Is Free Trade the Great Destroyer of Biological Resources?

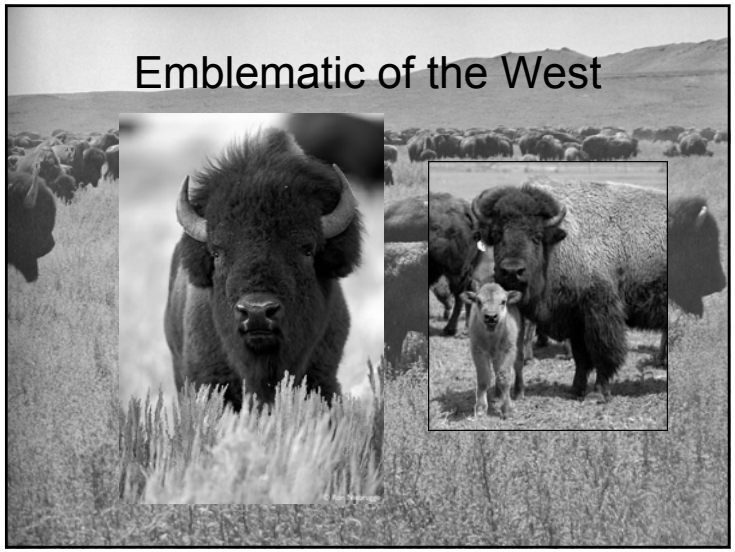
- An Empirical Example: Buffalo Hunt
- The Canonical Model
- Its too extreme
- Its trade pattern is wrong
- Property rights enforcement changes
- Empirical implementation

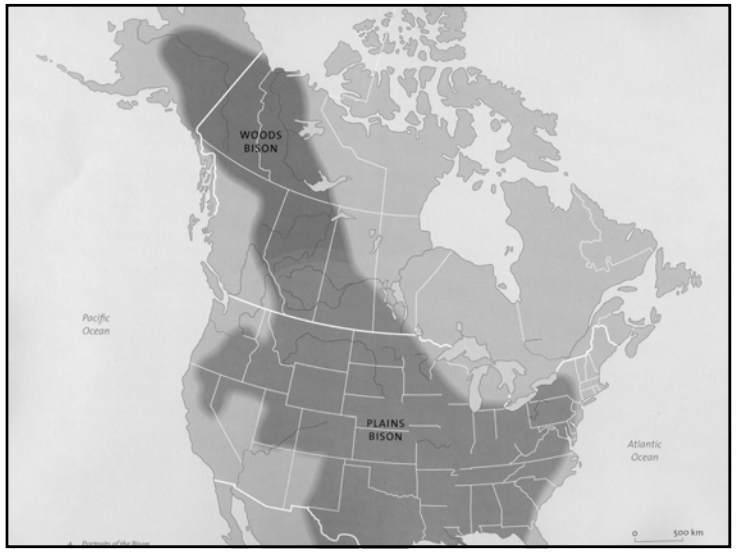
Buffalo Hunt

International Trade and the Virtual Extinction of the North American Bison

M. Scott Taylor, July 2007

Emblematic of the West





Not all of History is pleasant

- Unprecedented slaughter of the American Bison or Buffalo.

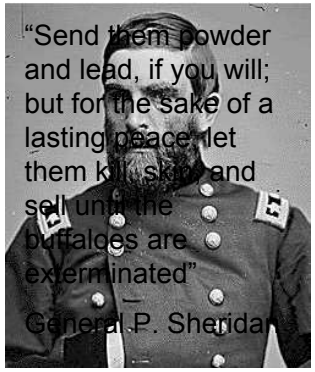
Facts About the Slaughter

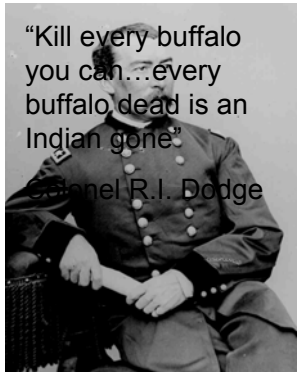
- Pre-European contact population of 25 to 30 million animals.
- Post civil war 1865 population of 10-15 million
- Slaughter on the “Great Plains”. In a little more than 10 years time, all but 100 killed.

