Economics 210A
Spring 2015

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LECTURE 4
Industrialization

February 18, 2015

I. Overview

Three Debates

- Pace of GDP growth and productivity growth.
- Nature of the productivity change in manufacturing: widespread or limited?
- Did ordinary workers benefit?

Estimates of GDP and Productivity Growth

Table 1
Previous estimates of productivity growth in England, 1760–1831

Annual percentage rate of change	Y	K	L	T	TFP
Feinstein (1981)					
1760–1800	1.1	1	0.8	—	0.2
1801–1831	2.7	1.4	1.4	—	1.3
1831–1860	2.5	2.0	1.4		0.8
Crafts (1985)					
1760–1800	1	1	0.8	0.2	0.2
1801–1831	2	1.5	1.4	0.4	0.7
1831–1860	2.5	2.0	1.4	0.6	1.0
Crafts and Harley (1992)					
1760–1801	1	1	0.8	—	0.1
1801–1831	1.9	1.7	1.4	—	0.35
1831–1860	2.5	2	1.4		0.8
Broadberry, et al. (2011)					
1760–1801	1.2				
1801–1830	1.6				
1830–1870	2.5				

From: Antràs and Voth, "Factor Prices and Productivity Growth," and Broadberry, et al., "British Economic Growth, 1270-1870"

Papers for today all use unusual data or approaches to advance the debates.

- Temin uses trade data to investigate the question of whether the changes were widespread or limited.
- Nicholas and Steckel use height data to infer changes in the standard of living.
- Antràs and Voth use factor prices to deduce overall productivity growth.

II. Peter Temin

"Two Views of the British Industrial Revolution"

TABLE 1
CONTRIBUTIONS TO NATIONAL PRODUCTIVITY GROWTH, 1780–1860
(percentage per annum)

Sector	McCloskey	Crafts	Harley
Cotton	0.18	0.18	0.13
Worsteds	0.06	0.06	0.05
Woolens	0.03	0.03	0.02
Iron	0.02	0.02	0.02
Canals and railroads	0.09	0.09	0.09
Shipping	0.14	0.14	0.03
Sum of modernized	0.52	0.52	0.34
Agriculture	0.12	0.12	0.19
All others	0.55	0.07	0.02
Total	1.19	0.71	0.55

Sources: McCloskey, "Industrial Revolution," p. 114; Crafts, *British Economic Growth*, p. 86; and Harley, "Reassessing the Industrial Revolution," p. 200.

From: Temin, "Two Views of the British Industrial Revolution"

Comparative Advantage with Many Goods

- Focus just on manufactured goods.
- Assume labor is the only input.
- a_i is the hours of labor needed to produce one unit of good i in Britain.
- a_i^* is the hours of labor needed to produce one unit of good i elsewhere.
- a_i^*/a_i is relative productivity.

Comparative Advantage with Many Goods

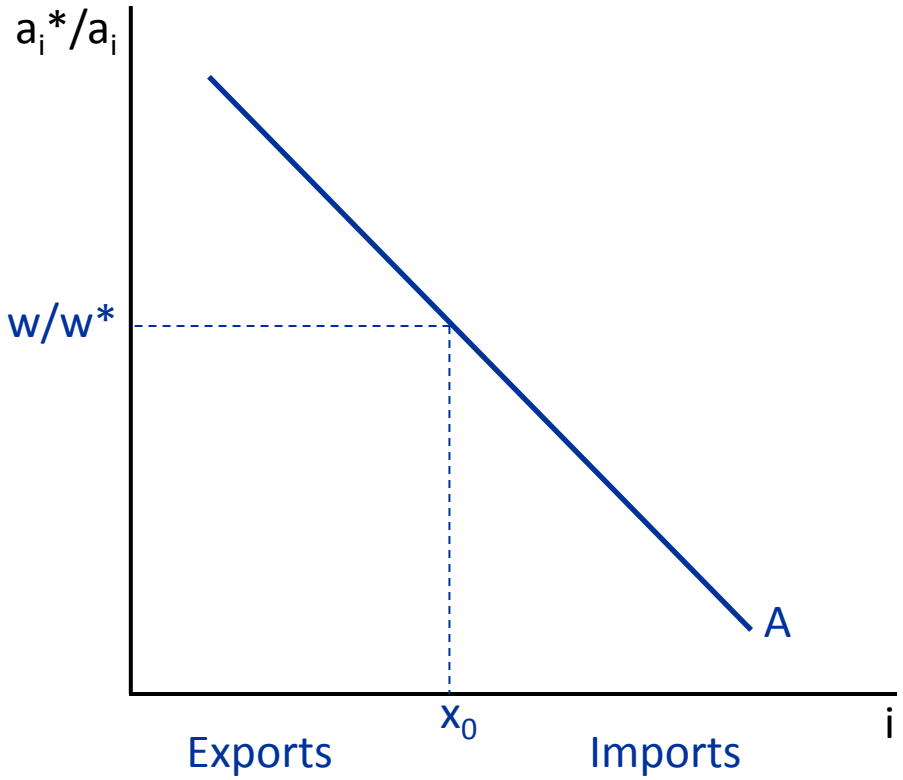
- Can order manufactured goods from 1 to N, where 1 has greatest productivity advantage for Britain.

