A Micro Study of the Role of Energy for Economic Development in Denmark

Sofia Henriques, Lund University Paul Sharp, HEDG, University of Southern Denmark, CEPR, CAGE

+ a PhD student!

But first...

- This is part of a large project financed by the Danish Research Council
- This builds on previous work by Sofia Henriques and me:
- Published in the Economic History Review (2016), 69:3, pp. 844-869

The Danish Agricultural Revolution in an Energy Perspective: A Case of Development with Few Domestic Energy Sources

Sofia Henriques, Lund University

Paul Sharp, HEDG, University of Southern Denmark, CEPR, CAGE

The Question!

- Is a lack of domestic energy resources necessarily a limiting factor to growth?
- We answer this looking at Denmark a country which has few domestic resources
- Present new energy accounts from 1800
- Show that Denmark's take off (through dairying) was relatively dependent on coal and imported feed (concentrates)
- Demonstrate that domestic energy resources are not necessary if cheap imports are available
- Energy also important for agricultural development path

Hypotheses on the role of energy in the 19th century

- Growth hypothesis Transition to fossil fuel is *necessary* for industrialization (Wrigley)
- Location hypothesis Location of industry determined by location of coalfields (Allen)
- Others argue
 - the use of coal is more a symptom of modernization
 - alternative fuels were available
 - coal can anyway be transported
- Denmark might suggest low energy activities such as agriculture might be an alternative development path
- New energy accounts shows this **not** to be the case

Danish Energy Consumption by source (%)



Percentage of Energy Consumption from Coal for Selected Countries, 1800-1913



Including feed in the energy accounts, 1800-1913, PJ



The Danish development story

- Enjoyed a rapid 'take off' from around 1880 based on agriculture, especially dairying
- Based largely on exports of butter then bacon to UK
- Converges rapidly with leading countries in terms of GDP/head
- Usual story
 - Technology: Automatic cream separator
 - Institution: Cooperatives

Centrifuges and cooperative creameries















Total energy per capita in GJ

	Excluding non-working cattle														
			England												
	Denmark	France	& Wales	Germany	Italy	Netherlands	Portugal	Spain	Sweden						
1880	30	35	142	43	18	40	19	19	39						
1900	35	49	146	74	19	45	21	22	51						
1913	46	60	162	97	24	63	23	25	64						
	Including non-working cattle														
			England												
	Denmark	France	& Wales	Germany	Italy	Netherlands	Portugal	Spain	Sweden						
1880	44	41	145	48	18	47	19	20	47						
1900	49	55	150	80	19	51	21	23	59						
1913	65	67	165	102	24	70	23	28	75						

HP per worker for the main branches of Danish industry, 1897

	All Fac	ctories	Mecha facto	nized ries	Total	HP/	HP/ worker		
	number	workers	% of total	workers	HP	worker	(mechanized)		
Food,bv & t.	11301	30517	41	19660	19151	0.6	1		
Creameries	1233	4391	96	4283	6173	1.4	1.4		
Slaughterhouses	3180	3351	2	1086	1173	0.4	1.1		
Textiles	4358	12533	6	8762	4962	0.4	0.6		
Spinning mills	111	636	98	635	807	1.3	1.3		
Weaving mills	3061	6613	3	6131	3580	0.5	0.6		
Clothing	23557	28291	0.2	2369	293	0	0.1		
Construction,									
furniture	19781	42389	1	4957	3294	0.1	0.7		
Wood	4896	8119	12	4659	3722	0.5	0.8		
Leather	227	1227	31	857	310	0.3	0.4		
Nonmetallic									
minerals	1757	13700	17	9872	5833	0.4	0.6		
Metals	9383	27302	5	16402	4665	0.2	0.3		
Chemicals	602	4061	29	2992	1497	0.4	0.5		
Paper	82	2057	45	1721	1690	0.8	1		
Others	1248	5358	16	3290	677	0.1	0.2		
All	77192	175554	9	75541	46093	0.3	0.6		