Who Killed the Buffalo?

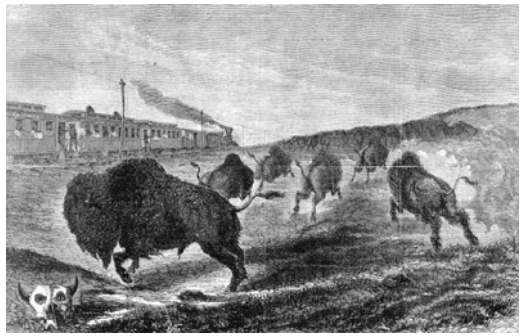
- Settlers came, bison habitat was reduced, buffalo numbers fell.

- The Army came, wanted the bison dead to "civilize" the Indians, they facilitated hunting, and buffalo numbers fell.

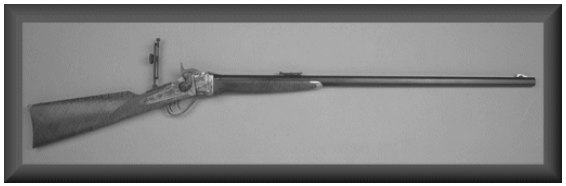




- The Railroads came, they created a market for their meat, robes and hides, they facilitated hunting, and buffalo numbers fell.



New rifles came, allowing hunters to shoot from 600 yards away and kill 100 buffalo in a "stand". The Sharp's Big 50 facilitated hunting, and buffalo numbers fell.



Whiskey and White traders altered Native hunting practices. Native hunting & drought killed the buffalo.

What needs to be Explained?

- Why was the slaughter a slaughter?
- Why didn't prices adjust to limit the slaughter?
- Where did all the buffalo products go?

My Claim

- An innovation in tanning of buffalo hides
- Open access to buffalo herds
- Fixed world price for hides

1. Slaughter compressed in time
2. Overshoot in hunter numbers, B&B.
3. Massive buffalo hide exports

Assumptions

- Large number of potential hunters
- Hunters differ in hunting skill
- Hunters hunt or produce outside good
- Killing is easier if the herd is larger
- No regulation of buffalo kill
- Tanning Innovation raises the value of buffalo products

The Model

$$h = \alpha S$$
$$o = 1$$

$$F(\alpha) \; with \; \alpha \in [0, \bar{\alpha}]$$
$$N = N_O + N_H$$

$$p\alpha S > w \rightarrow hunt$$
$$p\alpha S \leq w \rightarrow produce \, outside \, good$$

Define the marginal hunter

$\alpha^* : p\alpha^* S = w$

Define the smallest huntable herd

$S_S : p\bar{\alpha} S_S = w$

Define the kill function

$K(\alpha^*(p,S),S) = NS\int_{\alpha^*}^{\bar{\alpha}} \alpha f(\alpha) d\alpha \quad if\ S \geq S_S$

$K(\alpha^*(p,S),S) = 0 \quad if\ S < S_S$

$K(p,S) = K(\alpha^*(p,S),S)$

Resource Dynamics

$G(S) \geq 0$
$G(0) = G(C) = 0$
strictly concave

$\dot{S} = G(S) - K(p,S)$

Adding Up

$N = F(\alpha^*)N + [1 - F(\alpha^*)]N$

$F(\alpha^*) < 1,\ if\ S_S < C$

Prop. 1 & 2: Steady State is unique & stable

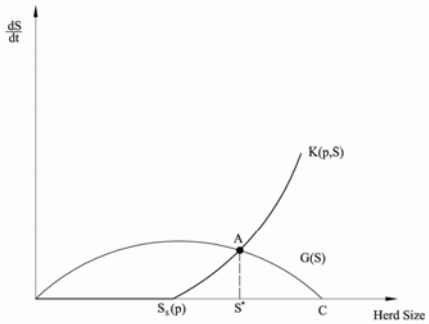


Figure 1

Prop. 3: Innovation creates excessive entry, and then exit along transition path. Herd size falls.

