2. International comparisons, cont.: (d) more indicators

Not only compare B&F but also discuss whether there exist general patterns.

> Many have thought about this and developed theories, taxonomies, descriptive frameworks.
>
> We will base our discussion on Crafts OEP and JEH articles of 1984. Descriptive rather than theoretical.

Establishing a European norm for development/industrialisation/growth

> Assemble database of measures of structure or living stds, plus GNP p.c.
>
> GNP p.c. as basic index of development, with which other indicators will be correlated. "*Y*". Actually ln(Y), so nonlinear.
>
> Time is no longer the index. This exercise takes time out of the picture. It asks not whether Russia looked like Britain in 1850 but whether Russia at $500 p.c. looked like Britain had looked at $500 p.c.
>
> This means that the pace of development doesn't matter. Without time, there is no rate of growth. The question is only about the structure of the economy at a particular level of prosperity/productivity.
>
> Most of data actually from relatively late period, when many European countries still poor.
>
> Regress variable of interest on *Y and population* (and *sometimes also country dummies* for Britain, France, and Russia).
>
> > Imagine scatterplot of datapoints, variable of interest vs. *Y*, and choosing line that best fits, or best represents the average relationship.
>
> Is there a predictable pattern?
>
> > Is there an economically significant effect of Y on the variable of interest, such that as *Y* grows, variable *X* tends to rise or fall?
> >
> > > Yes, though not always easy to work out from Crafts' table.
> >
> > Is there a statistically significant effect?
> >
> > > Yes in all cases but government's share of expenditure.
> >
> > Does *Y* explain much of the variation in *X*? i.e. are regression R2's high?

Yes except perhaps for investment's share of expenditure.

Roughly 1/3 to 1/2 of variation explained for most variables.

Most useful way to see the implications is a table showing predicted (i.e. average) value of each variable as function of *Y*.

TABLE 4

Patterns of Development in Nineteenth Century Europe Compared With the World in 1950–70
(Income Level in 1970 U.S. dollars; simulations for countries of 10 mn. people)

Forecast Values at	$300	$400	$550	$700	$900
(a) 19*th Century Europe*[b]					
CBR	38.8	36.5	34.0	32.0	30.0
CDR	28.9	26.4	23.7	21.6	19.5
AGLAB	72.9	64.3	54.6	47.4	39.8
AGY	54.2	46.5	38.0	31.6	24.9
MANY	18.1	21.3	24.8	27.5	30.3
SCHOOL	0.174	0.262	0.360	0.435	0.512
INVT	10.5	12.2	14.2	15.7	17.2
CONSN	83.4	81.5	79.4	77.9	76.2
INFL[a]	0.9	0.5	0.1	−0.1	−0.4
GOVT[a]	8.0	7.5	7.0	6.7	6.3

As an economy develops and Y grows:

Demography

Crude birth rate falls by about a quarter
Crude death rate falls by a third (before much advance of medical science)
=> population growth accelerates

Sectoral composition of Y, LF

LF share in agriculture falls fairly dramatically = industrialisation
Y share of agriculture falls dramatically
Y share of manufacturing almost doubles = industrialisation

Schools

School enrolments more than double.

Composition of demand

Investment share nearly doubles.
Consumption share falls.
Deficit on current account falls and switches to a surplus.

Government

Share of government in national expenditure falls a little bit.

Crafts next compares B&F to this European norm. At each level of GNP p.c., how did they compare to average?

Britain – is an outlier

Agriculture is the big difference.

B has far less employment in agriculture at every level of development.

Alternatively, other countries achieved same wealth with more agriculture. Same true for agriculture's share of output.

Less difference in mfg.

Drastically lower investment share in expenditure throughout.
Correspondingly higher consumption share.

Huge surplus on current account compared to norm.

Considerably **lower school enrolment** rates, esp. at first.

Govt spending rises a lot and then falls a bit, rather than declining steadily as norm.

Demography is a bit different from norm. Birth rate starts low but falls less, so higher than normal at more advanced stage of dvpt. Death rate is mostly higher, but only a bit. (In early 19c Britain's population growth was more rapid than anywhere else.)

France – has some surprises but closer to average

Demography notably different.

