulation: The Case of Ontario and New York Dairy Farms

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July 1, 2011

Motivation

- Ongoing public and academic debate regarding supply management
- See Goldfarb (2009); Robson and Busby (2010); Barichello, Cranfield and Meilke (2009)

Dairy Farm Policy

- Canada
    - Pricing formula
    - Quantity restrictions
    - Import restrictions

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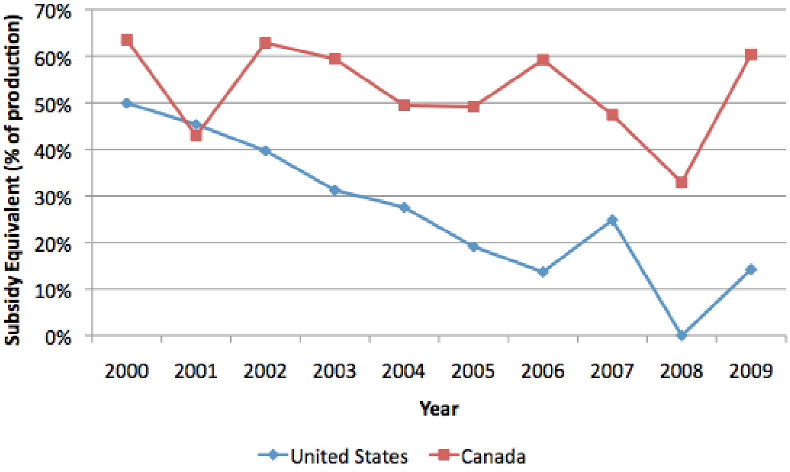
- Canada
  - Pricing formula
  - Quantity restrictions
  - Import restrictions
- United States
  - Marketing orders
  - Price support
  - Countercyclical subsidy
  - Import Restrictions

Producer subsidy equivalents

Figure: Producer Subsidy Equivalent for Canadian and US Dairy



Theoretical Implications

- Production decisions based on "rules of thumb", changed only when shown to be sub-optimal (Winter, 1971)

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- Natural selection through competition

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  - Calculate technical efficiency using a nonparametric stochastic frontier model

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  - Calculate technical efficiency using a nonparametric stochastic frontier model
- Other studies include: Weersink et al (1990), Tauer (1993 and 1996), Hailu et al (2005) and Mosheim and Lovell (2009)

Data

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- Sources

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- Sources
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- Variables
  - Output: milk, crops & livestock
  - Input: feed, labour, capital & other

Descriptive statistics

	New York	Ontario
Mean dairy cows per farm	106	67
Mean output per cow (liters)	8,635	8,096
Mean milk price ($CAD)	0.46	0.69
Mean crop revenue ($CAD)	10,024	25,306
Livestock revenue per cow ($CAD)	276	108
Mean purchased feed per cow ($CAD)	1,239	779
Mean labour quantity index per cow	84.89	87.56
Mean physical assets ($CAD)	988,145	1,366,125
Mean physical assets per cow ($CAD)	9,303	20,259
Mean other quantity index per cow	771	1181

Empirical Strategy

- Data envelopment analysis (3 models)

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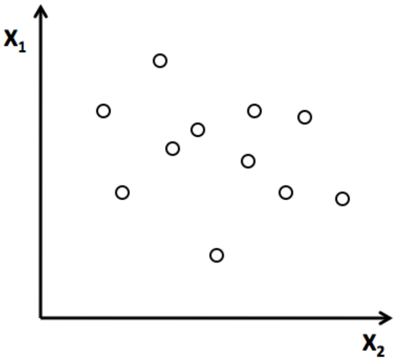
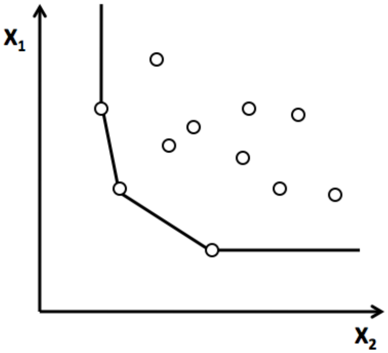
- Econometric estimation of the distance function