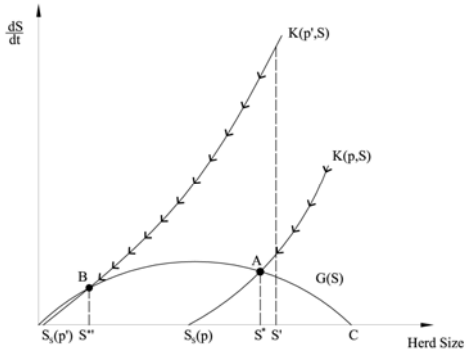


Figure 2

Is Trade Necessary?

- Suppose Innovation *was known* in the U.S
- Pennsylvania Tanners were successful
- Hides never traded: used domestically
- Innovation raises demand for buffalo products as before, but now the market for buffalo products has to clear.
- What would the implications be for prices, quantities, entry and exit?

Autarky

$$RD = \beta p^{-\sigma}$$

$$RS = K(p,S)/F(\alpha^*(p,S))$$

At a point in time, relative prices determined by

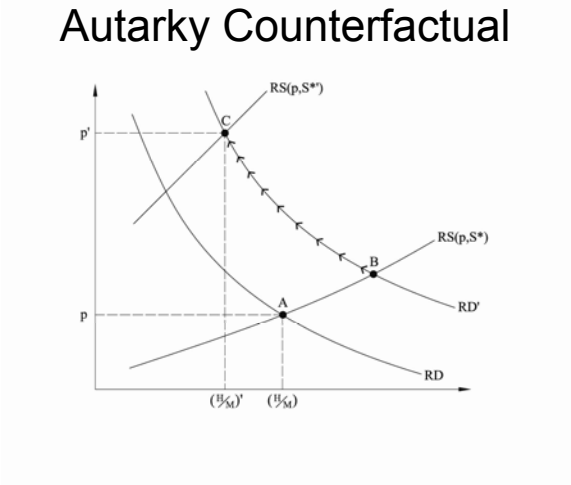
$$p^e : RD = RS$$

$$\alpha^* : \alpha^*(p^e, S)$$

Over time stock changes

$$\dot{S} = G(S) - K(p^e, S)$$

Autarky Counterfactual



Lemma 1, 2, Prop 4

Demand shock created by Innovation

1. Lowers steady state herd size
2. Raises hunter numbers on impact
3. Leads to excessive entry and then exit along the transition path only if σ>1
4. Hunter numbers either constant or rising along the transition path when σ≤1.

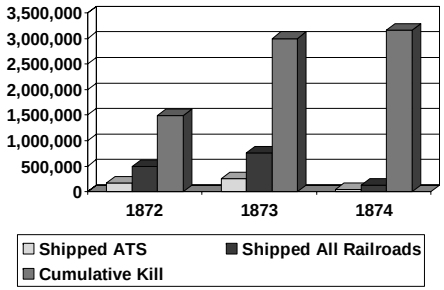
Empirical Evidence

Problem: There is no data!

"Had there been a deliberate plan for the suppression of all statistics relating to the slaughter of buffalo in the United States, and what it yielded, the result could not have been more complete barrenness than exists to-day in regard to this subject. There is only one railway company which kept its books in such a manner as to show the kind and quantity of its business at that time. Excepting this, nothing is known definitely"

William Temple Hornaday, Smithsonian National Museum Washington, 1889

Existing Empirical Evidence Colonel Dodge's 3 Numbers



- Some numbers from Northern shipping points.