$$a_1^*/a_1 > a_2^*/a_2 > a_3^*/a_3 > \cdots > a_N^*/a_N$$

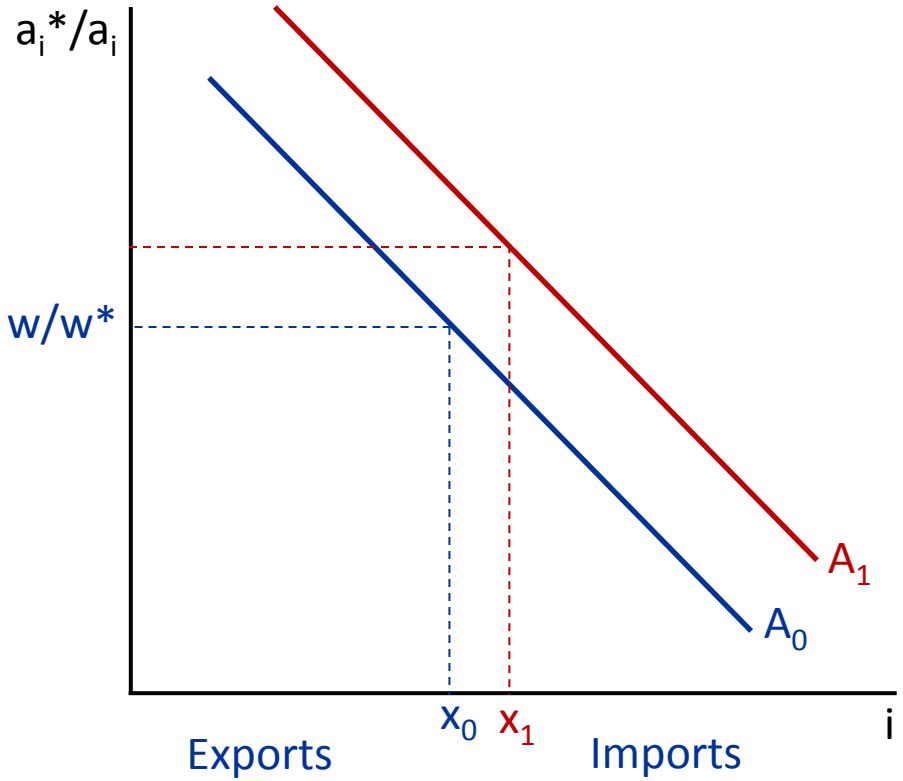
- Let w be the wage in Britain; w* the wage elsewhere.

