Intensive versus Extensive Dairy Production Systems: Dairy States in the Eastern and Midwestern U.S. and Key Pasture Countries the E.U.: Determining the Competitive Edge

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Abstract

In recent years, significant structural and production system changes have been noted in the U.S. and European Union, as well as increased interest in pasture-based dairy systems. Technical efficiency, returns to scale, and farm characteristics are compared by size and production system in traditional U.S. dairy states and E.U. countries.

Introduction

The dairy industry has exhibited significant structural changes and production system changes in the past few decades, in both the United States (U.S.) and European Union (E.U.) (see e.g. for the US: Gillespie et al. (AgEcon 2009), MacDonald et al. (ERS 2007), Melhim et al. (JARE 2007), McBride and Greene 2009 and for the E.U.: Perrot et al. 2007, Sauer 2008). Further, the E.U. plans on eliminating the dairy quota by 2015 and move dairy from the least efficient to the most efficient areas across borders. The current push in Common Agriculture Policy (Cap) reform is to include payments to farmers to counter the effects of climate change and reduction of greenhouse gas (GHG) emissions from dairy animals in particular. Thus Europe's longer term potential to be a dairy products exporter is enhanced. This has implications for the higher cost regions of Europe. That would, in turn, provide a measure of the incentive to keep some form of protection for smaller producers. The promotion of organic farming has become an essential element of supranational and national food policy throughout Europe to promote safe and environmentally friendly food production, and is also an important feature of U.S. dairy policy.

Given the current fundamental changes in the E.U. (intensive and extensive) dairy sector, the purpose of this paper is to provide in-depth analyses of the underlying production structure both in the EU member countries as well as in parts of the US—focusing on traditional dairy states in the Corn Belt, Lake States, and Northeast –

considering policy developments over about the last decade. We provide a quantitative comparison of the different production systems in the EU and US using a multi-output approach. Using a common analytical framework allows for insights on the state of the production structure of different production systems in the two regions. The relative efficiency of each system, its development over time, as well as simulated future developments given the described policy framework changes can be derived. Conclusions can be drawn regarding the EU's low cost dairy producers potential to remain/become net dairy products' exporters given the changes in the dairy market framework with the intention increasing the efficiency dairy production in the E.U.

Background

For the U.S., MacDonald et al (2007) state that the cost advantage of larger farm size allows larger dairy farms to be profitable, on average, while most small farms are unable to earn enough to replace their capital. Historical survey evidence, including farm financial data, suggests further consolidation is inevitable if current trends continue. Though pasture-based operations (including organic operations) often yield lower milk per cow, they are perceived to be more environmentally friendly than conventional systems.

In the EU, milk production takes place in all EU member states and represents a significant proportion of the value of EU agricultural output (approximately 14%). The share of milk in total production varies between Member States, from 5.8% to 33.5% in 2006 whereas the share tends to be higher in northern Europe and is below 10% in Mediterranean countries (EC, 2006). In the early 1980's, the EU experienced a large surplus production of milk and dairy produce. To prevent further increase and to limit milk production, it was decided to introduce a country specific milk quota scheme as a measure to control production, effectively putting a limit on the amount of milk EU dairy farmers produce each year.

Eurostat data indicates that significant structural change and improvements in dairy herd productivity have occurred in several EU countries in recent years. UK dairy farms, for example, are developing within the context of liberal agricultural policy (allowing a geographical mobility of quotas), a low level of milk price and difficulties maintaining the global volume of production. Farms are characterized by strong labor productivity and low investments, enabling one of the highest mean agricultural income per family among the different regions of the European Union. In Denmark, dairy farms are characterized by the highest average level of labour productivity in the E.U. (Perrot et al 2007). In contrast, the larger dairy sectors in the E.U., Germany, France, and Italy—with a combined dairy herd nearly four time larger than that of the U.S.—have experienced large reductions in total dairy number have occurred in recent years, while average herd sizes remain small and milk output relatively low. In France, for example, low mobility of dairy quotas and the high quality of the soil have led to the prevalence of traditional, less specialized, dairy farms. Hence these dairy farms produce less milk than in EU countries with more specialized dairy sectors, with a large part of their output consisting of cereals and beef (Perrot et al 2007).

The Transformation Function and its Measures

The dairy farms included in our cross country sample use technological process to produce milk, other livestock products, and crops. Hence, it is desirable to model these processes using a transformation function to model multiple outputs and inputs. Following Paul and Sauer we use a transformation function to represent the most output producible from a given input base and existing conditions, which also represents the feasible production set. This function in general form can be written as $0=F(\mathbf{Y},\mathbf{X},\mathbf{T})$, where $\mathbf{Y}$ is a victor of outputs, $\mathbf{X}$ is a vector of inputs, and $\mathbf{T}$ is a vector of (external) shift variables, which reflects the maximum amount of outputs producible from a given input vector and external conditions. By the implicit function theorem, if F(Y,X,T) is continuously differentiable and has non-zero first derivatives with respect to one of its arguments, it may be specified (in explicit form) with that argument on the left hand side of the equation. Accordingly, we estimate the transformation function $Y_1 = G(\mathbf{Y}_{\mathbf{-1}},\mathbf{X},\mathbf{T})$, where, Y_1 is the primary output of dairy farms (milk) and $\mathbf{Y}_{\mathbf{-1}}$**,** the vector of other outputs, to represent the technological relationships for the dairy farms in our data sample. Note that this specification does not reflect any endogeneity of output and input choices, but simply represents the technologically most Y_1 that can be produced given the levels of the other arguments of the transformation function. This is important because in an input distance function approach, for example, one input is required for normalization. This raises issues not only about what variable should be expressed as ratios with respect to the left hand variable, but also about econometric endogeneity because the right hand side variables are expressed as ratios with respect the the left hand side variable. We approximate the transformation function by a flexible functional form. More precisely we econometrically estimate a generalized linear functional form suggested by Diewert (1973) as follows $Y_{M,it}$ = F($Y_{NM,it,}$, $\mathbf{X}_{it}$,T) where Y_M is milk production measured in real dollars or Euros for farm i in period t , and where $Y_{NM,}$ is non milk production to include crops, non milk production, and off farm income measured in real dollars or Euros, and **X** is a vector of inputs : to include labor, fuel, fertilizer, pesticides , seed, miscellaneous (including purchased feed, general overhead expenses, and interest and insurance expense), capital, and land measured in real dollars or Euros.[1] See Paul and Sauer for details on the generalized linear form.

To represent and evaluate the production structure, we compute the first- and second-order elasticities of the transformation function. The first-order elasticities of the transformation function in term of the milk output Y_M represent the (proportional) shape of

[1] The real input costs used for the U.S. analysis are not cost of production estimates developed by ERS. Rather they are variables such as cash wages or feed purchase as reported in ARMS that are deflated by a prices paid indexes available in Ag Statistics. Similarly, dairy revenues and other outputs are not ERS estimates but variables appropriately deflated using prices paid indexes from Ag. Statistics. It is important to note that the U.S. dairy data is constructed using a whole farm approach so all outputs, including off farm income are considered, so that labor used in the dairy enterprise or in another enterprise such as a cow/calf operation are added together. Similarly, other inputs may be used in more than the dairy enterprise. This approach contrasts with a dairy enterprise approach used by, for example, Mosheim and Lovell where only the outputs and inputs produced or used in the dairy enterprise are considered. Further we use the hired wage rate as the opportunity cost for labor. ERS publications used a more complicated algorithm based on an index of labor costs and the price of milk (www.ers/data/gov 2011).

the production possibility frontier (given inputs) for output Y_{Crop} and the shape of the production function (given other inputs and Y_{Crop}) for input X_K – or output trade-offs and input contributions to milk output respectively. That is, the estimated output elasticity with respect to the "other" (non-milk) output, $\partial_{M,Crop} = \partial \ln Y_M / \partial \ln Y_{Crop} = \partial \ln Y_M / \partial \ln Y_{Crop} *(Y_{Crop} / Y_M)$, would be expected to be negative as it reflects the slope of the production possibility frontier, with its magnitude capturing the marginal trade-off. The estimated output elasticity with respect to input k, $\varepsilon_{M,K} = \partial \ln Y_M / \partial \ln X_K = \partial Y_M / \partial X_K *(X_K / Y_M)$, would be expected to be positive, with its magnitude representing the (proportional) marginal productivity of X_K .