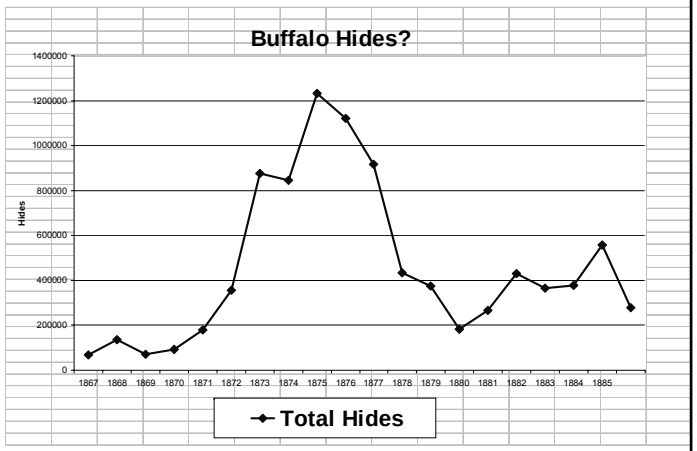
An Indirect Approach

- Hide Exports from United States to all countries annually over 1850-1890 Period
- Data includes country specific destination of exports
- Data mostly in value terms, but some quantity data as well.
- Problem: Hides include cattle hides & probably deer and goat skins

Table 1 – Hide Prices ($/Hide)

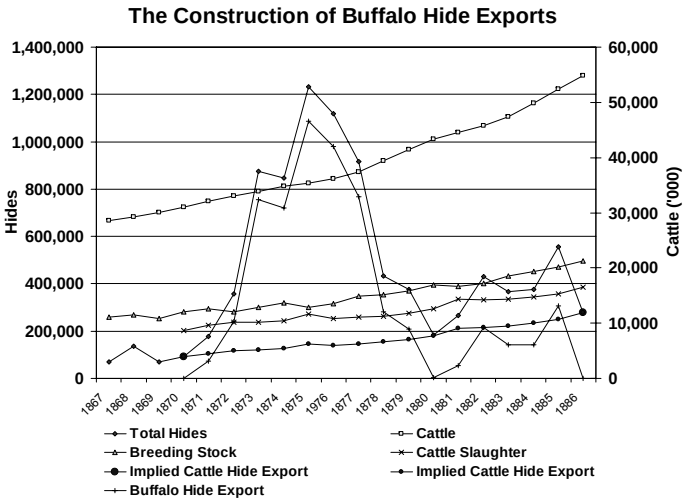
Year	W.P.	N.Y.	H.P.	Year	W.P.	N.Y.	H.P.
1866	4.56	4.74	0	1876	3.25	4.04	2.32
1867	4.12	4.82	0	1877	3.40	3.42	2.43
1868	3.93	4.43	0	1878	2.96	3.03	2.12
1869	4.18	4.66	0	1879	3.12	4.51	2.23
1870	3.99	4.51	0	1880	3.53	3.58	2.52
1871	3.93	4.35	2.81	1881	3.40	3.42	2.43
1873	4.12	4.35	2.94	1882	3.37	3.26	2.41
1873	4.12	4.35	2.94	1883	3.34	3.34	2.38
1874	3.99	4.20	2.85	1884	3.46	3.26	2.47
1875	3.84	3.89	2.74	1885	3.28	3.58	2.34

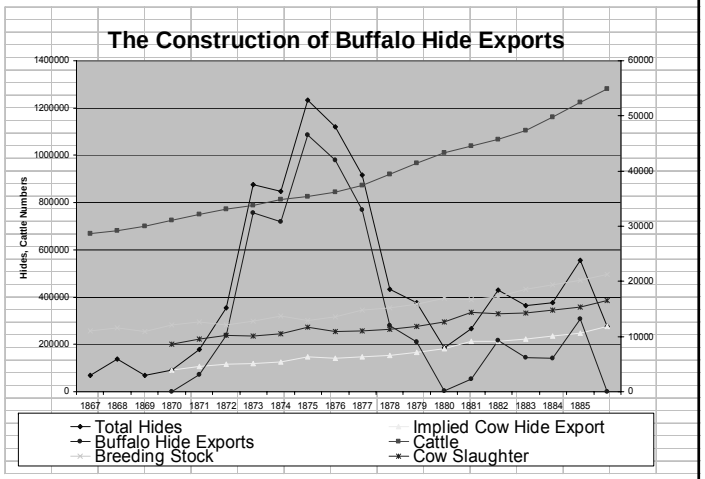
Notes: W.P. is hide prices found using the Warren and Pearson price index. N.Y. is hide prices found using data drawn from the Annual NY Chamber of Commerce reports. H.P. is the price-to-hunters series.