Data Envelopment Analysis



Data Envelopment Analysis



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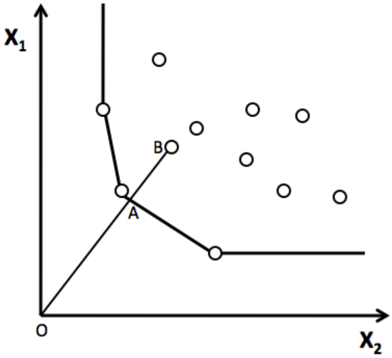
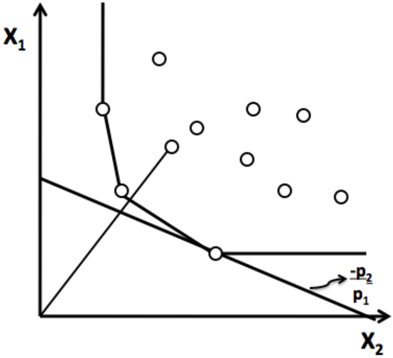


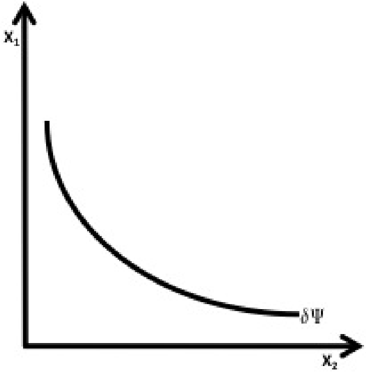
- Technical efficiency $= \frac{OA}{OB}$

Data Envelopment Analysis



- Cost efficiency $= \frac{OC}{OB}$
- Allocative efficiency = (Cost efficiency) / (Technical efficiency)

Bootstrapping



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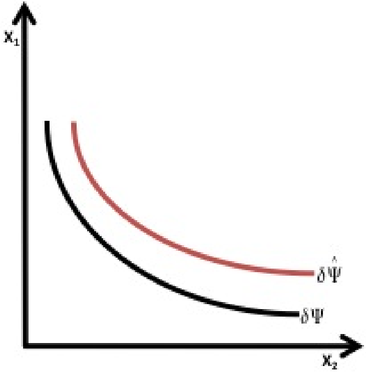

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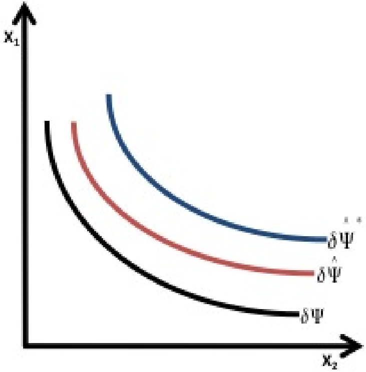

$$\left(\hat{\theta}^*(x,y) - \hat{\theta}(x,y)\right)|\hat{\rho}(\chi_n) \approx \left(\hat{\theta}(x,y) - \theta(x,y)\right)|\rho. \qquad (1)$$

Econometric Estimation

$$\ln \delta_{it} = C + \sum_{j=1}^{J} \alpha_j \ln y_{itj} + \sum_{k=1}^{K} \beta_k \ln x_{itk} + \sum_{t=1}^{T} \gamma_t \ln td_{it} + u_{it} \quad (2)$$

$$-\ln x_{it1} = C + \sum_{j=1}^{J} \alpha_j \ln y_{itj} + \sum_{k=2}^{K} \beta_k \ln(x_{itk}/x_{it1}) + \sum_{t=1}^{T} \gamma_t \ln td_{it} + e_{it} \quad (3)$$

where:

$$e_{it} = u_{it} - \ln \delta_{it} \quad (4)$$

- Duality is used to derive the cost function and cost efficiency scores analytically

DEA results

Table: Weighted Average Efficiency Scores from Separated Model (Non-corrected scores in parenthesis)

	Technical Eff	Allocative Eff	Cost Eff
New York	0.769 (0.885)	0.917 (0.912)	0.704 (0.809)
Ontario	0.732 (0.832)***	0.751 (0.736)***	0.549 (0.609)***
Overall	0.757 (0.868)	0.863 (0.855)	0.654 (0.744)

Non-corrected scores are in parenthesis.
*, **, **** represent significant differences between regions at the .1, .05 and .01 levels.