Energy in dairying, 1890-1913

	1890-1894	1900-1904	1910-1913
Butter production, tons	68,000	97,000	110,000
kg of coal per kg of butter	1.8	1.1	1.1
Total Coal for butter production (PJ)	3.6	3.2	3.5
kg milk per kg of butter	27	26	25
ton milk per cow	2.0	2.3	2.8
Butter cows, thousands	924	1100	1016
Feed per cow (GJ)	21	22	25
Total Feed embodied in milk delivered to the dairies (PJ)	19.6	24.3	24.9
Total Energy, Dairying	23.2	27.5	28.4
in (%) of total Energy (including cows)	21%	21%	16%

Sources: Butter production is from Bjørn (1982, p.124). Kg of coal per kg of butter: 1890-1894, own calculations (see the text). Kg of milk per kg of butter: for 1890-94, Henriksen et al (2011); for 1900-04, MDS (1900); for 1910-13, MDS (1914). Metric tons of milk per cow comes from Wade (1981), using linear interpolation. Feed per cow as in the appendix.

Why Denmark?

- Free trade during first era of globalization: cheap grain
- Geography means cheap to transport coal anywhere in the country: relatively cheap coal
 - Nowhere more than 52km from the coast
 - One third (135) of European ports involved in coal trade Danish in 1865
- Labor expensive

Coal prices at the pithead and ports in current shillings per ton, 1850-1900

	United Kingdom	Germany	France	Italy	Denmark	Spain	Portugal
	Pithead	Pithead	Pithead	Imports	Imports	Imports	Imports
1850s	5.3				15-18		18
1860s	5.6			32	16-20	31-41 ^a	19
1870-72	6.5			29	19	28	23
1879-81	5.4			24	13	21	20
1884-86	5.1	5	9	21	13	18	17
1889-91	7.5	7	10	25	15	21	16
1899-01	9.2	9	12	29	14	24	18

Bob Allen's story: Incentive to switch to capital/energy intensive production



Conclusion

- Denmark relatively heavily dependent on energy during her development
- Relatively expensive labor, inexpensive energy
- Incentive to invest in capital intensive production form
- Feed also inexpensive due to free trade stance
- Incentive to begin capital intensive dairying
- Growth hypothesis: YES, coal was necessary
- Location hypothesis: YES, but economic not geographic distance

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The idea

- To provide a counterfactual to the point made by Henriques and Sharp (2016):
 - How would Denmark have looked without access to coal?
- We will use the First World War as a sort of 'natural experiment': coal from the UK was more or less cut off
- Creameries turned to alternative sources of fuel, e.g. wood and peat
- We expect to find much of the superiority of the Danish dairy industry would have been (was) lost
 - Potentially other development routes would have been taken

The data

- From 1899 a Committee for Creamery Statistics was responsible for compiling extremely detailed information annually for a large sample of creameries in Denmark
 - Dansk Mejeri-Drifts-Statistik (MDS, 'Operational Statistics for Danish Creameries')
- Includes information on, e.g.:
 - Inputs and outputs (mostly of butter)
 - Technologies employed
 - Energy source

A small excerpt from 1914

Fyns Mejeriforaning. 6 Tabel I. (Fortsat).									7																		
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A small excerpt from 1917

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Our approach

 Stochastic frontier model with a time-varying technical efficiency term (Battese and Coelli 1995)

$$y_{it} = \boldsymbol{\beta}' \boldsymbol{x}_{it} + \boldsymbol{v}_{it} - \boldsymbol{u}_{it}$$
(2)

where $u_{it} = g(z_{it})|U_i|$ where U_i is half normal

and $g(z_{it}) = \exp(\eta' z_{it})$

The method

 Stochastic Frontier Analysis (see also Henriksen, Lampe and Sharp 2010 and Lampe and Sharp 2015)

butter



Hypotheses

- We expect to see productivity losses when using sources other than coal
- Perhaps some areas were hit harder than others
 - E.g. Bornholm had some (poor quality) coal
- Of course the machinery was made to run on coal, so other technologies might have been used if it was not available...
- On the other hand the literature describes the difficulties for coal-poor countries when steam was the General Purpose Technology

Coal in Bornholm