Birth rate much lower at every level of development.
Death rate similar to elsewhere – a bit lower at first.
=> population growth unusually slow

Manufacturing/construction considerably bigger than norm.

School enrolments above norm.

Current account surplus bigger.

LF and output in agriculture a bit less than normal.

> (Lower share more pronounced for output => agr less productive.) This is a bit surprising. Remember it refers to 19th century and the comparison is not w/B, but with peripheral European countries.

Government normal.

Investment normal. Consumption normal.

TABLE 2
THE DEVELOPMENT TRANSITION IN THE BRITISH ECONOMY, 1700–1910

Year	*1700*	*1760*	*1800*	*1840*	*1870*	*1890*	*1910*
Income Level (in 1970 American dollars)	$333	$399	$427	$567	$904	$1,130	$1,302
Crude Birth Rate							
Actual	33.1	33.9	37.7	35.9	35.2	30.2	25.1
European Norm	38.0	36.5	36.0	33.7	30.0	28.2	27.0
Crude Death Rate							
Actual	26.5	28.7	27.1	22.2	22.9	19.5	13.5
European Norm	28.0	26.4	25.9	23.4	19.4	17.5	16.3
Proportion of the Labor Force in Agriculture and Extractive Industry							
Actual	57.1	49.6	39.9	25.0	20.0	16.3	15.1
European Norm	69.8	64.3	62.3	53.7	39.7	32.9	28.6
Income Originating in Agriculture and Extractive Industry as a Proportion of National Output							
Actual	37.4	37.5	36.1	24.9	18.8	13.4	10.3
European Norm	51.4	46.6	44.8	37.2	24.8	18.9	15.1
Income Originating in Manufacturing and Construction as a Proportion of National Output							
Actual	20.0	20.0	19.8	31.5	33.5	33.6	31.8
European Norm	19.3	21.3	22.0	25.2	30.3	32.8	3[illegible]
Fraction of the Population Aged 5–19 Enrolled in Primary or Secondary Schools							
Actual	n.a.	n.a.	n.a.	n.a.	0.168	0.385	0.542
European Norm					0.514	0.582	0.626
Proportion of Gross National Expenditure Devoted to Gross Domestic Investment							
Actual	4.0	6.0	7.9	10.5	8.5	7.3	7.0
European Norm	11.1	12.2	12.6	14.4	17.2	18.6	19.5
Proportion of Gross National Expenditure Devoted to Personal Consumption							
Actual	91.2	74.4	76.8	80.4	80.5	81.6	73.8
European Norm	82.7	81.5	81.1	79.2	76.2	74.8	73.8
Deficit on Current Account of the Balance of Payments as a Proportion of Gross National Expenditure							
Actual	n.a.	n.a.	0.6	−1.2	−6.2	−5.2	−11.0
European Norm[a]			0.5	0.1	−0.4	−0.7	−0.9
Proportion of Gross National Expenditure Devoted to Government Spending on Current Goods and Services							
Actual	4.8	12.7	15.3	7.9	4.8	5.9	8.2
European Norm[a]	7.8	7.5	7.4	7.0	6.3	5.9	5.7

TABLE 3
THE DEVELOPMENT TRANSITION IN THE FRENCH ECONOMY, 1830–1910

Year	*1830*	*1850*	*1870*	*1890*	*1910*
Income Level (in 1970 American dollars)	$343	$432	$567	$668	$883
Crude Birth Rate					
Actual	29.9	26.8	25.9	21.8	19.6
European Norm	37.7	35.9	33.7	32.4	30.2
Crude Death Rate					
Actual	25.0	21.4	28.4	22.8	17.8
European Norm	27.7	25.8	23.4	22.0	19.6
Proportion of the Labor Force in Agriculture and Extractive Industry					
Actual	n.a.	51.8	49.3	45.9	41.0
European Norm		61.9	53.9	48.8	40.4
Income Originating in Agriculture and Extractive Industry as a Proportion of National Product					
Actual	38.5	33.0	33.5	28.0	28.7
European Norm	50.6	44.5	37.2	32.9	25.5
Income Originating in Manufacturing and Construction as a Proportion of National Product					
Actual	35.9	39.3	36.0	36.8	38.6
European Norm	19.6	22.1	25.2	27.0	30.1
Fraction of the Population Aged 5–19 Enrolled in Primary or Secondary Schools					
Actual	n.a.	0.351	0.467	0.567	0.588
European Norm		0.286	0.370	0.420	0.506
Proportion of Gross National Expenditure Devoted to Gross Domestic Investment					
Actual	n.a.	12.4	12.5	14.0	13.6
European Norm		12.7	14.4	15.4	17.1
Proportion of Gross National Expenditure Devoted to Personal Consumption					
Actual	n.a.	n.a.	78.4	77.2	74.3
European Norm			79.2	78.2	76.4
Deficit on Current Account of the Balance of Payments as a Proportion of Gross National Expenditure					
Actual	n.a.	−2.7	−2.1	−1.5	−3.8
European Norm		0.4	0.1	−0.1	−0.4
Proportion of Gross National Expenditure Devoted to Government Spending on Current Goods and Services					
Actual	n.a.	n.a.	7.0	7.3	8.3
European Norm			7.0	6.7	6.3