- Britain exports goods for which $a_i^* w^* > a_i w$, or $a_i^*/a_i > w/w^*$

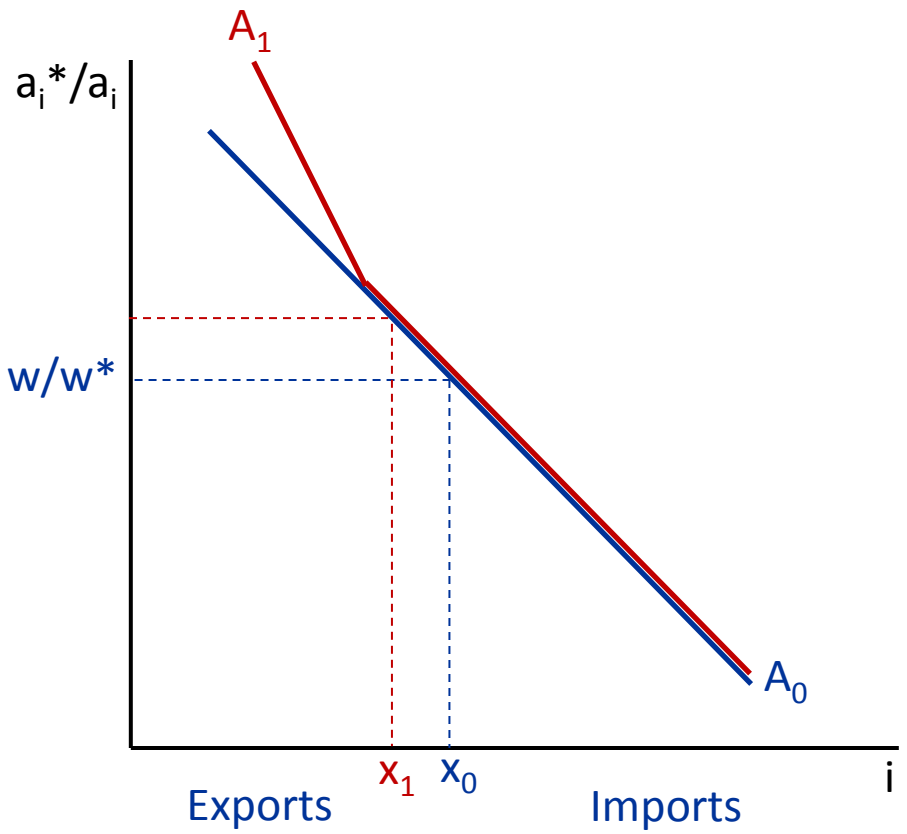
Comparative Advantage with Many Goods



Widespread Technological Progress in Manufacturing



Technological Progress in a Few Industries



Predictions for the Range of Manufactured Goods Exported

- General technological change in manufacturing leads to a widening of the range.
- Technological change in just a few key industries leads to a narrowing of the range.
- Productivity increase in agriculture (relative to manufacturing) will accentuate the narrowing of the range.

TABLE 3
EXPORTS OF OTHER MANUFACTURES, 1850–1852

Export	Value (pounds sterling)
Linens	4,694,567
Hardwares and cutlery	2,556,441
Brass and copper manufactures	1,830,793
Haberdashery and millinery	1,463,191
Silk manufactures	1,193,537
Earthenware of all sorts	975,855
Machinery and millwork	970,077
Tin and pewter wares and tin plates	904,275
Apparel, slops, and Negro clothing	892,105
Beer and ale	513,044
Arms and ammunition	505,096
Stationary/stationery of all sorts	373,987
Apothecary wares	354,962
Lead and shot	339,773
Glass/glass of all sorts	296,331
Plate, plated ware, jewelry, and watches	286,738
Soap and candles	275,200
Painters' colors and materials	237,880
Books, printed	234,190
Cabinet and upholstery wares	155,407
Cordage	155,127
Leather saddlery and harness	121,401
Hats of all other sorts	106,933
Musical instruments	85,006
Umbrellas and parasols	72,928
Carriages of all sorts	57,018
Spirits	52,843
Fishing tackles	41,607
Hats, beaver and felt	34,351
Mathematical and optical instruments	34,289
Spelter, wrought, and unwrought	22,097
Bread and biscuit	15,529
Tobacco (manufactured) and snuff	14,762

Source: U.K., *Parliamentary Papers*, 1852 (196), vol. 28, pt. 1.

TABLE 4

CORRELATIONS AMONG OTHER MANUFACTURING EXPORTS

Years	Number of Observations	Correlation
1811–1813 and 1830–1832	18	0.95
1830–1832 and 1850–1852	28	0.93
1811–8113 and 1816–1818	15	0.78
1816–1818 and 1821–1823	21	0.90
1821–1823 and 1826–1828	21	0.97
1826–1828 and 1830–1832	28	0.98

Source: U.K., *Parliamentary Papers*, 1812–13 (100), vol. 11, pt. 1; ibid., 1818 (147), vol. 12, pt. 1.; ibid., 1823 (220), vol. 12, pt. 1; ibid.,1828 (130), vol. 16, pt. 1; ibid., 1831–32 (310), vol. 26, pt. 1; ibid., 1852 (196), vol. 28, pt. 1.

From: Temin, "Two Views of the British Industrial Revolution"

TABLE 5
VALUE OF IMPORTS, 1850–1852

Import	Value (pounds sterling)
Wool, cotton	23,670,472
Sugar	10,762,045
Corn, meal, and flour	9,167,600
Tea	5,796,086
Silk	5,163,865
Coffee	3,480,594
Flax, and tow or codilla of hemp and flax	3,123,329
Wool, sheep's	2,049,348
Hides, raw or tanned	1,999,233
Cochineal, granilla, and dust	1,909,848
Oil	1,793,320
Madder, madder root, and garancine	1,687,568
Guano	1,476,940
Tallow	1,333,889
Indigo	1,191,495
Wood and timber	1,153,477
Dye and hardwoods	1,104,308
Hemp, dressed or undressed	990,917
Spelter	957,540
Wines	927,721
Spirits	902,351
...	
Cloves	106,630
Animals, living; viz. oxen, bulls, cows, and calves	103,463
Watches	95,928
Safflower	94,911
Boots, shoes and calashes, and boot fronts	94,779
Pepper	93,744
Lace, thread, and cushion or pillow lace	82,816
Leather gloves	81,441
Shumac	80,320
Oranges and lemons	74,845
Yarn, worsted or silk and worsted	73,690
Clocks	73,661
Rhubarb	70,912
Whalefins	69,277

From: Temin, "Two Views of the British Industrial Revolution"

Evaluation of Temin's Analysis

- Very clever.
- More narrative evidence might have been useful.
- Data analysis could have been more precise; in particular more focus on changes than on list of exports as of 1850.

