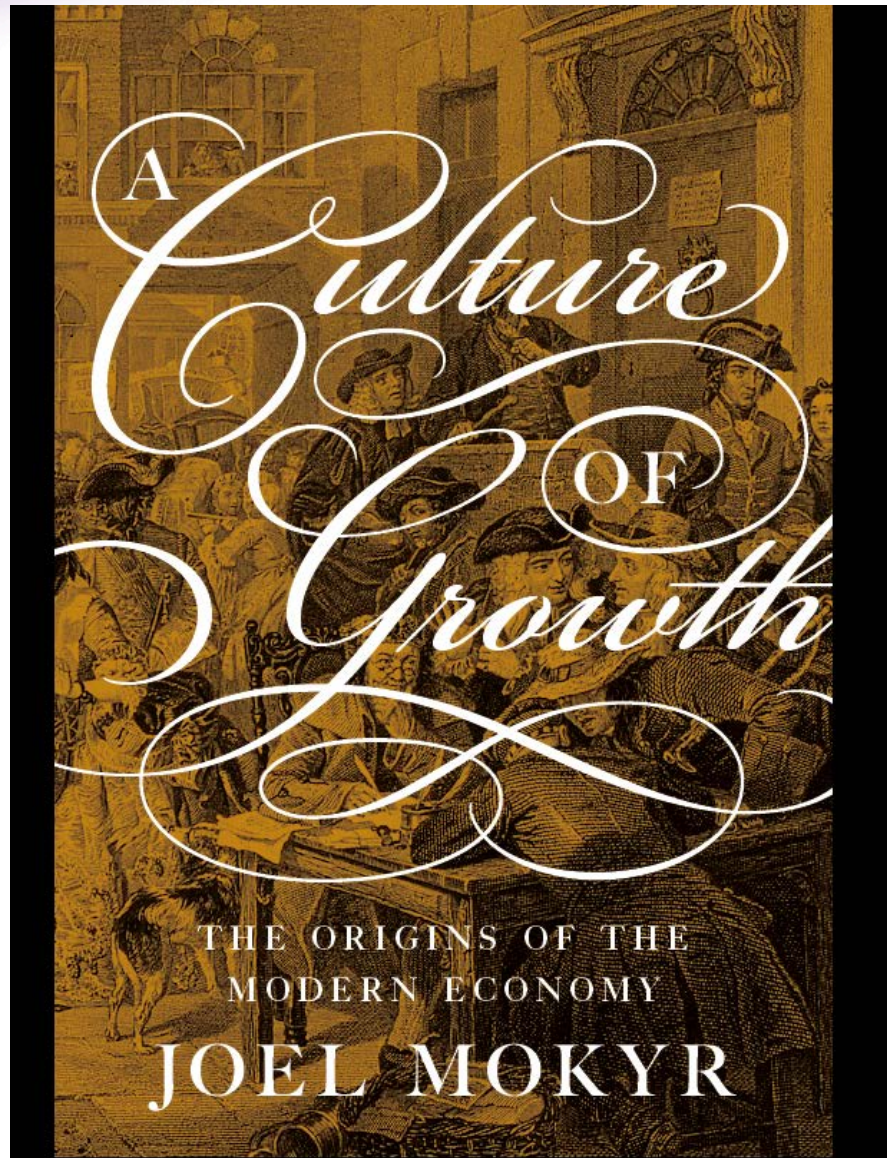


Knowledge, Institutions and the Origins of the Great Enrichment

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The puzzle of institutions and the Great Enrichment

There is a Great Logical Puzzle of the new institutional economic history and the rise of the modern economy.

The puzzle is this: In recent years, following the work of North, Rodrik, Greif, Acemoglu, and many others, a consensus has emerged that “institutions” are central in explaining economic performance.

Law and order, good property rights, effective third-party or private-order contract enforcement, free trade, low rent-seeking, mobility and inclusiveness, efficient and low-corruption governance, efficient regulation and provision of public goods are among the mechanisms associated with “good” institutions.

Institutions and Useful knowledge

However:

The European Industrial Revolution that started modern growth and the Great Enrichment after 1750 was above all about *technological* progress based on more “useful knowledge,” not just more efficient markets.

Institutional change in the “narrow” sense of better markets (gains from trade, improved allocations, and better government) cannot by themselves explain the full extent of *sustained* modern growth. It would have run into diminishing returns.