3. Traditional account of Industrial Revolution

An example in some ways is Landes *The Unbound Prometheus* (1969).
Mokyr and Allen have elements of this too.

IR = Technical Change / Improvement.

1. machines replace human skill.
2. inanimate replaces animate sources of power.
3. new, abundant raw materials are exploited, esp. mineral > vegetable.

These developments raise labour productivity.

And process becomes self-sustaining, and diffuses widely.

Tech change happens in large industrial establishments.

Timing and location of IR: where and when key technical changes happened.

Britain, roughly 1760-1830.

(Ashton told the story of a student who wrote that "About 1760 a wave of gadgets swept over England.")

The key innovations, the examples always cited and analysed:

Cotton textiles
Iron smelting
Steam power (coal production/cons an index for both iron and steam)

All of these point to **late 18.c**. All were areas of **British** leadership.

Specific entrepreneurs and particular inventions highlighted.

Just a bit of detail – more when we talk about technology

Cotton textiles

Recall how important a part of discretionary consumption at the time.

Clean and straighten fibres: carding
Twist and pull them into yarn/thread: spinning
Weave them
Bleach and/or dye and/or print
Sizing and other finishing operations.

Spinning was the bottleneck at first.

> Domestic spinners couldn't keep up with weavers. Later after spinning mechanised, weaving becomes the problem until power looms. The mechanisation of spinning created a boom in traditional handloom weaving – the old and new technologies were complementary.

Particular inventions:

> Flying shuttle (patent John Kay 1733)
>
> Spinning jenny (Hargreaves 1784). Small, hand powered, but multiple threads.
>
> Spinning frame (Richard Arkwright, patent 1762) used rollers to draw out the roving instead of moving a mechanical part like a human arm. (Later called water frame.)
>
> Mule (Samuel Crompton 1779) lots of spindles. Movement to and fro manual. Can spin fine yarn. Alternative is ring spinning, stationary, perfected later.
>
> Self-acting mule (Roberts patent 1825)
>
> Power loom (Cartwright patent 1785 but not commercially useful for 40 years)
>
> Chlorine based powder bleach (Charles Tennant patent 1799)
>
> Roller/cylinder printing (Bell 1785) – 10,000 yards per day per machine possible (wikipedia)
>
> Other textiles mechanised later, less successfully.

Iron

Issue is to remove impurities from the iron ore, to get the carbon content right, and to shape the metal. Not only is ore full of impurities; so is fuel (if the fuel is coal, anyway).

Smelting required both heat and some kind of structure to support the charge in the furnace. Historically charcoal used. (Charcoal is partly burnt wood, from which moisture and possibly some impurities have been removed. Charcoal production requires vast amounts of wood.) Idea of blast furnace known since medieval times.

Key innovation is substitution of coke for charcoal in smelting iron ore. (As charcoal is to wood, so is coke to coal. It has been heated and partially burnt to remove some impurities.) Coke cheap but dirty, too many impurities.

Coke pig iron (Abraham Darby 1707) – problem of quality b/c silicone in pig.

Next is problem of refining the pig iron into steel, removing impurities and getting carbon content right. Traditionally this involved a lot of hammering, which drives impurities out.

Puddling / furnace (Henry Cort patent 1784). Allows coke as fuel because no direct contact, and allows quality control of process. Is it less labour intensive than older methods of refining?