Returns to scale may be computed as a combination of the Y_M elasticities with respect to the non-milk output(s) and inputs. For example, for a production function returns to scale is defined as the sum of the input elasticities to reflect in a sense the distance between isoquants. Similarly for a transformation function such a measure must control for the other output(s). Formally, returns to scale are defined for the transformation function as $\varepsilon_{M,X} = \sum_K \varepsilon_{M,K} /(1-\varepsilon_{M,Crops})$.

Data and Methodology

For the EU we use data sets for 1999 through 2007 from Denmark (3,744 observations), France (12,180), Germany (15,524), Italy (13,272), Spain (11,315) and the UK (5,970) to represent EU dairy production. Pasture based and organic operations in these dairy surveys are self identified. These EU countries account for about 70 percent of EU milk production, with Germany accounting for 21 percent, France 18 percent, UK 10 percent, Italy 8 percent, Spain more than 4 percent, and Denmark more than 3 percent. For the U.S we use data on dairy farms in the Corn Belt, Lake States, and North East (relatively pasture based dairy states accounting for about 40 percent of U.S. milk production) from USDA's Agricultural Resource Management Survey (ARMS), and determine the extent and location of U.S. conventional and pasture-based milk production during 1999-2008 based on data on more than 5,000 dairy farms (determining the pasture/conventional split from technical data surveyed in 2005). The states included in the analysis are Illinois, Indiana, Iowa, Michigan, Minnesota, New York, Ohio, Pennsylvania, Vermont, and Wisconsin. It is important to note that the micro data sets used are harmonized with outputs and inputs similarly defined, so that cost advantage by country, by technology, can be identified. We then estimate for each country the net returns, scale efficiency (returns to scale) and technical efficiency (TE) associated with conventional versus pasture-based production using a multi-output framework approach (transformation or distance function). Finally, we compare the financial performance of conventional versus non-pasture-based producers in each country and assess the competitive potential of dairy farms by country by technology, and by size. Chart 1 compares the structural trends in the dairy sector for the countries analyzed. Chart 2 identifies the major dairy producing districts by country of EU countries analyzed, and Chart 3 identifies the major dairy producing counties by state in the United States.

Since we are interested in estimating economic performance measures associated with the forage groupings, we use a stochastic production frontier (SPF) approach to analyze performance within the groups over the 9-year period, using a unique approach based on a transformation function. The SPF results allow for determination of TE and RTS. The SPF measurement involves econometric estimation of a three outputs (crops, livestock, and off-farm activities), four inputs (labor, miscellaneous, capital, and land), using a transformation or distance function. We use a pooled approach with all dairy farm observations, as well as estimating own-technology models for each of the two systems.

Results

In general, the transformation function estimates by country, with sixty-five right hand side parameter estimates, involved more than 50 percent significant coefficients on the parameters estimated. And in general the calculation of output elasticities (negative signs) and input elasticities (positive signs) resulted in correct signs in all countries. This was uniformly so for the EU countries; for the U.S. traditional dairy states the off-farm output and fertilizer input calculations resulted in wrong signs for the forage observations in particular. Tables 1 through 7 present the summarized scale and technical performance results by size and type of technology as captured by the stocking rate partition of cows per hectare. We present 5 herd size categories and three technology cow/hectare partitions with important technical and financial information by category. We find that the two forage systems as represented by stocking rates are, in fact, operating on different production functions, or technologies. We also find that large conventional farms generally outperform smaller farms using most economic measures – particularly in terms of profitability, and returns to scale, but not technical efficiency. From an environmental perspective, large numbers of cows generally mean more manure per acre, thus more nitrogen, phosphorus, and other nutrients per acre plus higher emissions.

More precisely, we find that both in the U.S. traditional dairy states and in most EU countries analyzed that the RTS measure declines as the stocking density increases, indicating greater scale efficiency. In particular as the stocking density increases from the well populated categories of >0.5 to <=1.5 cows per hectare to >1.5 cows per hectare RTS to scale decrease strongly in most countries analyzed. For example in Germany, the RTS declines from 1.258 to 1.165, in the United Kingdom, the RTS declines from 1.623 to 1.389, and in the United States, RTS declines from 2.291 to 1.395 (See Mosheim and Lovell AJAE 2009 for an alternative presentation of RTS for the United States using 2000 data for a representation of all U.S. dairy farms—pasture and nonpasture, with data cleaned up to remove outliers and farms with negative operating profits). The higher stocking density represents a "different" technology generally characterized by much lower total costs per cow, as farms exploit high technology milking systems and by generally lower costs for energy and other inputs per cow. Feed costs per cow[2], however, do not decline with size as

[2] Note that feed costs (which may include feeds purchased for nondairy enterprises) are defined as purchased feed costs per cow; for the E.U. feed costs are defined as homegrown and purchased feed costs per cow. In the case of the labor input: the labor input is defined as the value of cash wages and an opportunity cost for nonpaid operator and family labor used in the dairy and other enterprises pursued on the farm; for E.U. the labor charge is based on

high energy rations (e.g. corn to achieve high milk yields) drive up costs for feed per cow. In general, we see a similar pattern as herd size increases. For example, RTS in Germany decline from 1.538 to 1.037 as herd size increases from <50 cows per farm to more than 1000. As size increases milk yields increase, driven by higher energy feeds, suggested by the increase in feed costs per cow, but generally lower costs for other inputs. Stocking density increases, generally (the former East German large farms are an exception). We also see a decline in off farm work with the exception of large German farms. We see no general trend in technical efficiency scores by technology or by size, with the exception that the U.S. size comparisons indicating that smaller operations may be more technically efficient, possibly reflecting a less costly land input.

The attached land price maps by country indicate that dairy production in the EU and U.S. traditional dairy states often occurs in areas with high prices for agricultural land. Previous work by Nehring et al. (2006) indicates that urbanization factors represent a negative economic factor in livestock production. Land prices are high in many major dairy producing regions of the EU, e.g. in Denmark and in the northwest region of France. In future research, it is desirable to identify the areas in the EU as well as the United States (particularly California, southeastern Wisconsin, and Pennsylvania) where increasing agricultural land prices due primarily to urbanization are sharply boosting costs for dairy production. Future research using latent variable techniques or multinomial logit models (see Appendix table 1) to identify technology could allow us to drill down more precisely differences in technology than stocking rate partition allows.

Other noteworthy trends—previously identified in a 2010 AAEA poster – include 1) net household returns are generally comparable but French producers achieve significantly higher returns, possibly derived from high value crop production; 2) the milk yield gap in

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data on labor units per farm based on 2200 labor units per year and a uniform cash wage rate per hour for each country. Energy costs for both the U.S. and E.U. include the value of fuel and oil. The RTS estimates derived from specialized operations reported in this document in Corn Belt, Lake States and key eastern States are somewhat higher for large farms on the size groupings then the results reported by Mosheim and Lovell. The stocking rate results and binomial logit results--- more aggregated size groupings-- appear reasonable.