Factors that Could Affect the Results

- A rise in net capital outflows.
- Including another factor: scarce land.
- Technological progress abroad.
- Changes in trade protection.

III. Stephen Nicholas and Richard Steckel

"Heights and Living Standards of English Workers during the Early Years of Industrialization, 1770-1815"

Alternative Real Wage Series

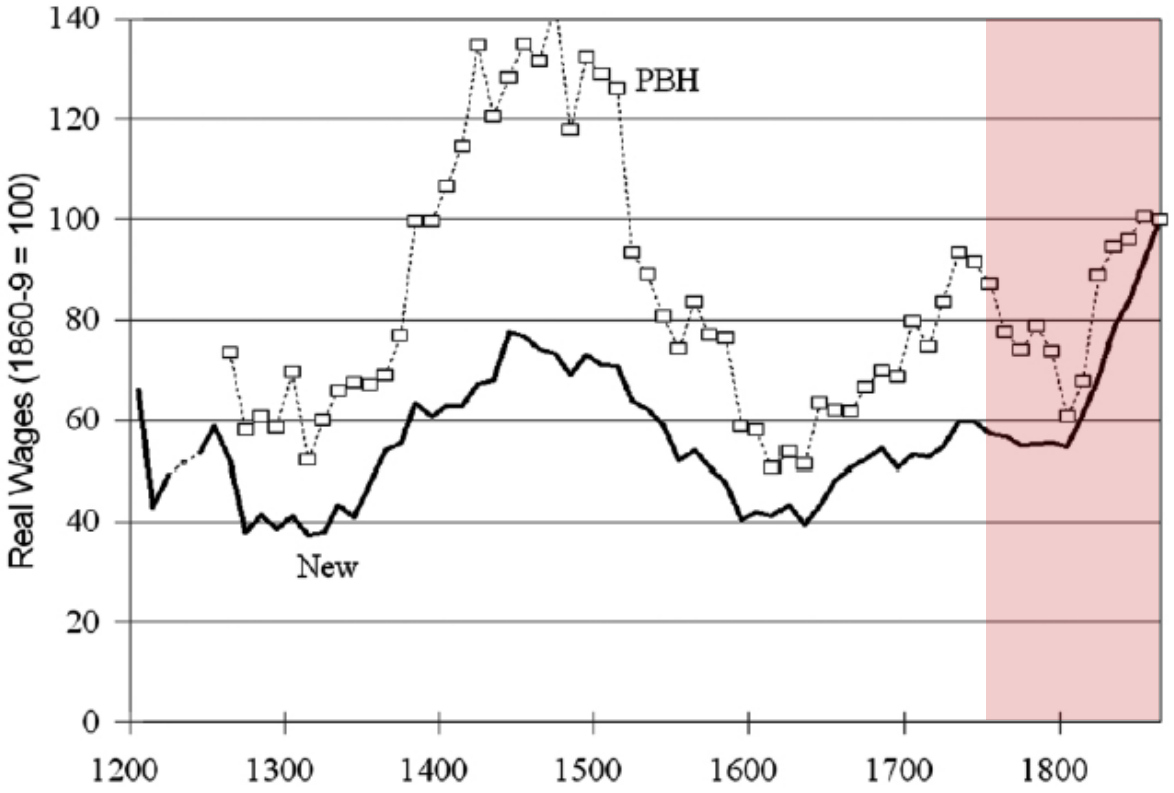


FIG. 4.—Real wages, 1200–1869, Phelps Brown and Hopkins vs. new series. In both series, 1860–69 has been set to 100. Sources: Phelps Brown and Hopkins (1981, 28–31), table A2.

From: Clark, "The Condition of the Working Class in England, 1209-2004"