Hot blast (Neilson patent 1828)

Steam power

Newcomen engine 1705, Watt 1776 separate condenser, then compound engine…

Landes saw IR as response to challenges of rapidly growing demand peculiar to Britain.

We will talk about this more later in term

This big home market arose from

- per capita income higher
- income more evenly distributed
- social mobility encouraged the right sort of consumption patterns, i.e. even the lower classes aped, and were allowed to do so, their betters
- export markets in colonies
- no internal customs barriers also increases mkt size

And Landes saw successful response to those challenges as due to peculiarly British culture/attitudes.

More on this, too later.

Business is ok for the Brits, even among the nobility.
Everyone wanted wealth, and there was class mobility if you had it.
Profits were seen as more important than craft.
There was an interest in technology: lectures, societies, journals.
(All this relative to other countries, rather than absolute.)

→ Talent and Capital went into industry
and

→ w/in industry, profit maximization led to experimentation

Other factors:
- good mechanics
- openness to partners and outside finance
- a much better banking system → cheap capital

(Note to me: there is more material in my Glasgow notes.)

Some evidence of the IR, its Britishness, and apparent retardation of French development, from Bob Allen's book.

Capacity of stationary steam engines
thousands of horsepower

	1760	*1800*	*1840*	*1870*
Britain	5	35	200	2060
France		3	33	336
Prussia			7	391
Belgium			25	176
US		0	40	1491

Raw cotton consumption
thousand tons

	UK	F	Germany	Belgium	US
1781-90	8	4			2
1791-1800	14				4
1801-14	32	8			7
1815-24	55	19		2	14
1825-34	106	34	4	3	25
1835-44	192	54	11	7	47
1845-54	290	65	21	10	111
1855-64	369	74	42	13	126
1865-74	476	86	86	16	194

The difference in levels between B&F seems more dramatic if we recall that F was much bigger in terms of population.

O'Brien and Keyder (1978, Table 3.2) have the following population estimates (in millions).

	B	F
1780s	9.4	26.5
c. 1830	16.0	32.6
c. 1910	40.0	39.6

Growth rates

Growth of real output, % per year. From Crafts 1985. Britain only.

	Cotton	iron	coal
1700-60	1.4	0.6	0.6
1760-70	4.6	1.7	2.2
1770-80	6.2	4.5	2.5
1780-90	12.8	3.8	2.4
1790-1801	6.7	6.5	3.2
1801-11	4.5	7.5	2.5
1811-21	5.6	-0.3	2.8
1821-31	6.8	6.5	3.7

Cotton based on net imports.
Iron is pig iron.

All these classic IR sectors show huge acceleration in growth rates.

And growth is maintained. 5% growth implies 72/5 = 14 years doubling time.

Difficult to find comparable French data on coal or iron production, but **F imported both** from B.

Coal

Coal production was apparently negligible before 1780; Allen (2009) reports being unable to even find data on pithead prices.

Iron

Also from Allen (based on a 1957 source) is estimate of similar iron production in late 18c in B&F. He cites about 125k tons annually for B and 140k for F at end of century.

In 19c B ceases to import iron and becomes a substantial exporter. F is one of the main customers.

Pig iron exports grow from 5k to 627k between early 1820s and late 1860s.

Bar iron exports from 31k to 270 (605 if rails included).

F, meanwhile, is a net importer. Net imports of pig iron around 10% of production in mid-century. Less for bar iron. (These numbers from Fremdling EREH article.)

Prices

Meanwhile prices collapsed.

Crafts 1985 Table 2.5 data
Cotton falls from 100 in 1770 to 66 in 1831 (and I think not quality adjusted)
Iron falls from 100 to 30!

Harley EHR 98 data on cotton yarn prices

	Current prices			Deflated prices		
	18 weft	40 warp	100 twist	18 weft	40 warp	100 twist
1769 33	33					
1778 34	34					
1780/4	33	122		47	168	
1785/9	33	99	532	47	142	761
1790/4	27	74	240	36	97	318
1795/9	33	71	104	36	77	112
1800/4	31	62	92	27	55	80
1805/9	22	46	78	19	39	66
1810/4	21	42	69	15	30	50
1815/9	18	35	72	15	30	62
1820/4	11	22	51	11	22	51
1825/7	10	21	53	10	20	52

Explain differences in types of yarn.