France remains particularly large, possibly reflecting dual purpose breeds; 3) stocking intensity does not appear to be increasing in France, Germany, or the UK, in stark contrast to stocking rate trends in Demark, Italy, Spain, and the US traditional dairy states and consistent with scale economies as variable costs per cow decline; and 4) off-farm income, to include business operations as is suggested by the German data, is an important source of competiveness but is in general declining in importance over time.

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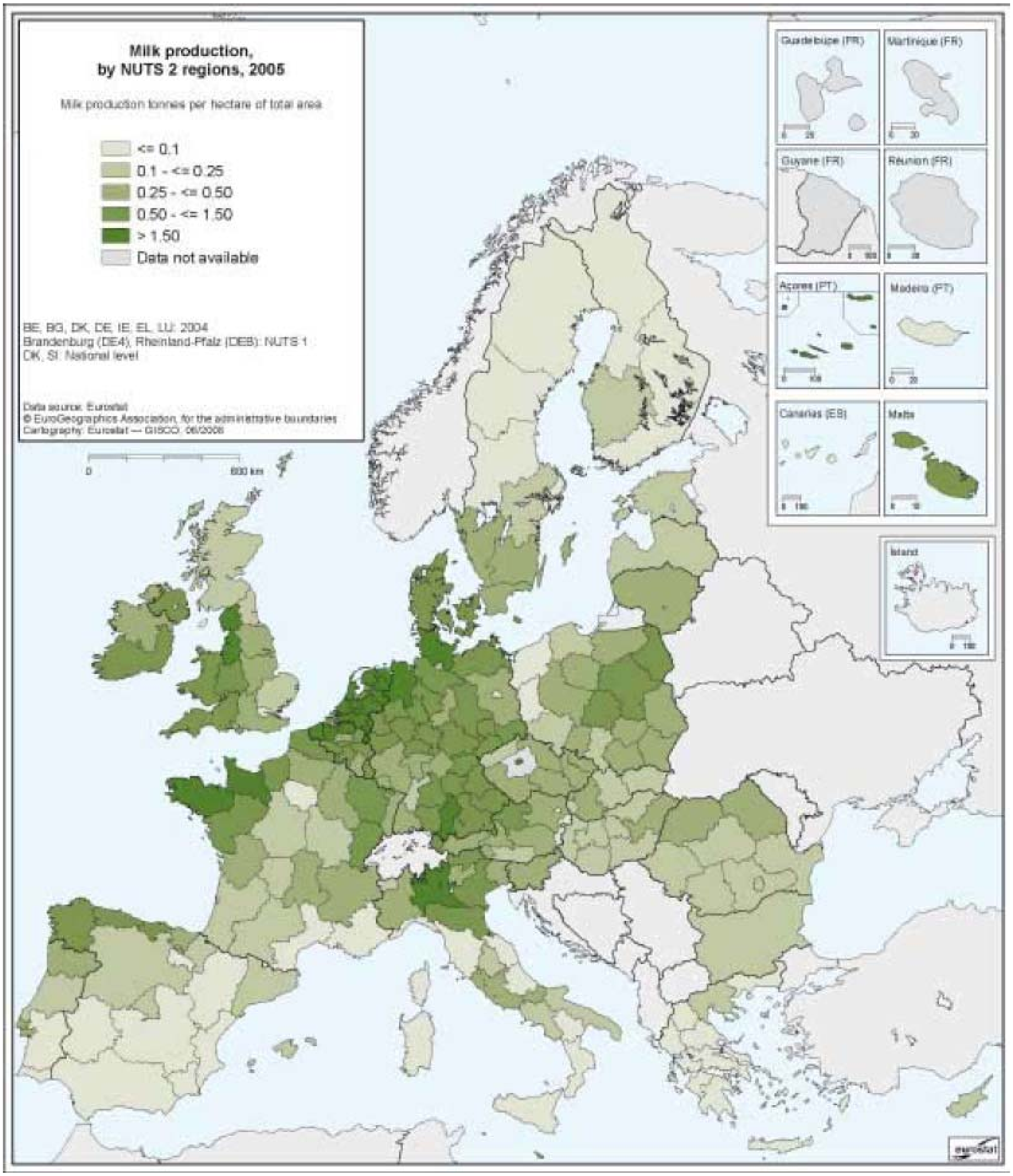
Chart 1

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

Country	Number of Operations		% Chg	Cows per Farm		Milk per cow kilograms		%Chg
	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
Ger	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
Neth	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

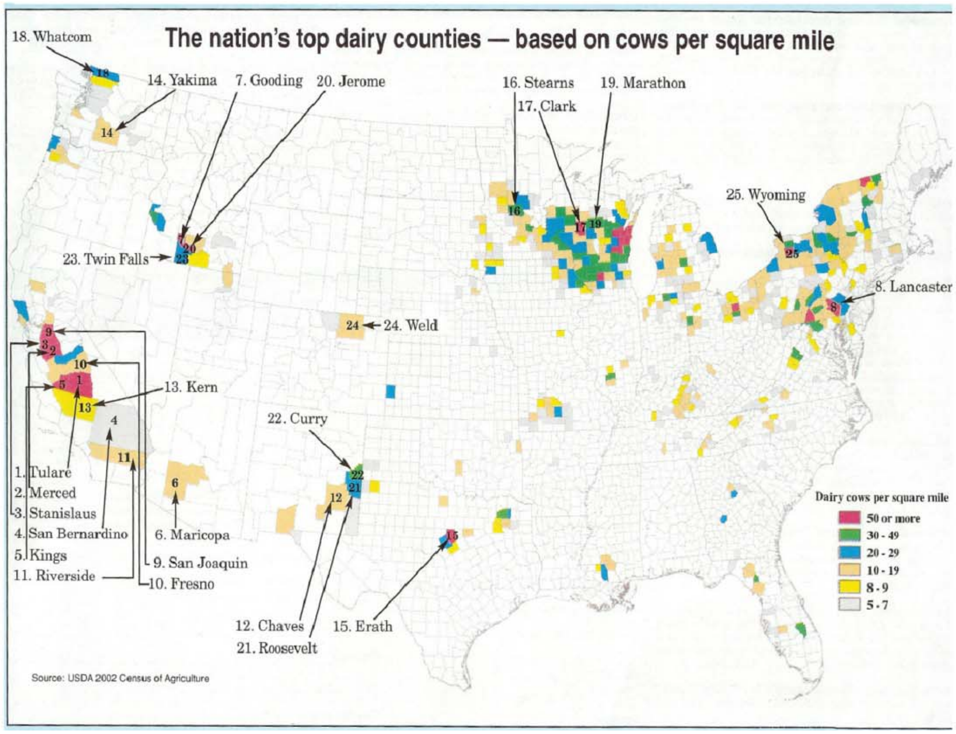
Source: Agricultural Statistics and Eurostat, selected issues.

Chart 2



Source: Eurostat, 2009.

Chart 3 Top Dairy Counties in the United States 2003



Source: Hoards Dairyman 2004

Table 1. U.S. Midwest and Eastern States production expenses: Means and Statistics by Pasture Usage, Organic Status, and Herd Size.