Econometric Results

Table: Results From ML Estimation

	Coefficient	Standard Error
Milk	-0.7835	0.0111***
Livestock	-0.0296	0.0069***
Crop	-0.0049	0.0014***
Labour	0.2659	0.0142***
Capital	0.1731	0.0119***
Other	0.2412	0.0127***
σ^2	0.0698	0.0236***
γ	0.5464	0.1812***

Econometric Results (ctd.)

Table: Weighted Average Efficiency Scores from Parametric Estimation

	Technical Eff	Allocative Eff	Cost Eff
New York	0.927	0.847	0.785
Ontario	0.933**	0.734***	0.684***
Total	0.929	0.810	0.753

*, **, **** represent significant differences between regions at the .1, .05 and .01 levels.

Triangulation

Table: Correlation and Rank Correlation of DEA and Econometric Efficiency Scores

	Correlation	Rank Correlation
Technical	0.67	0.70
Allocative	0.37	0.30
Cost	0.31	0.26

Input usage

Table: Change in Input Usage Necessary to Achieve Cost Efficiency

	Feed	Labour	Capital	Other
New York	-21.4%	-18.2%	-29.7%	-14.6%
Ontario	64.2%	-26.6%	-61.4%	-39.9%

Explaining efficiency

	Technical Efficiency		Allocative Efficiency	
	Estimate	Standard error	Estimate	Standard error
Ontario	-4.28e-02	6.32e-03***	-2.61e-01	1.78e-02***
# of cows	-9.34e-06	6.00e-05	2.34e-04	1.59e-04
Age	-1.86e-03	2.59e-04***	-1.28e-03	5.99e-04**
Education	9.24e-03	6.17e-03	1.31e-02	1.35e-02
Tie-stall	-1.45e-02	1.36e-02	3.95e-02	3.37e-02
Pipeline	-1.88e-02	1.64e-02	-9.05e-02	4.20e-02**
Parlour	-1.40e-02	1.59e-02	-4.16e-02	3.94e-02
bST	3.52e-08	6.60e-07	1.67e-05	3.27e-06***

Does scale matter?

- Number of cows not significant
- Scale efficiency
  - Ontario - 91.6%
  - New York - 92.7%
  - Overall - 92.1%

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- Ontario farms are overcapitalized, relying too heavily on homegrown feed
- Both empirical techniques have the same broad findings across regions, through the correlation between them is very low
- Scale is not a major differentiator

Thank you

Data Envelopment Analysis

- Define the production possibilities set

$$\hat{\Psi} = (x, y) \,\epsilon\, R^{N+M} \tag{5}$$

where

$$\begin{aligned} y &\leq \sum_{i=1}^{n} \lambda_i y_i \\ x &\geq \sum_{i=1}^{n} \lambda_i x_i \\ \lambda_i &\geq 0 \text{ for } i = 1, 2 \ldots n. \\ \sum \lambda_i &= 1 \end{aligned}$$

Data Envelopment Analysis (ctd)

- Measure technical efficiency

$$\hat{\theta}(x, y) = \inf\{\theta | (\theta x, y) \ \epsilon \ \hat{\Psi}\}. \tag{6}$$

- Measure cost efficiency

$$\text{Cost } \widehat{\text{Efficiency}}_i = \frac{C_i^*}{C_i}. \tag{7}$$

where

$$C_i^*(y_i, w_i) = \min\{w_i x \,|\, x \ \epsilon \ \hat{\Psi}\}. \tag{8}$$

Econometric estimation

- Econometric estimation of the distance function

$$D_i(X, Y) = max\{\delta_i : (X/\delta_i, y)\epsilon\Psi\} \tag{9}$$

$$\theta_i = 1/\delta_i \tag{10}$$

Concept of efficiency

- Technical efficiency

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- Technical efficiency
- Cost efficiency

Concept of efficiency

- Technical efficiency
- Cost efficiency
- Allocative efficiency = CE / TE