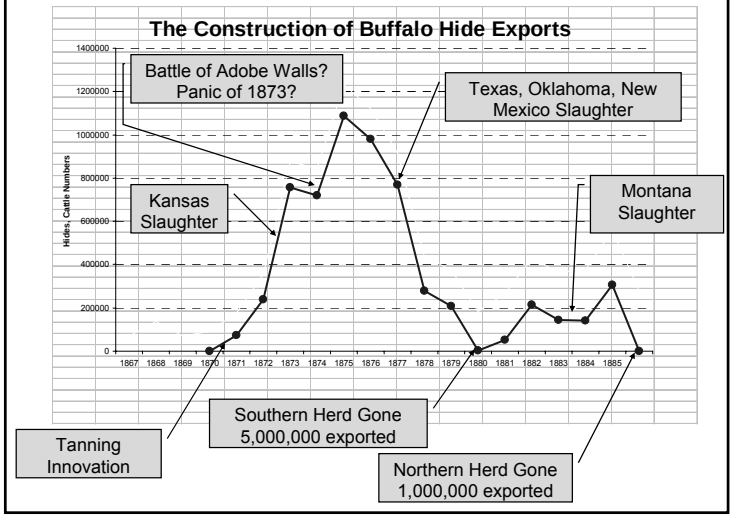


Method

- Eliminate cattle hides using model of the cattle industry (Rosen, Murphy and Scheinkman JPE (1994)).
- Cross-check export series against other historical data on variation over time in the slaughter, its location, and the geographic distribution of exports.
- Use country import data to provide another check using quasi-experimental approach.







Over Time Variation

- London Times Article of 1872 dates U.K innovation to 1871
- Timing of Destruction is correct for both North and South
- Blip at time of Adobe Walls and Panic of 1873
- Pause from 1879 to 1881 as Hunters move North

Magnitudes

- Relative size of Northern versus Southern exports accords with other accounts.
- Approximate kill for exports is 9 million over the entire period
- To destroy a Southern herd of 10 million by 1880, we need some domestic demand since exports represent only 7.6 million.

Geographic Variation

- Numerous Historic Accounts link W.C. Lobenstein with sales to England & J.N. Dubois with sales to Germany.
- Export data shows exports to U.K. boom first, followed by Germany and then France.
- English Business Directories list many tanneries offering Buffalo leather products; also show French tanneries offering buffalo products.


LEATHER MARKET, SOUTHWARK, LONDON, S.E.
Tanneries:—LONG LANE, BERMONDSEY, and DARTFORD, KENT.

SOLE LEATHER.

DRESSING LEATHER.

CURRIED LEATHER.

HEPBURN & GALE,
MANUFACTURERS OF
WIRE-SEWN AND OTHER MACHINE BANDS,
LEATHER HOSE PIPES, CUP & HYDRAULIC LEATHERS.

HEPBURN'S PUMP LEATHER WATERPROOF

SINGLE, DOUBLE, AND COMPOSITE WIRE-SEWN LEATHER BANDS FOR PORTABLE ENGINES.
INDIA RUBBER BELTS, AND RUBBER GOODS FOR ALL MECHANICAL PURPOSES.

EXCELSIOR COMPOUND,
FOR PRESERVING LEATHER BELTS AND INCREASING THEIR GRIPPING POWER.

LONG LANE, SOUTHWARK, LONDON, S.E.
85 M—1a


JOHN TULLIS & SON,
TANNERS, CURRIERS, AND
LEATHER BELT MANUFACTURERS.
SPECIAL MACHINERY FOR MANUFACTURING MAIN DRIVING BELTS. ALL STRAPS INDIVIDUALLY STRETCHED & TRIMMED BEFORE FITTING UP

The Leather we use is all Oak Bark Tanned, and being from the primest of Native Fresh Hides, is necessarily of the best selection and description possible, well grown and well seasoned. Our Manufactory embraces:—Belting, both Single and Double, with Lace Sewing, Wax Thread Sewing, Copper Wire Sewing, Copper Riveted, or Cemented only, just as may be required: Hose Piping, light and heavy, for Brigade and other purposes; Pump Butts; Press Butts; Picking Bands (Oak Tanned and Green); Skirps; Crown, Antilope, Cordovan, Cowhide and White Laces; Leather and Buffalo Pickers of all kinds and dimensions, with every variety of Mechanical Leathers generally.
We are the largest Makers in the Trade. Our Works, in extent and thorough completeness and efficiency of productive facilities, are unsurpassed.
*** *Manufacturing Mechanical Leather has been our Sole Business for Forty Years.* ***
PRICE LISTS AND SAMPLES ON APPLICATION.