Nicholas and Steckel's Approach

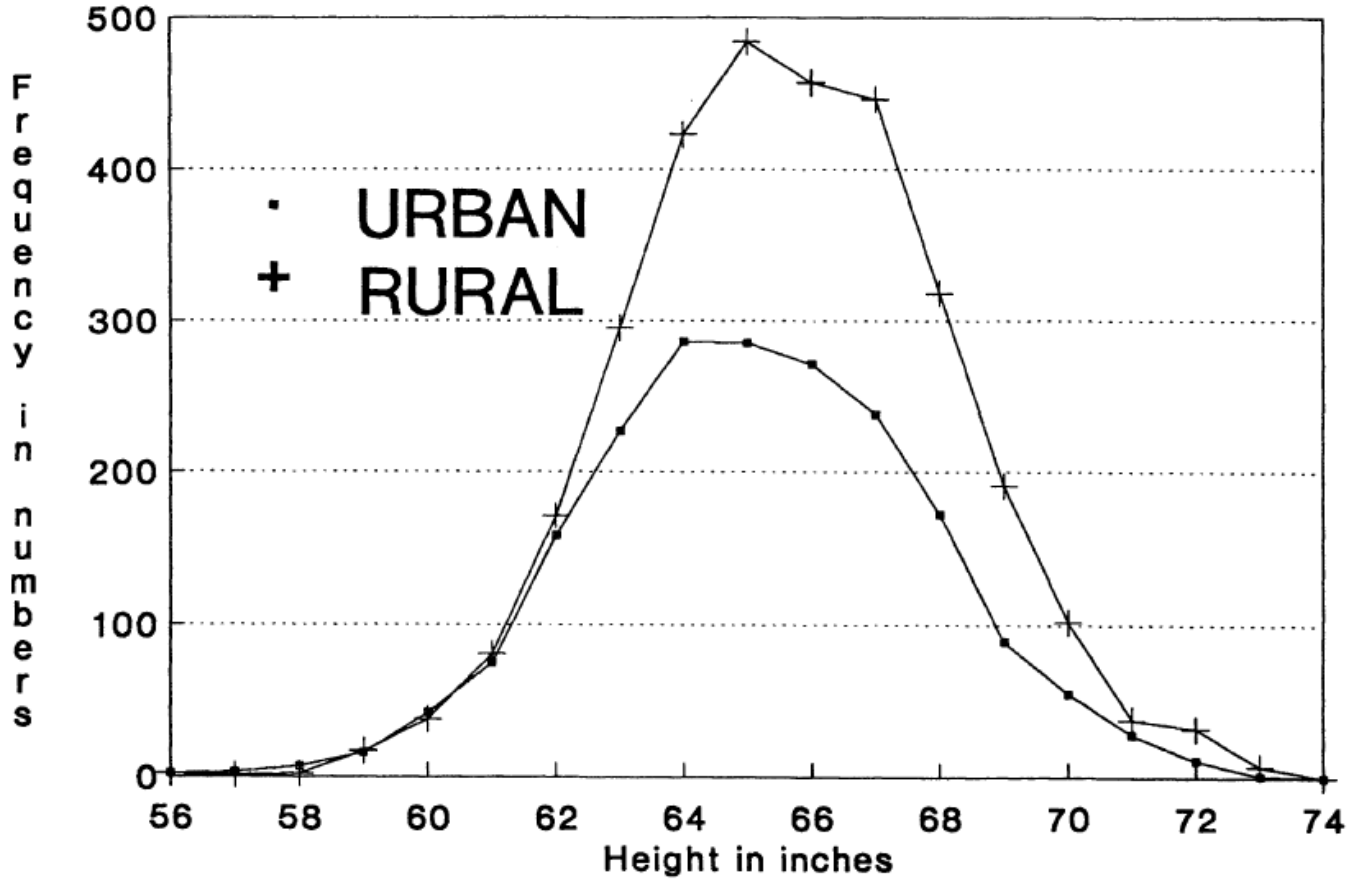
- Use height of a cohort as an indicator of standard of living in first 15-20 years of life.
- Sensible?

Nicholas and Steckel's Data

- Source?
- Strengths and weaknesses?

FIGURE 1

HEIGHT FREQUENCY FOR URBAN AND RURAL MALE ENGLISH WORKERS
(23 TO 49 YEARS)



From: Nicholas and Steckel, "Heights and Living Standards"

Nicholas and Steckel's Data

- Source?
- Strengths and weaknesses?
- Why do we want Irish convicts as a control?
- Is the sample representative; do we care?

TABLE 2
SKILL CLASSIFICATION OF ENGLISH WORK FORCE AND ENGLISH TRANSPORTED CONVICTS
(in percentages)

Armstrong Classification	English 1841 Census (Male Only)	English Convicts (Male Only)
1. Professional	1.7	0.3
2. Intermediate	9.2	3.1
3. Skilled	47.9	45.6
4. Semiskilled	25.7	26.3
5. Unskilled	15.5	24.7

Sources: Great Britain, *1841 Census*; and *Convict Indents*.

From: Nicholas and Steckel, "Heights and Living Standards"

TABLE 4

TERMINAL HEIGHT AND *t*-TEST OF DIFFERENCES IN TERMINAL HEIGHTS OF CONVICTS

	English	Rural English	Urban English	Irish	Rural Irish	Urban Irish
Height (in inches)	65.76	65.96	65.44	66.03	66.10	65.82
English		3.61*	4.82*	5.25*	5.20*	0.63
Rural English			7.12*	1.07	1.94	1.39
Urban English				7.87*	8.16*	3.57*