Item	A *Cows* <50	B *Cows* >50 <=100	C *Cows* >100<=500	D *Cows* >500<=1000	E *Cows* >1,000	F *Stocking* <=0.5 cows/ha	G *Stocking* >0.5<=1.5 cows/ha	H *Stocking* >1.5 cows/ha	I *Pasture* Binomial logit model	J *Conventional*
Obser-vations	202	1,274	2,881	487	180	833	2,975	1,216	2973	2,051
% of Farms	4.0	25.4	57.3	9.7	3.6	18.6	57.1	24.2	59.2	40.8
% Value of Production	1.0	7.4	43.9	23.7	23.9	9.9	47.8	42.3	37.1	62.9
-----Farm Size and Pricing Information-----										
Dairy Cows Per Farm	46.5	76.7	224.6	692.3	1871.9	122.7	235.5	519.1	191.5	418.8
Farm Size acres	280.5	323.7	661.5	1191.5	2093.8	961.1	635.2	527.7	515.1	877.9
Land price $/ acre	2187	2820	3122	2788	2528	2308	3429	4124	3928	2624
-----Measures of Efficiency and Profitability-----										
Milk/Cow kg	6902.3	8015.9	8717.3	10403.3	10005.0	7682.3	9032.7	9610.0	7879.5	9154.1
Net Return On Assets %	6.8	5.8	7.1	10.7	17.0	6.1	7.3	12.5	6.2	8.0
Stking Den	1.28	1.38	2.07	7.00	26.02	0.35	0.90	10.27	1.63	5.46
Offfarm % Total out	9.9	7.6	3.0	0.4	0.3	6.8	4.1	1.7	1.6	1.2
Dairy out % Total out	63.4	74.3	81.7	90.4	87.1	61.7	85.6	88.0	85.5	83.4
Lab cost/ Cow Euro	1071.9	870.10	521.3	403.2	352.7	814.2	521.4	384.0	555.0	434.4
Feed cost/ Cow Euro	544.1	467.5	449.9	558.8	604.7	219.5	476.3	560.6	455.5	553.7
Eng cost/ Cow Euro	101.8	81.8	71.1	62.1	62.0	146.3	73.1	49.1	68.1	69.2
-----Performance Measures-----										
Returns to Scale	2.267	1.424	1.182	1.232	1.395	1.104	1.288	1.105	1.272	1.165
Efficiency Score	0.974	0.973	0.952	0.879	0.872	0.958	0.958	0.938	0.947	0.921

Table 2. Italy cost of production Means and Statistics by Pasture Usage, Organic Status, and Herd Size.

Item	A *Cows* <50	B *Cows* >50 <=100	C *Cows* >100<=500	D *Cows* >500<=1000	E *Cows* >1,000	F *Stocking* <=0.5 cows/ha	G *Stocking* >0.5<=1.5 cows/ha	H *Stocking* >1.5 cows/ha
Obser-vations	9,662	2,251	1,317	29	12	954	2,573	9,744
% of Farms	72.8	17.0	9.9	0.2	0.4	7.2	19.4	73.4
% Value of Production	29.3	24.4	39.7	2.9	0.1	3.8	8.7	87.5
--------Farm Size and Pricing Information--------								
Dairy Cows Per Farm	22.7	70.7	181.5	635.4	1,498.6	32.8	24.5	57.44
Farm Size Ha	28.9	56.7	82.2	206.1	708.7	172.1	37.2	27.6
Rental Rate Euro/ Ha	67.3	130.9	270.2	519.6	155.0	222.7	732.5	252.3
--------Measures of Efficiency and Profitability--------								
Milk/Cow kg	4823.5	6397.8	7168.7	6448.5	6658.6	3654.7	4519.6	5707.0
Net Return On Assets %	7.8	9.1	10.5	9.9	8.8	11.0	8.1	9.2
Stking Den	3.29	5.53	131.75	10.02	9.78	0.27	1.05	22.08
Offfarm % Total out	2.3	0.8	0.4	0.9	----	2.7	2.8	0.1
Dairy out % Total out	68.8	73.7	76.0	81.5	74.2	79.2	76.3	86.5
Lab cost/ Cow Euro	586.4	297.7	184.3	153.0	133.1	535.8	577.8	307.0
Feed cost/ Cow Euro	1024.4	1121.0	1268.0	1172.0	1107.8	920.3	1042.8	1167.0
Eng cost/ Cow Euro	106.8	112.7	114.4	108.7	123.1	67.9	108.3	114.3
--------Performance Measures--------								
Returns to Scale	3.509	1.218	1.299	1.277	1.106	1.610	2.005	1.672
Efficiency Score	0.866	0.877	0.875	0.844	0.818	0.8462	0.862	0.871

Table 3. Denmark cost of production Means and Statistics by Pasture Usage, Organic Status, and Herd Size.

Item	A *Cows* <50	B *Cows* >50 <=100	C *Cows* >100<=500	D *Cows* >500<=1000	E *Cows* >1,000	F *Stocking* <=0.5 cows/ha	G *Stocking* >0.5<=1.5 cows/ha	H *Stocking* >1.5 cows/ha
Obser-vations	484	1,515	1,735	10	----	13	352	3,379
% of Farms	12.9	40.5	46.3	0.3	----	0.3	9.4	90.3
% Value of Production	3.7	36.3	58.1	1.9	----	0.4	9.0	90.6
---Farm Size and Pricing Information---								
Dairy Cows Per Farm	35.7	76.4	155.3	681.8	----	132.8	98.8	110.3
Farm Size Ha	40.5	84.2	152.4	552.3	----	0.0	146.8	108.2
Rental Rate Euro/ Ha	282.93	318.18	495.08	747.26	----	0.0	172.91	128.36
---Technical and Financial measures---								
Milk/Cow kg	6629.3	7526.1	7921.8	7965.6	----	8932.6	7615.5	7587.4
Net Return On Assets %	6.8	7.8	8.3	9.4	----	6.7	8.1	8.2
Stking Den	2.95	2.32	2.61	3.44	----	0.0	1.32	2.67
Offfarm % Total out	2.8	2.1	3.2	5.0	----	14.5	3.9	2.8
Dairy out % Total out	78.3	79.7	76.0	66.3	----	94.6	75.3	76.9
Lab cost/ Cow Euro	258.5	175.1	137.9	104.7	----	118.3	164.7	152.3
Feed cost/ Cow Euro	700.0	736.8	851.9	1124.6	----	1157.8	830.3	812.9
Eng cost/ Cow Euro	74.6	80.4	89.9	101.9	----	74.1	62.3	85.5
---Performance Measures---								
Returns to Scale	1.557	1.094	0.959	0.822	----	1.200	0.967	1.037
Efficiency Score	0.895	0.926	0.922	0.862	----	0.953	0.936	0.918

Table 4. France cost of production Means and Statistics by Pasture Usage, Organic Status, and Herd Size.

Item	A *Cows* <50	B *Cows* >50 <=100	C *Cows* >100<=500	D *Cows* >500<=1000	E *Cows* >1,000	F *Stocking* <=0.5 cows/ha	G *Stocking* >0.5<=1.5 cows/ha	H *Stocking* >1.5 cows/ha
Obser-vations	8,074	3,626	480	----	----	51	6,995	5,134
% of Farms	66.2	29.8	3.9		----	0.4	57.4	42.2
% Value of Production	48.3	43.4	8.3	----	----	0.2	51.3	48.5
Farm Size and Pricing Information								
Dairy Cows Per Farm	32.7	66.7	128.8	----	----	27.5	44.5	49.6
Farm Size Ha	63.3	109.6	159.5	----	----	99.2	86.3	73.3
Rental Rate Euro/ Ha	128.00	96.45	130.80	----	----	41.47	80.42	111.11
Technical and Financial measures								
Milk/Cow kg	5797.6	6172.7	6038.9	----	----	4859.5	5752.1[j]	6156.4
Net Return On Assets %	13.7	19.9	17.9	----	----	2.1	14.0	17.1
Stking Den	1.43	1.56	1.56	----	----	0.41	1.14	1.92
Offfarm % Total out	3.5	4.3	4.5	----	----	9.1	3.8	4.0
Dairy out % Total out	67.8	68.8	68.8	----	----	77.5	70.6	65.9
Lab cost/ Cow Euro	343.8	258.6	170.3	----	----	359.9	293.8	280.5
Feed cost/ Cow Euro	336.6	339.8	269.8	----	----	322.7	307.7	357.7
Eng cost/ Cow Euro	93.5	87.7	70.9	----	----	99.0	86.2	91.4
Performance Measures								
Returns to Scale	1.153	1.109	1.106	----	----	1.484	1.126	1.105
Efficiency Score	0.858	0.885	0.857	----	----	0.797	0.864	0.868

Table 5. Germany cost of production Means and Statistics by Pasture Usage, Organic Status, and Herd Size.