ST. ANN'S LEATHER WORKS, GLASGOW.
Manchester Office, 6 New Market Lane—EDWARD ASHWORTH, Manager
80 M—1-1

Alternative Explanations for the Data

- Could the data be explained by a European demand shock that raised US exports of hides at just the right time?
- Could the data be explained by a US supply shock that raised supply of hides in the US?

European Demand Shock

- Collected data from all European countries that were large destinations for U.S. hide exports.
- Data is the complete set of U.K. and French hide imports from all countries from 1866 to 1888.
- Data is on raw hide imports.
- Construct US shares of European markets. Is the share stable over time?

Table 2 – Difference in Means Test

H_0: m_0-m_1=0
H_1: m_0-m_1<0

	Difference	T	P<t
France	-5.02[a]	-3.69	0.001
	(1.36)		
UK	-3.39[a]	-2.71	0.001
	(1.25)		

Notes: m_1 is the mean of the Southern Treatment Group and m_0 is the mean of the Other group. Standard errors are reported in parentheses, t is Student's t-statistic, and P indicates probability values. The superscripts. [a,b,c]: indicate significance at 0.01, 0.5, 0.1 level respectively. The dependent variable is the share of raw hide imports from the U.S. in total raw hide imports from all countries.

U.S. Supply Shock

- Collected UK, French, Canadian and German import statistics. German data useless.
- U.K, France as Treatment with Innovation
- Canada as control without Innovation
- Share of Raw Hide imports from U.S. as dependent variable.
- Difference-in-Difference-in-Difference Estimation on shares.

3D Estimation

$$s_{it} = \alpha_i + \beta_{it} t + \gamma T_{it}^S + \delta T_{it}^N + \varepsilon_{it}$$

$i = Canada, France, U.K.$

$t = 1, 2, 3, ...$

s_{it} *share of raw hide imports from the U.S. in total raw hide imports*

For the U.K and France

T_{it}^S *= 1 when Southern herd eliminated, 1872 - 1879, and 0 otherwise*

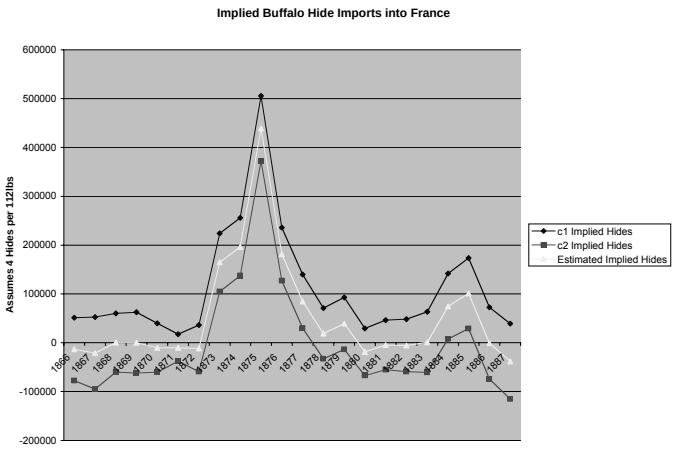
T_{it}^N *= 1 when Northern herd eliminated, 1882 - 1886, and 0 otherwise*

