Determining the Competitive Edge:
Diversified Dairy Production Systems in the United States and the European Union

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Purpose and Methodology

- Investigate structural change in the U.S. and EU dairy industries and the level of pasture versus conventional production, comparing basic technical and financial trends
- Investigate structural change in the U.S. dairy industry and the impacts of pasture technology and size on:
  - Scale economies
  - Technical efficiency using an input distance function and stochastic production frontier estimation
- Use a binomial logit model to forecast pasture technology

U.S. and EU Dairy Sector Production Trends

- In the United States, the cost advantages of a larger farm allow larger dairies to be relatively more profitable:
  - Most small farms are unable to earn enough to replace capital
  - Further farm consolidation is inevitable if current trends continue
  - Pasture-based operations usually involve less milk per cow
  - Based on U.S. and EU policies, promotion of pasture-based and organic dairies is important
- The EU plans on eliminating the dairy quota by 2015 to emphasize efficiency
  - Common Agricultural Policy (CAP) reform includes some form of payment to smaller producers in the higher cost areas of the EU

Changing structure of dairy farms in selected EU-27 countries and the United States

Country	Number of operations		Percent change	Cows per farm		Milk per cow (kilograms)		Percent change
	2000	2007		2000	2007	2000	2007	
United States	105,170	75,140	**-29.0**	88	121	8,257	9,193	**11.3**
Denmark	9,767	4,940	**-45.9**	68	107	6,930	8,919	**14.5**
Germany	136,000	101,000	**-25.7**	35	41	6,122	6,944	**13.4**
France	116,647	97,368	**-29.0**	36	38	5,623	6,381	**13.5**
Ireland	29,425	23,511	**-20.0**	40	45	4,289	4,846	**13.0**
Italy	97,000	48,487	**-50.0**	35	41	4,894	5,998	**22.6**
The Netherlands	34,354	23,677	**-31.0**	48	62	7,417	7,879	**6.2**
United Kingdom	25,944	15,385	**-40.7**	90	130	6,155	7,175	**16.6**

Source: Agricultural Statistics Selected Issues, and Eurostat

Some U.S. and EU Dairy Facts

- The EU is the world's largest milk producer with 27 percent of total production, followed by India at 20 percent and the United States at 16 percent
- In France, low mobility of dairy quotas and high quality soils have led to very nonspecialized dairy production; France produces close to 13 percent of the EU's milk supply
- Restructuring of the Danish dairy sector has caused the most significant change: herd size has doubled over the last ten years and Denmark produces 3 percent of the EU's milk supply
- English dairy farms are developing within the context of liberal agricultural policy (allowing a geographic mobility of quotas); the UK produces 10 percent of the EU's milk supply

Analysis: Conventional versus Pasture-based Dairy Production Systems

Modeling approach:

- A binomial logit model is used to systematically categorize farms into conventional and pasture-based groups
- The dependent variable includes two categories describing the extent of pasture use based on percentage of the dairy herds' forage needs derived from pasture: conventional (less than 25 percent) and pasture-based (25 percent or more)
- Independent variables include production regions, number of dairy cows, age of operator, stocking rate (pasture acres per cow), labor and machinery costs per dairy cow, percent of expenditures on feed, and percent of harvested acres in alfalfa, other hay, and silage

Source: Gillespie, J.M., R.F. Nehring, C. Hallahan, and C.L. Sandretto. "Dairy Resource Management: A Focus on Conventional and Pasture-Based Systems," selected paper at the Northeastern Agricultural and Resource Economics Association Annual Meetings, Rehoboth Beach, Delaware, June 10-12, 2007.

USDA's ARMS Data

- 1999-2008 Agricultural Resource Management Surveys (ARMS)
  - 11,909 observations for 24 States;
  - Multi-frame, probability based sample
- 24 States across seven regions: Appalachia, Corn Belt, Lake States, Northeast, Mountain States, Pacific, and Southern Plains.
- Probabilities for pasture and conventional technologies estimated from the ARMS 2005 Cost of Production survey and mapped to Phase III Household version observations for 1999-2008

Source: 1999-2008 ARMS data.

EU Micro Datasets

- Observations on dairy operations for 1999-2007
- Outputs--dairy, other livestock, and crops off-farm income
- Inputs– labor, fertilizer, pesticides, capital, miscellaneous, and land
- Information on household returns, stocking intensity, milk yields, and rental rates
- 12,180 observations for France
- 5,973 observations for the United Kingdom
- 3,744 observations for Denmark

Source: Eurostat.