Item	A	B	C	D	E	F	G	H
Cows	*Cows* <50	*Cows* >50 <=100	*Cows* >100<=500	*Cows* >500<=1000	*Stocking* >1,000	*Stocking* <=0.5 cows/ha	*Stocking* >0.5<=1.5 cows/ha	>1.5 cows/ha
Obser-vations	9,352	4,756	1,253	108	55	20	3,815	11,689
% of Farms	60.2	30.6	8.1	0.7	0.4	0.1	24.6	75.3
% Value of Production	26.5	32.7	22.5	10.1	8.1	0.2	24.2	75.6
---Farm Size and Pricing Information---								
Dairy Cows Per Farm	30.8	68.6	172.3	740.2	1260.4	73.8	62.7	63.2
Farm Size Ha	40.5	86.0	241.4	1283.4	1784.1	334.3	124.6	72.3
Rental Rate Euro/ Ha	204.16	237.81	141.2	75.1	105.20	65.77	99.34	220.50
---Technical and Financial measures---								
Milk/Cow kg	6070.3	7005.5	7372.2	7843.3	7956.6	5382.2	6237.0	6562.4
Net Return On Assets %	2.1	5.7	4.2	14.7	12.4	0.0	3.4	5.5
Stking Den	1.90	2.00	2.12	1.97	2.49	0.41	1.21	2.20
Offfarm % Total out	10.5	4.9	7.2	19.7	17.3	18.0	12.6	8.7
Dairy out % Total out	74.9	77.8	78.9	68.8	72.3	70.1	75.1	76.2
Lab cost/ Cow Euro	360.1	226.5	248.2	404.0	400.2	357.7	353.2	279.1
Feed cost/ Cow Euro	429.1	470.1	547.8	882.4	746.7	575.6	527.0	529.0
Eng cost/ Cow Euro	183.3	169.9	191.5	265.8	232.3	291.7	229.0	178.2
---Performance Measures---								
Returns to Scale	1.538	1.311	1.307	1.123	1.037	1.389	1.258	1.165
Efficiency Score	0.903	0.915	0.906	0.889	0.881	0.867	0.903	0.908

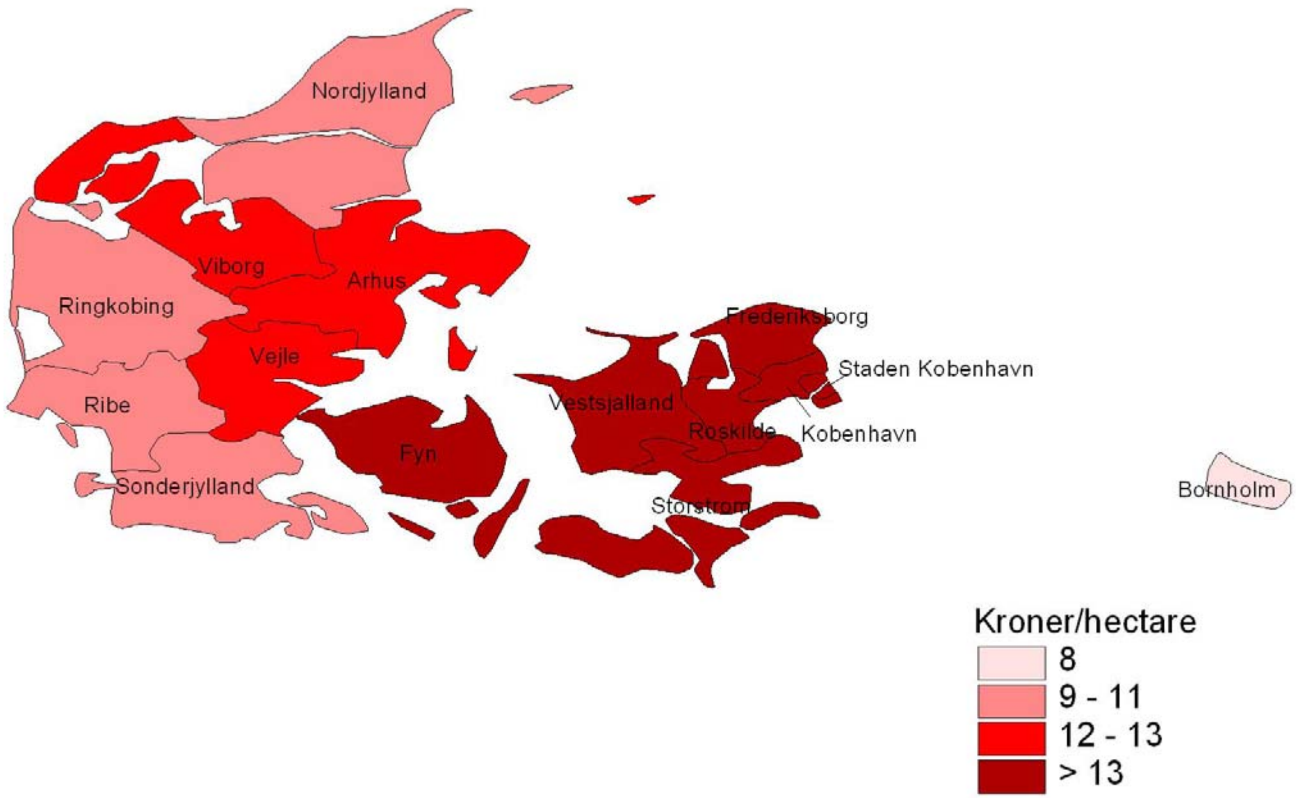
Table 6. Spain cost of production Means and Statistics by Pasture Usage, Organic Status, and Herd Size.

Item	A *Cows* <50	B *Cows* >50 <=100	C *Cows* >100<=500	D *Cows* >500<=1000	E *Cows* >1,000	F *Stocking* <=0.5 cows/ha	G *Stocking* >0.5<=1.5 cows/ha	H *Stocking* >1.5 cows/ha
Obser-vations	8,438	2,286	587	3	----	553	1,635	9,127
% of Farms	74.6	20.2	5.2	0.3	----	4.9	14.5	80.7
% Value of Production	47.4	33.3	18.9	0.4	----	7.2	9.8	83.0
-----Farm Size and Pricing Information-----								
Dairy Cows Per Farm	27.8	68.2	181.5	623.7	----	70.4	30.2	42.2
Farm Size Ha	17.7	30.5	45.4	156.7	----	25.9	39.8	18.3
Rental Rate Euro/ Ha	92.87	113.48	111.44	114.69	----	62.00	67.47	118.66
-----Technical and Financial measures-----								
Milk/Cow kg	5757.9	6841.8	7595.8	6902.9	----	6233.7	5560.6	6154.5
Net Return On Assets %	5.6	8.3	10.5	4.5	----	18.0	12.9	7.0
Stking Den	3.42	7.21	22.25	2.40	----	0.07	0.30	6.19
Offfarm % Total out	0.3	0.5	0.6	----	----	0.6	0.3	0.4
Dairy out % Total out	79.2	86.2	87.6	90.0	----	87.8	77.9	83.3
Lab cost/ Cow Euro	393.9	220.1	167.1	163.4	----	196.7	354.2	301.1
Feed cost/ Cow Euro	804.2	871.2	975.1	572.2	----	636.3	782.4	885.8
Eng cost/ Cow Euro	60.8	62.0	66.9	25.1	----	48.8	66.8	62.9
-----Performance Measures-----								
Returns to Scale	1.452	1.334	1.257	1.003	----	1.285	1.622	1.347
Efficiency Score	0.833	0.843	0.836	0.900	----	0.826	0.818	0.838