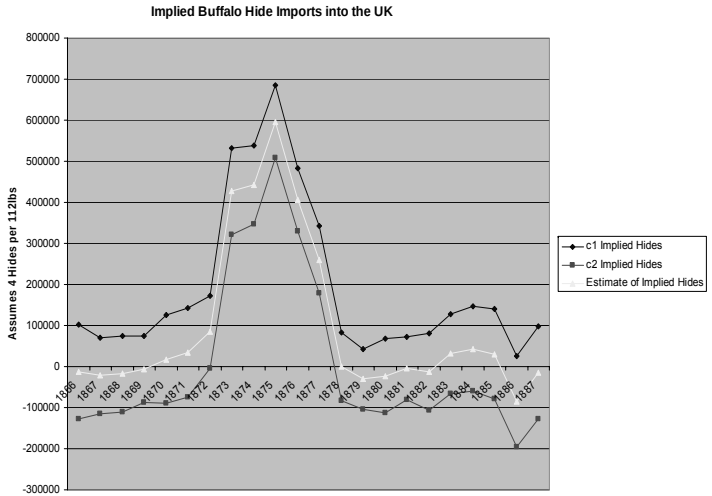
For Canada

$T_{it}^S = T_{it}^N = 0$, *always*

Table 4 – A Quasi Experiment

Dependent variable is s_{it} i={Canada, France ,UK}	I	II	III	IV	V
France Intercept	-.33	.24			
	(2.24)	(1.83)			
UK Intercept	1.24	.67			
	(2.24)	(1.83)			
Europe Intercept			.46	.47	.60
			(1.67)	(1.46)	(1.42)
Canada Intercept	91.12 [a]	91.12 [a]	91.12 [a]	91.08 [a]	90.73 [a]
	(2.06)	(2.05)	(2.03)	(1.57)	(1.41)
France Time	.09			.04	.07
	(.19)			(.11)	(.09)
UK Time	-.01				
	(.19)				
Europe Time		.04	.03		
		(.15)	(.15)		
Canada Time	.03	.03	.03		
	(.16)	(.15)	(.15)		
Time				.04	.07
				(.11)	(.09)
North Treatment	1.07	1.07	1.07	1.10	
	(2.51)	(2.49)	(2.47)	(2.16)	
South Treatment	4.80[a]	4.80[a]	4.80[a]	4.81[a]	4.38[a]
	(1.71)	(1.70)	(1.68)	(1.65)	(1.41)
R^2 adjusted	.99	.99	.99	.99	.99
RMSE	4.67	4.63	4.60	4.56	4.53
No. Obs	66	66	66	66	66





Who killed the Buffalo?

- Tanning Innovation created in Europe
- Robust demand comes from Europe
- Is Europe responsible for the most shameful Environmental event in U.S. history?

Conclusion

- Standard accounts of the “Slaughter on the Plains” are incomplete. Theory and empirical evidence strongly in favor of the export driven slaughter explanation. Economics works!
- Tells us institutional or regulatory change can be very slow relative to the speed of market forces.
- Market forces are also extremely powerful. Waiting for development to create regulatory changes is a risky business.