Technical Efficiency Estimation

- Input distance function
  - $D^I(X,Y,R) = Max\ \{\rho: (x/\rho)\ \epsilon\ L(Y,R)\}$
    - X = input vector: labor (adjusted to reflect labor cost of working off-farm), miscellaneous (feed, fertilizer, etc.), capital, and land
    - Y = output vector: crops/livestock (value of production) and off-farm income (earned income from wages and salaries, rental, etc.)
    - R = external production determinants
  - Identifies the least input use possible for producing given output vector $L(Y,R)$
  - Parametric procedures.

***Source:** Morrison-Paul, Catherine, Richard Nehring, David Banker and Agapi Somwaru. "Are Traditional Farms History?"* **Journal of Productivity Analysis** *22 (2004): pp. 185-205.*

Input Distance and Technology Results

- Input distance function: marginal outputs and inputs with correct signs and generally significant
- Binomial Logit Model
  - Correctly predicted 76.6 percent of the time the allocation of dairy farms into the conventional and pasture-based categories
    - Percent of forage needs from pasture during grazing season:
      - Conventional (less than 25 percent)
      - Pasture-based (25 percent or more)
  - Independent variables significant (at the 10 percent level or better):
    - Region
    - Stocking rate (pasture acres per cow)
    - Labor per cow
    - Machinery per cow
    - Share alfalfa acres/harvested acres
    - Share silage acres/harvested acres

U.S. Cost and Production Statistics for Conventional and Pasture-based Dairy Farms, 24 States, 2000

Item	Pasture-based		Conventional		
	Stock (>=1.5) Pasture acres/cow	Stock (<1.5) Pasture acres/cow	<=500 cows	>500 cows Non-West States	>500 cows West
Number of farms	242	669	322	44	92
Percent of farms	21.0	50.4	24.7	1.1	2.8
Value of production (%)	11.0	38.5	24.7	6.1	19.7
Dairy cows per farm	101^{BCDE}	160^{ADE}	157^{ADE}	864^{ABCE}	1,436^{ABCD}
Net return on household assets (%)	7.4^{C}	7.9^{C}	12.1^{AB}	10.0	8.6
Total variable costs/cow ($)	1,559^{BCE}	1,268^{AC}	1,505^{BDE}	1,346^{ACE}	1,122^{ACD}
Price of land per acre ($)	1,087^{BCDE}	1,886^{ADE}	1,894^{ADE}	1,393^{ABCE}	7,109^{ABCD}
Efficiency score	0.897	0.897	0.893	0.898	0.897
Returns to scale	0.409^{CDE}	0.424^{CDE}	0.477^{ABDE}	0.552^{ABC}	0.553^{ABC}
Off-farm/total income (%)	8.3^{BDE}	4.4^{ACDE}	7.5^{BDE}	1.5^{ABC}	1.3^{ABC}
Dairy output/total output (%)	74	87	74	93	98

Notes: Significance at the 10 percent level (t=1.645) or higher where A represents at least 25 percent of forage needs met from pasture during the grazing season and stock >=1.5; B represents at least 25 percent of forage needs met from pasture during the grazing season and stock <1.5; C represents conventional dairies with 500 cows or less; D represents conventional dairies with more than 500 cows not in the West; and E represents conventional dairies with more than 500 cows in the West. The t-statistics are based on 1,369 observations using weighting techniques constructed in Dubman's CV15 model.

Source: 2000 ARMS Cost of Production and Cost and Returns Report data for observations with more than 40 cows.

U.S. Cost and Production Statistics for Conventional and Pasture-based Dairy Farms, 24 States, 2005 (1999 dollars)

Item	Pasture-based		Conventional		
	Stock (>=1.5) Pasture acres/cow	Stock (<1.5) Pasture acres/cow	<=500 cows	>500 cows Non-West States	>500 cows West
Number of farms	460	1,414	648	212	165
Percent of farms	17.0	59.4	19.6	1.8	2.1
Value of production (%)	5.9	33.5	15.7	12.9	32.0
Dairy cows per farm	97^{BCDE}	138^{ACDE}	174^{ABCDE}	1,302^{ABC}	2,741^{ABC}
Net return on household assets (%)	3.8^{BCDE}	6.5^{ADE}	6.0^{ADE}	11.4^{ABC}	10.2^{ABC}
Total variable costs/cow ($)	799^{D}	793^{D}	745	691^{AB}	743
Price of land per acre ($)	2,246^{BCE}	2,918^{ADE}	2,842^{ADE}	2,216^{BCE}	8,292^{ABCD}
Efficiency score	0.817^{D}	0.826^{D}	0.826^{D}	0.855^{ABC}	0.822
Returns to scale	0.390^{BCDE}	0.422^{ACDE}	0.471^{ABDE}	0.596^{ABCDE}	0.572^{ABCD}
Off-farm/total income (%)	9.5^{BCDE}	4.0^{ACDE}	6.7^{ABDE}	1.1^{ABC}	0.6^{ABC}
Dairy output/total output (%)	80	84	79	85	93