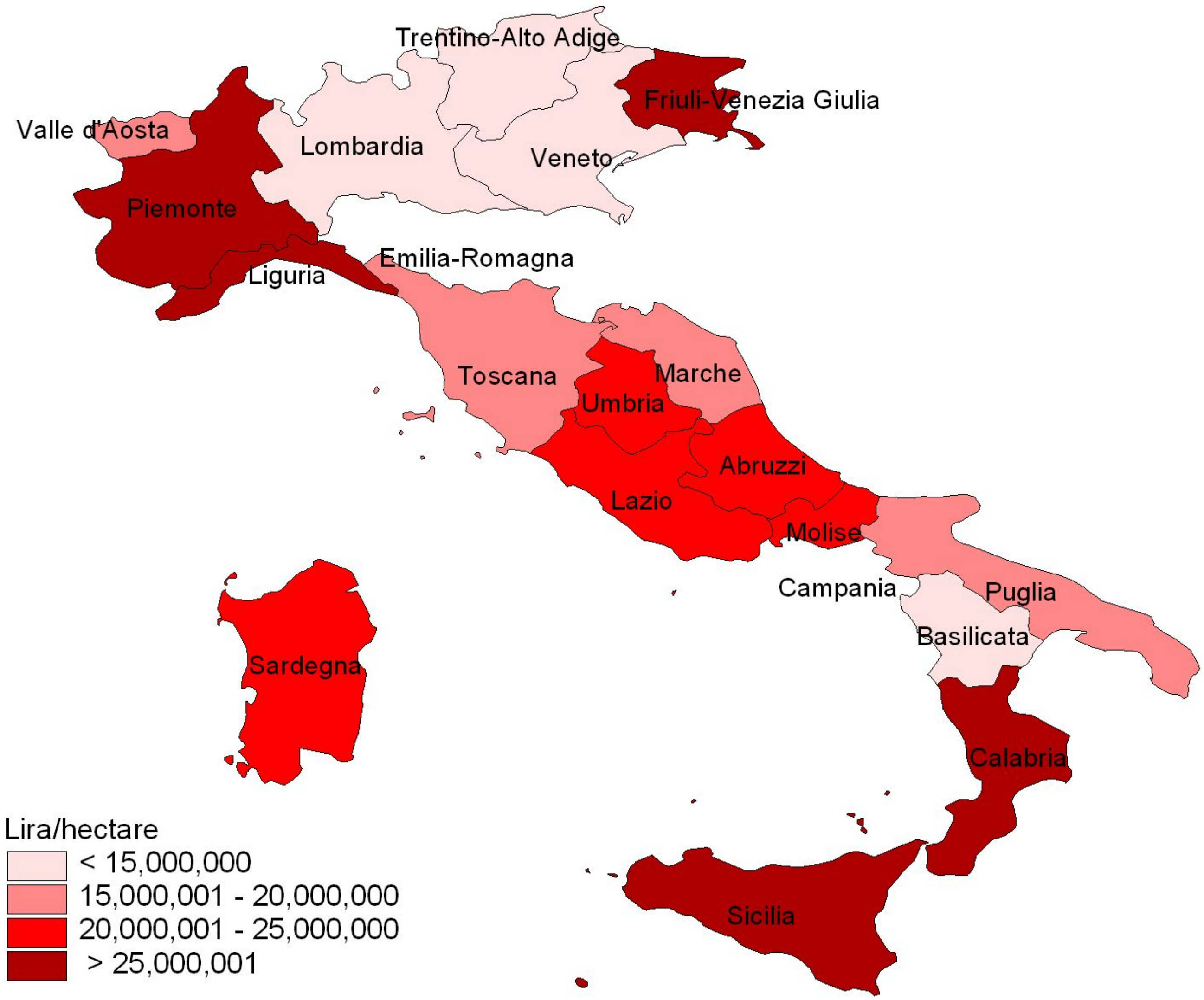
Table 7. United Kingdom cost of production Means and Statistics by Pasture Usage, Organic Status, and Herd Size.

Item	A	B	C	D	E	F	G	H
Cows	*Cows*	*Cows*	*Cows*	*Cows*	*Stocking*	*Stocking*	*Stocking*	
	<50	>50 <=100	>100<=500	>500<=1000	>1,000	<=0.5 cows/ha	>0.5<=1.5 cows/ha	>1.5 cows/ha
Obser-vations	1,410	2,249	2,290	21	----	9	998	4,963
% of Farms	23.6	37.7	38.4	0.4	----	0.2	16.7	83.1
% Value of Production	7.5	29.3	63.9	2.0	----	0.01	11.2	90.6
---Farm Size and Pricing Information---								
Dairy Cows Per Farm	36.3	74.7	164.7	629.4	----	45.8	68.1	109.1
Farm Size Ha	51.3	77.9	138.2	370.4	----	329.2	123.6	89.8
Rental Rate Euro/ Ha	238.82	239.45	300.78	308.35	----	10.05	167.32	318.23
---Technical and Financial measures---								
Milk/Cow kg	5410.56	6326.9	7014.5	6892.4	----	5222.1	5826.0	6488.9
Net Return On Assets %	7.6	8.8	10.7	14.5	----	5.2	8.2	9.8
Stking Den	1.85	2.09	2.37	2.63	----	0.40	1.22	2.33
Offfarm % Total out	3.6	2.3	2.4	0.9	----	6.3	4.2	2.2
Dairy out % Total out	73.0	70.2	81.9[j]	89.0	----	62.3	75.2	79.2
Lab cost/ Cow Euro	306.7	196.0	145.6	100.5	----	372.1	459.3	165.0
Feed cost/ Cow Euro	473.2	509.7	561.6	509.4	----	693.9	545.3	537.8
Eng cost/ Cow Euro	103.8	84.6	93.1	63.1	----	117.5	100.2	78.4
---Performance Measures---								
Returns to Scale	1.705	1.492	1.345	1.319	----	1.939	1.623	1.389
Efficiency Score	0.863	0.884	0.889	0.837	----	0.833	0.881[j]	0.880