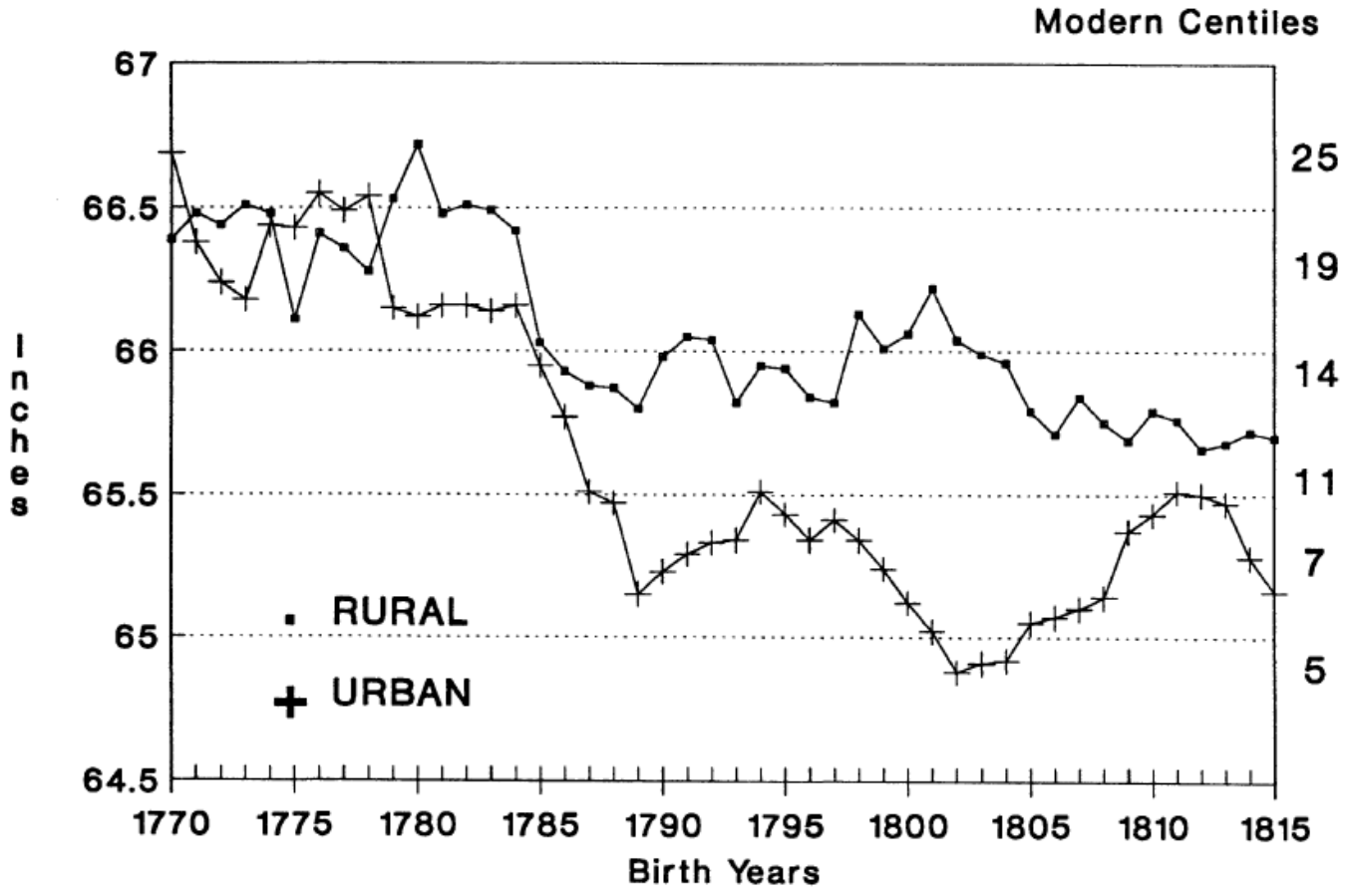
* = significant at the 5 percent level

Source: *Convict Indents*.

From: Nicholas and Steckel, "Heights and Living Standards"

FIGURE 3

HEIGHT PROFILE OF ENGLISH WORKERS 23 TO 49: 5-YEAR MOVING AVERAGE



From: Nicholas and Steckel, "Heights and Living Standards"

TABLE 7
TERMINAL HEIGHT FOR THE REGIONAL MODEL
(in inches)

Region	Rural	Urban
London/home counties	65.68	64.80
	(490)	(642)
South	65.92	65.91
	(1,000)	(337)
Midlands	65.84	65.41
	(713)	(439)
North	66.05	65.63
	(670)	(456)
Fringe	66.59	66.20
	(67)	(41)

Note: Sample sizes are given in parentheses.

- North and Fringe taller than London, South, and Midlands

From: Nicholas and Steckel, "Heights and Living Standards"

Evaluation of Nicholas and Steckel

- Clever; innovative at the time.
- Needs more separation of the forest from the trees.
- Did you find them convincing?