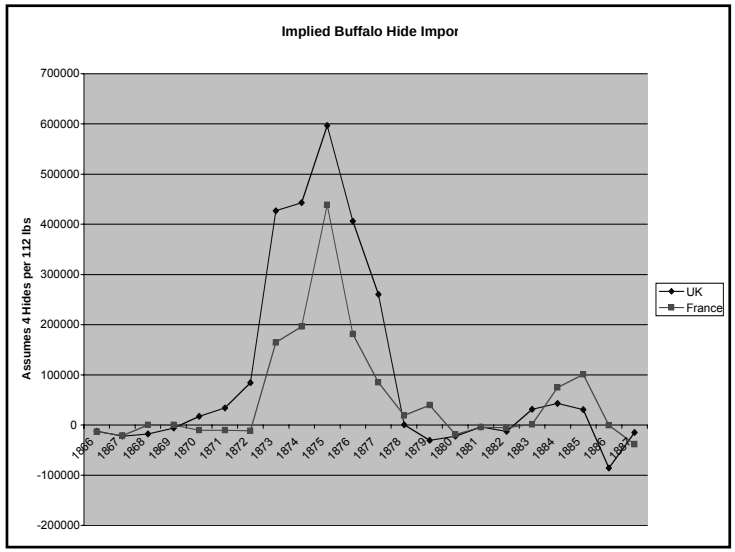
- The Canonical Model

- Its too extreme

- Its trade pattern is wrong

- Property rights enforcement change

- Empirical implementation



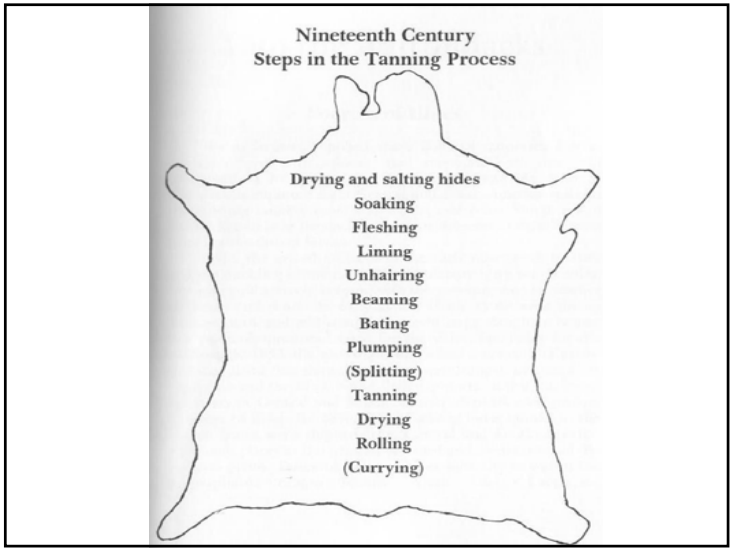


Table 3 – Summary Statistics
U.S. Share of Raw Hide Imports

Country	Mean	Median	Std. Dev.	Min.	Max.	No.Obs.
Canada	91.5	93.1	6.6	70	97	22
France	2.9	1.7	3.3	.03	13.4	22
UK	3.4	1.6	3.9	.11	13.6	22

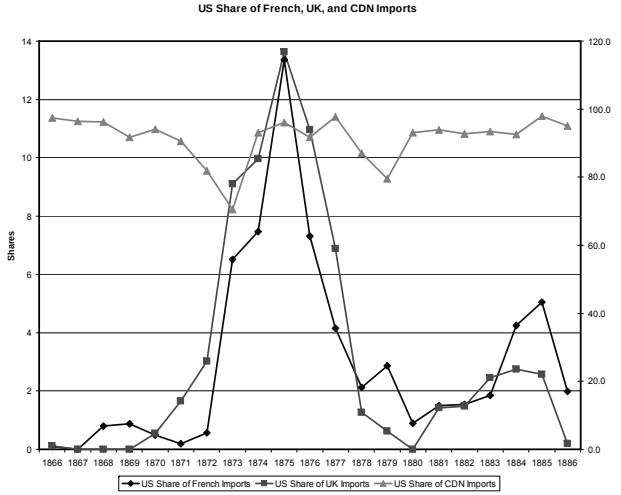
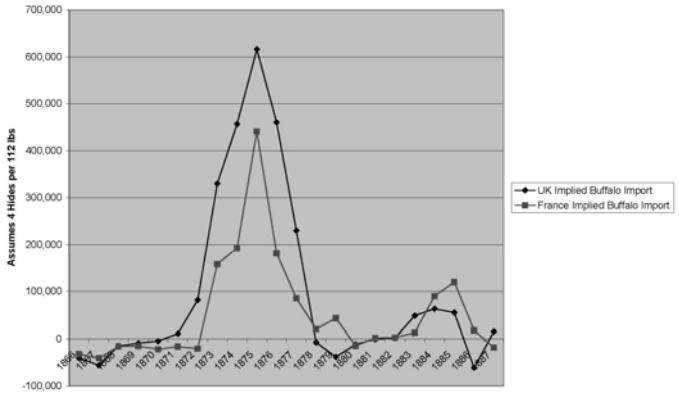


Figure 4
Implied Buffalo Hide Imports



Not quite!

- US policymakers are complicit but not causal.
- Railroads were helpful but not critical.
- New rifles helped as did perhaps the Civil War.
- Little evidence that environmental change or native over hunting did much at all.