Danish Land Prices by Region 1996



Italy Land Prices by Region 1996



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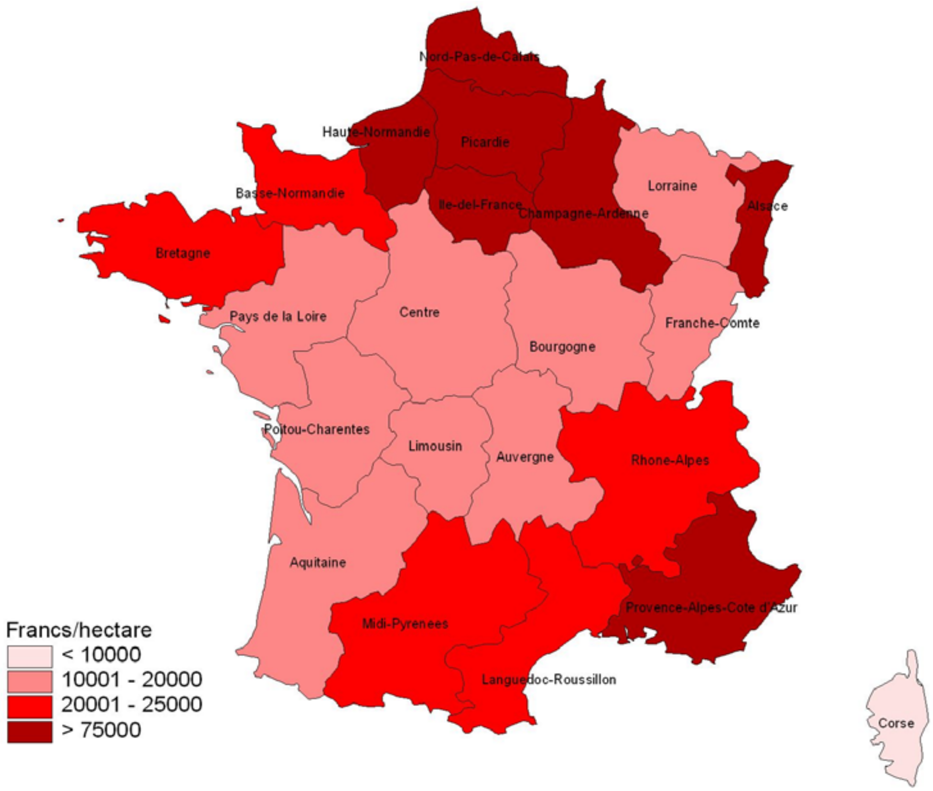
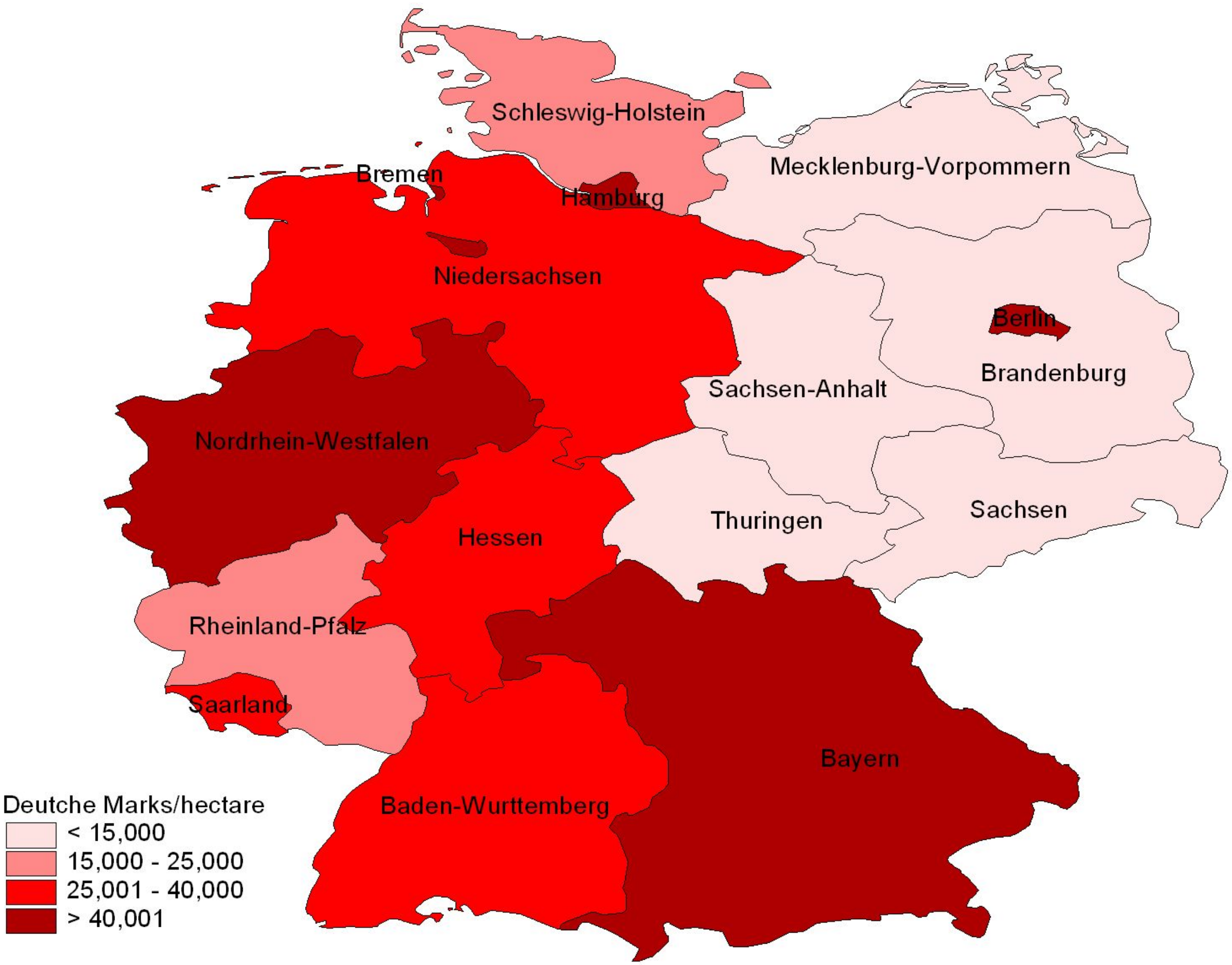