IV. Pol Antràs and Hans-Joachim Voth

"Factor Prices and Productivity Growth during the British Industrial Revolution"

The Dual Approach

- Simple case: One factor of production, so $Y(t) = F(L(t); t)$. Constant returns to scale in *L*.
- Constant returns implies that labor's marginal product equals its average product: $Y(t) = MPL(t)L(t)$.
- So: $\dot{Y}(t) = MPL(t)\dot{L}(t) + L(t)\dot{MPL}(t)$,

which implies $\dot{Y}(t) - MPL(t)\dot{L}(t) = L(t)\dot{MPL}(t)$.

- Dividing both sides by Y yields: $\frac{\dot{Y}(t)}{Y(t)} - \frac{\dot{L}(t)}{L(t)} = \frac{\dot{MPL}(t)}{MPL(t)}$.
- Thus: Growth not coming from increases in inputs is reflected in a higher marginal product of labor.

The Big Advantage of the Dual Approach

- Recall: $\frac{\dot{Y}(t)}{Y(t)} - \frac{\dot{L}(t)}{L(t)} = \frac{\dot{MPL}(t)}{MPL(t)}$.

- If factors are paid their marginal products: Mainly requires data on prices, not quantities.

Multiple Factors

- Assume $Y(t) = F(K(t), L(t), T(t); t)$, with constant returns to scale in *K*, *L*, and *T* (*T* is land).

- The constant returns to scale assumption implies:

$$Y(t) = MPK(t)K(t) + MPL(t)L(t) + MPT(t)T(t).$$

- Differentiating both sides with respect to t:

$$\dot{Y}(t) = MPK(t)\dot{K}(t) + MPL(t)\dot{L}(t) + MPT(t)\dot{T}(t) + K(t)\dot{MPK}(t) + L(t)\dot{MPL}(t) + T(t)\dot{MPT}(t).$$

Multiple Factors (continued)

- $\dot{Y}(t) = MPK(t)\dot{K}(t) + MPL(t)\dot{L}(t) + MPT(t)\dot{T}(t) + K(t)\dot{MPK}(t) + L(t)\dot{MPL}(t) + T(t)\dot{MPT}(t)$.
- Hence, the Solow residual (in terms of the change in *Y*, rather than its growth rate), $\dot{Y}(t) - MPK(t)\dot{K}(t) + MPL(t)\dot{L}(t) + MPT(t)\dot{T}(t)$, equals $K(t)\dot{MPK}(t) + L(t)\dot{MPL}(t) + T(t)\dot{MPT}(t)$.
- Intuition: If technology improves, at least some factors of production will have higher marginal products. We can use a weighted sum of increases in marginal products to estimate technological progress.

From Time Derivatives to Growth Rates

- Algebra yields:

$$g_Y(t) - [\eta_K(t)g_K(t) + \eta_L(t)g_L(t) + \eta_T(t)g_T(t)]$$
$$= \eta_K(t)g_{MPK}(t) + \eta_L(t)g_{MPL}(t) + \eta_T(t)g_{MPT}(t),$$

where:

$g_X(t) \equiv \frac{\dot{X}(t)}{X(t)}$, the growth rate of *X*,

$\eta_X(t) \equiv \frac{MPX(t)X(t)}{Y(t)}$, the elasticity of *Y* with respect to *X*.

- Thus: Productivity growth equals a weighted average of the growth rates of factors' marginal products.

Some Issues in Implementing This Approach

- Did factor payments equal marginal products?
- Capital is owned, not rented. User cost of capital: $p_K \left\{ r + \delta - E\left[\frac{\dot{p_K}}{p_K}\right] \right\}$.
- $r = i - \pi^e$. What i to use? How do we measure π^e?
- Labor is heterogeneous. (So are capital and land.)
- Need <u>real</u> marginal products, so need a price index.
- …

Some Specifics

- They set $\eta_L = 0.5$, $\eta_K = 0.35$, $\eta_T = 0.15$.
- Baseline data sources ("Benchmark 1"): Wages from Feinstein; land rents from Clark: prices from Feinstein; price of capital from Feinstein; depreciation from Feinstein and Pollard; interest rate from consol yields.
- "Benchmark 2": Same as Benchmark 1, but corrects for CPI vs. GDP deflator.
- "Preferred": Same as 1, but uses GDP deflator in place of CPI, and corrects for indirect business taxes.