Notes: Significance at the 10 percent level (t=1.645) or higher where A represents at least 25 percent of forage needs met from pasture during the grazing season and stock >=1.5; B represents at least 25 percent of forage needs met from pasture during the grazing season and stock <1.5; C represents conventional dairies with 500 cows or less; D represents conventional dairies with more than 500 cows not in the West; and E represents conventional dairies with more than 500 cows in the West. The t-statistics are based on 2,899 observations using weighting techniques constructed in Dubman's CV15 model.

Source: 2005 ARMS cost of Production and Costs and Returns Report data of observations with more than 40 cows.

Technology and Size Comparisons for the United States, 2000 and 2005

- Performance measures:
  - Net return on assets:
    - Generally much higher for conventional dairy farms
  - Returns to scale:
    - Consistent pattern in both time periods (lowest for extensive pasture use to highest for large conventional dairy farms)
  - Efficiency score:
    - Similar value in both time periods, about .85
    - High-cost land appears to reduce efficiency on large Western dairies

Sources: 2000 and 2005 ARMS data.

U.S. Farm and Production Shares, 2000 and 2005

Major shift out of pasture and small conventional dairies

- Share of dairy farms (2000-2005):
  - Conventional operations:
    - Small (<= 500 cows) down (25 to 20 percent); large (>500 cows) Non-West States up (1.1 to 1.8 percent); and large (>500 cows) West down (2.8 to 2.1 percent)
  - Pasture-based:
    - Extensive (> 1.5 acres per cow) down (21 to 17percent); intensive (<= 1.5 acres per cow) up (50 to 59 percent)
- Share of value of production (2000-2005):
  - Conventional:
    - Small (<= 500 cows) down (25 to 16 percent); large (>500 cows) Non-West States up (6 to 13 percent); and large (>500 cows) West up (20 to 32 percent)
  - Pasture-based:
    - Extensive (> 1.5 acres per cow) down substantially (11 to 6 percent); intensive (< =1.5 acres per cow) down (39 to 34 percent)

Sources: 2000 and 2005 ARMS data.

Cost and Production Statistics for U.S., UK, French, and Danish Dairies

1999 EU and U.S. data centered on National estimates for 2000

	United States	Denmark	France	United Kingdom
Number of farms	3,665	391	1,479	895
Dairy cows per farm	88	82	40	93
Hectares per farm	153	86	71	87
Milk per cow (kilograms)	8,257	6,998	5,720	6,007
Stocking rate (cows/hectare)	3.69	2.66	1.51	2.20
Net return on household assets (%)	10.6	9.0	14.8	7.3
Total variable costs/cow ($ or Euros)	1,329	2,601	2,502	1,838
Nominal land price ($/acre 1999-2001, Euro/hectare 1999)	1,973	10,490	3,440	10,033
Off-farm/dairy output (%)	5.2	2.7	5.5	4.9
Dairy output/total output (%)	85.1	78.9	64.3	78.7

Source: 1999-2001 ARMS data; NASS; and Eurostat.

Cost and Production Statistics for U.S., UK, French, and Danish Dairies

2007 EU and U.S. data centered on National estimates for 2005

	United States	Denmark	France	United Kingdom
Number of farms	5,629	457	1,242	560
Dairy cows per farm	121	150	47	121
Hectares per farm	179	151	91	111
Milk per cow (kilograms)	9,193	8,092	6,088	6,751
Stocking rate (cows/hectare)	4.42	3.24	1.44	2.13
Net return on household assets (%)	10.1	9.4	13.4	12.3
Total variable costs/cow (1999 $ or Euros)	1,036	3,030	1,733	1,590
Nominal Land price ($/acre-2005/2008, Euro/hectares 2005)	5,225	19,950	4,100	11,424
Off-farm/dairy output (%)	2.7	6.1	3.7	2.5
Dairy output/total output (%)	87.4	62.1	63.7	79.0

Source: 2005-2008 ARMS data; NASS; and Eurostat

Key U.S./EU Comparisons, 1999 and 2007

- Net household returns are generally comparable, but French producers achieve significantly higher returns
- The milk yield gap in France remains large
- Stocking intensity does not appear to be increasing in France and the UK in stark contrast to trends in the United States and Denmark
- Variable costs per cow are generally declining reflecting scale economies—France is an exception
- Off-farm income is generally declining in importance, while crops are growing in importance in the EU
- Increases in land prices in the Western United States and Denmark and the UK are likely to reduce competitiveness