German Land Prices by Region 1996



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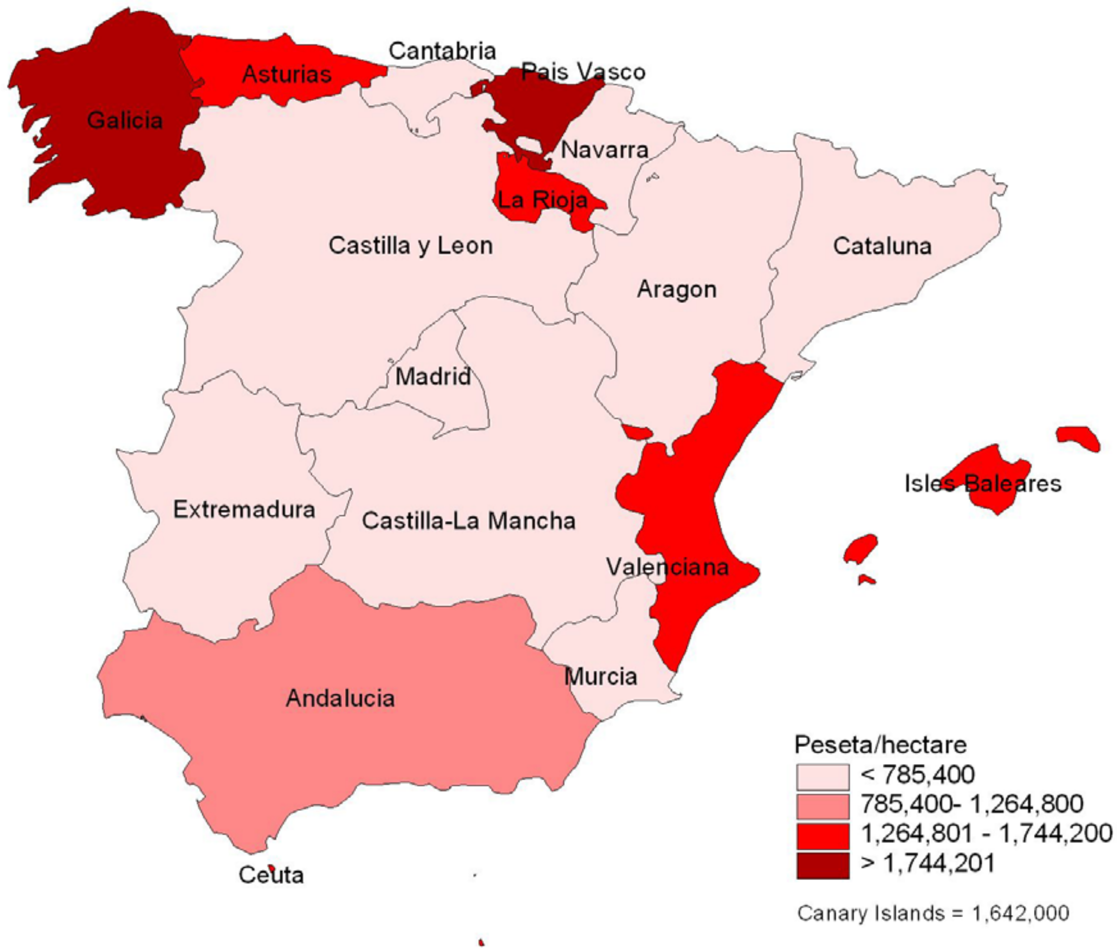
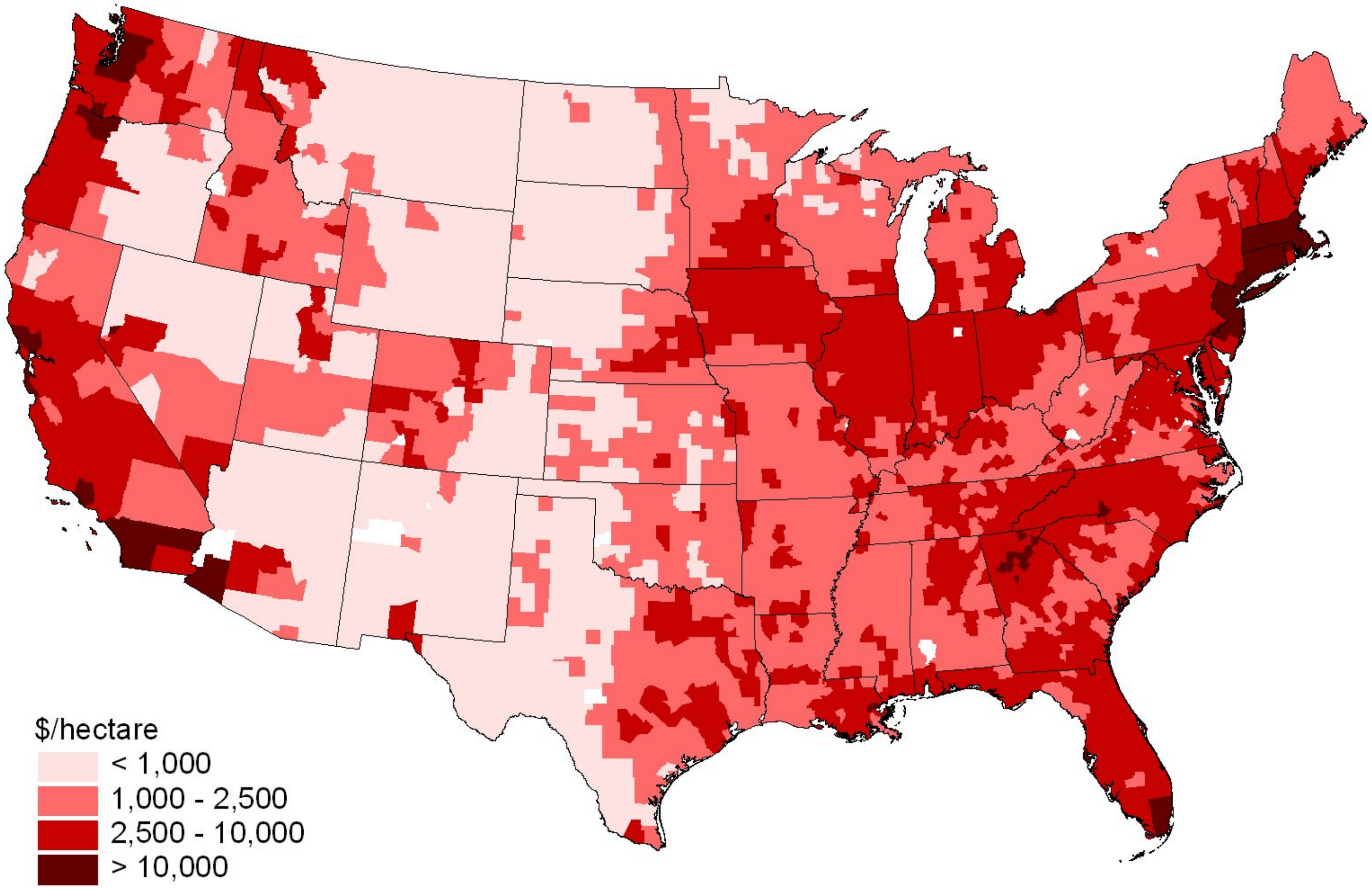


U.S. Land Prices by Region 1996



Appendix: Binomial Logit model

To systematically categorize the farms into Conventional and Pasture-based systems, a binomial logit model is used. The dependent variable includes two categories describing the extent of pasture use, where Conventional corresponds to <25% of forage being obtained from pasture during the grazing season and Pasture-based corresponds to ≥25% of forage being obtained from pasture during the grazing season. Farmers were asked about their use of grazing in the 2005 ARMS dairy version that allow for this categorization. The logit model is based upon 1814 observations. With logit model results, all 5,000 midwestern farms including dairy enterprises in the 2003-2008 ARMS can be predicted to fall into either the Conventional or Pasture-based categories. Both system categories can then be further sorted into the size categories.

Examination of Appendix Table 1 suggests a number of variables are significant in predicting system choice. The percentage correctly predicted is 75% and the percent concordant is 80%, suggesting a relatively good fit for prediction purposes. Region influenced system choice, pasture acres per cow, labor hours per cow, machinery expenses per cow, percentage of farm acres in silage and alfalfa, and off-farm income per cow.

Appendix Table 1. Logit Results for Choice of Production System, n=1,814.

Variable	Beta	t-statistic
Constant	0.2051	0.0407
Lake States	-1.2187 ***	7.9261
Corn Belt	-1.1744***	13.2741
Appalachia	0.8770***	2.4081
Southeast	1.2611***	2.2635
Southern Plains	-0.0106	0.0002
Mountain West	-2.3496***	11.6097
Pacific	-1.0409***	2.9003
Cows	0.0004	0.3092
Age	0.0168	1.5664
Pasture	0.5680 ***	8.8795
Labor	0.0017 ***	8.7534
Machinery	-0.0016 **	5.4836
Feed	-0.4719	0.1162
Silage	-1.5040 ***	4.0047
Hay	0.7757	1.5676
Alfalfa	1.1226 **	2.8626
Off-farm income	-0.0015 ***	4.7554

Percentage Correctly Predicted: 74.9%.

Percent Concordant: 79.5%

Percent Discordant: 20.3%

Percent Tied: 0.2%

Notes: *** Significance at the 1% level (t=2.576). ** Significance at the 5% level (t=1.96). * Significance at the 10% level t =1.645). T-tests are estimated using design standard errors using the delete-a-group jackknife estimation procedure, with 15 replicates.