Table 3
Estimates of productivity growth in England, 1770–1860

Annual percentage rate of change	r	w	q		TFP
Benchmark Estimate 1					
1770–1800	−0.39	0.40	0.27		0.10
1800–1830	0.82	0.34	0.87		0.59
1830–1860	−0.33	0.56	0.36		0.22
1770–1830	0.22	0.37	0.57		0.35
Benchmark Estimate 2				*tot*	
1800–1830	0.82	0.34	0.87	−1.22	0.71
1830–1860	−0.33	0.56	0.36	−1.61	0.44
Preferred Estimate				*gov*	
1770–1800	−0.40	0.35	0.26	2.60	0.27
1800–1830	0.71	0.25	0.76	1.11	0.54
1830–1860	−0.21	0.68	0.48	0.31	0.33
1770–1830	0.15	0.30	0.51	1.85	0.41

[…]

From: Antràs and Voth, "Factor Prices and Productivity Growth"

Table 3
Estimates of productivity growth in England, 1770–1860

Annual percentage rate of change	r	w	q		TFP
Preferred Estimate				*gov*	
1770–1800	−0.40	0.35	0.26	2.60	0.27
1800–1830	0.71	0.25	0.76	1.11	0.54
1830–1860	−0.21	0.68	0.48	0.31	0.33
1770–1830	0.15	0.30	0.51	1.85	0.41
[...]					
	Y	K	L	T	
Crafts and Harley (1992)					
1760–1801	1	1	0.8	–	0.1
1801–1831	1.9	1.7	1.4	–	0.35
1760–1831	1.45	1.35	1.1		0.22
Crafts and Harley (1992)—three-factors*					
1760–1800	1	1	0.8	0.2	0.19
1801–1831	1.9	1.7	1.4	0.4	0.50
1831–1860	2.5	2.0	1.4	0.6	1.00
1760–1831	1.45	1.35	1.1	0.3	0.34

From: Antràs and Voth, "Factor Prices and Productivity Growth"

What (If Anything) Is a Reasonable Candidate Source of Large Errors in Antràs and Voth's Results?

- * Large errors in the price index. *
- (Perhaps.) Missing a large part of income, perhaps from returns to entrepreneurship, or perhaps from monopoly or monopsony profits.
- (Perhaps.) A combination of many small errors.

Table 5
Sensitivity tests—alternative rent, cost of capital, and price indices

Estimate		Percentage rate of change	*r*	*w*	*q*	*gov*	TFP
Preferred estimate	1	1770–1800	−0.40	0.35	0.26	2.60	0.27
		1800–1830	0.71	0.25	0.76	1.11	0.54
		1830–1860	−0.21	0.68	0.48	0.31	0.33
		1770–1830	**0.15**	**0.30**	**0.51**	**1.85**	**0.41**
[...]							
Lindert–Williamson price index	5	1780–1800	1.00	0.11	0.41	2.56	0.64
		1800–1830	−0.24	0.79	1.33	1.67	0.60
		1830–1860	2.32	0.67	0.33	0.44	1.15
		1780–1830	**0.26**	**0.52**	**0.96**	**2.03**	**0.61**
Wholesale price index	6	1770–1800	−0.35	0.43	0.31	2.65	0.33
		1800–1830	1.44	0.95	1.49	1.83	1.26
		1770–1830	**0.54**	**0.69**	**0.90**	**2.24**	**0.80**

From: Antràs and Voth, "Factor Prices and Productivity Growth"

The User Cost of Capital in More Detail:

- Recall: The user cost of capital is $p_K \left\{ r + \delta - E\left[\frac{\dot{p_K}}{p_K}\right] \right\}$, where $r = i - \pi^e$.
- What is the right *i*? What do Antràs and Voth use?
- How measure π^e? What do Antràs and Voth do?
- How measure $E\left[\frac{\dot{p_K}}{p_K}\right]$? What do Antràs and Voth do?
- Effects of usury laws?
- Is it plausible that the marginal product of capital fell by 12% 1770–1800 and rose by 21% 1800–1830?

Table A.1
Impact of expectations about relative price of capital on TFP estimates

Estimate		Percentage rate of change	Cost of capital	Labour	Land rents	Govern-ment	TFP growth
Preferred	1	1770–1800	−0.40	0.35	0.26	2.60	0.27
		1801–1830	0.71	0.25	0.76	1.11	0.54
		1831–1860	−0.21	0.68	0.48	0.31	0.33
Relative price of capital corrected	2	1770–1800	−0.91	0.35	0.26	2.60	0.10
		1801–1830	0.88	0.25	0.76	1.11	0.60
		1831–1860	0.24	0.68	0.48	0.31	0.48

Table A.3
Impact of ex-ante interest rates on TFP estimates

Estimate		Percentage rate of change	Cost of capital	Labour	Land rents	Govern-ment	TFP growth
Preferred	1	1770–1800	−0.40	0.35	0.26	2.60	0.27
		1801–1830	0.71	0.25	0.76	1.11	0.54
		1831–1860	−0.21	0.68	0.48	0.31	0.33
Ex ante rates	2	1770–1800	−0.23	0.60	0.50	2.84	0.49
		1801–1830	0.85	0.27	0.78	1.12	0.60
		1831–1860	−0.21	0.60	0.39	0.22	0.27

From: Antràs and Voth, “Factor Prices and Productivity Growth”

Final Questions

- Relation of Antràs and Voth's findings to Temin's evidence?
- How important is all of this to the issue of whether we should think of this period as an "Industrial Revolution?"