Price falls really dramatic! Make clear the extent to which it was a supply shift that caused the increase in output, not demand.

4. Rethinking the IR in Britain

Evidence we considered showed progressive change, sometimes rapid, but not a lot of evidence for *revolution*.

Cotton really did take off. So did iron. The innovations really were dramatic.

But other sectors grew more slowly. And both old and new forms of organisation and technology coexisted.

> Steam and water power coexisted for quite a long time.
>
> Mechanised spinning and handloom weaving were complements.
>
> Family owned workshops continued to prosper in many trades, such as Birmingham metal working, for a long time. Even domestic production continued.
>
> Pottery, brewing, glass, shoes, metal wares grew, in some cases modernised, but not based on steam or important new macro-inventions or giant enterprises.
>
> Coal mining expanded hugely, but technology largely unchanged. No list of famous inventions here. (Humphry Davy's miner's lamp?) Construction also very important, but again no revolutions.
>
> Regional differences.

And population was growing rapidly, so that GNP per capita might actually be growing quite slowly. Maybe not at all, given debate about standards of living.

More real output growth rates from Crafts 1985

These sectors all show acceleration of growth rates, but irregular and much more gradual. Collectively these slowly growing sectors were more important.

	Wool	linen	silk	building	copper	beer	leather	soap	candles	paper
1700-60	1.0	1.3	0.7	0.7	2.6	0.2	0.3	0.3	0.5	1.5
1760-70	1.3	2.7	3.4	0.3	5.6	-0.1	-0.1	0.6	0.7	2.1
1770-80	0.5	3.4	-0.0	4.2	2.4	1.1	0.8	1.3	1.2	0
1780-90	0.5	-0.3	1.1	3.2	4.1	0.8	1.0	1.3	0.4	5.6
1790-1801	0.5	0	-0.7	2.0	-0.9	1.5	0.6	2.2	2.2	1.0
1801-11	1.6	1.1	1.7	2.1	-0.9	0.8	2.1	2.6	1.3	3.3
1811-21	1.6	3.4	6.0	3.6	3.2	-0.5	-0.9	2.4	1.8	1.7
1821-31	2.0	3.0	6.1	3.1	3.4	0.7	1.2	2.4	2.3	2.2

Data sources vary but typically based on some easily observable physical input or output, or tax data.

Growth rates of industrial sector *as a whole* depend on weights for each branch.

Classic *index number problem*.

Example (Table 2.6 Crafts 1985) for 1780s.

Weight the individual branch growth rates by 1770 value-added
=> overall growth is 1.60%

Weight them with 1801 value added, when cotton much bigger
=> overall growth is 3.68%

Alternative example, again for 1780s:

aggregate the individual quantities using prices to get total industrial output, then compute growth rate. Which prices?

1770 prices (Laspeyres) => growth rate of industry is 2.34

1831 prices (Paasche) => growth rate is 1.69

Discuss why this effect happens. Analogous to bias in consumer price indices today.

Crafts' guesses of sectoral and total output growth (1985 Tables 2.7, 2.10, 2.11)

	industry	agriculture	gnp	gnp p.c.
1700-60	0.7	0.6	0.7	0.3
1760-80	1.5	0.1	0.7	0.0
1780-01	2.1	0.8	1.3	0.4
1801-31	3.0	1.2	2.0	0.5

There is an acceleration, but it now looks gradual, irregular, and only a little faster than accelerating population growth.

Most recent revisions if anything nudge growth rates slightly downwards.

The IR, as classically understood, *did* happen. It wasn't an illusion.

And it *did* differentiate B & F.

And it may have been the root cause of a lot of other changes.

But it did not immediately affect the entire economy, much of which either grew very slowly or grew in a different and not-revolutionary kind of way.

The data are poor for France, but one has more the impression that, during the classic Industrial Revolution phase, France already lagged behind Britain in real wages or GDP p.c., but was reasonably successful at keeping up in terms of growth. Failing to catch up but not falling behind.

Perhaps the story was more about industrialisation in the couple of centuries preceding 1800, than a revolution from 1780 to 1830.