If economic growth before 1750 was based primarily on “Smithian Growth” [gains from trade and specialization] and afterwards increasingly (if never exclusively) on intellectual innovation and the growth of useful knowledge, whence the different dynamic? Does an institutional approach fail us here?

One way of approaching the issue is this: was there an institution that was instrumental in bringing about the rise in intellectual innovations and growth of useful knowledge that eventually led to the Industrial Revolution?



This is not a new issue:

Dr. Samuel Johnson's fictional Abyssinian prince Rasselas asked his philosopher friend in 1759

“By what means are the Europeans thus powerful; or why, since they can so easily visit Asia and Africa for trade or conquest, cannot the Asiatics and Africans invade their coasts, plant colonies in their ports... the same winds that carry them back would bring us thither.” The answer that was provided was: “they are more powerful than we, sir, because they are wiser; knowledge will always predominate over ignorance. But why their knowledge is more than ours I know not.”



Culture vs. Incentives

It is hard to think that the growth in useful knowledge happened independent of beliefs, preferences, and attitudes --- that is, culture.

Improvements were taking place in an environment in which the idea of “progress” and the willingness to challenge and control nature to improve the human condition had become part of the reigning culture.

Yet for this presentation, I will talk about *incentives*, which all economists believe in.



To make any progress, we need to distinguish between:

1. Prescriptive knowledge: Major inventions that could be patented.
2. Prescriptive knowledge: Minor cumulative improvements (“artisanal” progress).
3. Progress in “propositional knowledge” --- that is, the science and engineering theory that underlay technological advances.

Let me deal with (1) briefly, and then talk about the other two.



Incentives for major inventions

Incentives to produce major inventions are often equated with the rise of the patent system. The precise effect of patents on the Industrial Revolution is still in dispute.

While patents may have helped on the margin, there were many other incentives for inventors such as first-mover advantage, complemented (whenever possible) by secrecy; prizes by various organizations (including in some cases of course official ones such as Parliament); and non-pecuniary payoffs such as peer-recognition, medals and membership in honorary societies.



In this sense the institutional environment of the eighteenth century was much better for innovation than that of, say, the Middle Ages. Some writers (incl. Goethe) attributed Britain's success to the fact that "the clever Englishman transforms invention into real possessions and thereby avoids annoying disputes concerning the honor due...one may well ask why they are in every respect ahead of us" (Goethe, c. 1785).

The effectiveness of such innovative activities depended on more "good institutions" beyond just IPR protection. It required a weakening of the predatory and extractive nature of the state, the rule of law, and strong property rights so that successful entrepreneurs would be secure to enjoy the fruits of their efforts (e.g., Arkwright, Peel).

Yet incentives were not sufficient even if they were necessary: competence and savoir faire counted for just as much.

Skills and Dexterity

Technological progress depended not only on scientific breakthroughs but also on artisanal ability. Modern research has increasingly stressed the importance of anonymous artisans at the expense of “heroic inventors.”

As late as 1500, it is hard to argue that European artisanal skills were in any way superior to those in the Middle East or Asia, and many of the products of Asia skilled artisans were in great demand in Europe.

Yet the economics of the production of artisanal skills (a form of human capital) are still poorly understood.



One obvious point

Artisanal skills were important because up to some point they can generate technological progress that is a *substitute* for more science-based invention.

But there were also *complementarities*: major inventors needed skilled and competent workers to read their blueprints, build their designs, to provide them with the right parts and materials, to scale up their models, to install, maintain and operate new machinery.

It is at this level that Britain may have had its big advantage (Kelly, Mokyr, and O'Grada, 2016).



Before the Industrial Revolution, Europe produced some remarkable artisans:

The French potter, hydrologist, and geologist author Bernard Palissy (ca. 1510–1590), who wrote a widely read and influential book titled *Discours Admirables*.

Palissy proudly conceded that he was a modest potter ignorant of classical languages, but would openly challenge the theories of the ancient and modern physicians, alchemists, and philosophers .

Or consider Sir Hugh Plat (1552–1608), the author of many practical books full of recipes and prescriptions on a range of topics, from meat preservation and pest control to gardening.



Continuous, incremental, and cumulative artisanal improvements

- Some scholars (Berg, 2007) have argued that it was really artisans that explain Europe's industrialization.
- Others have gone further and proposed to get rid of such categories as “science” and “technology” altogether and instead proposed something like a “mindful hand” (Roberts and Schaffer 2007; Pamela Smith, 2007), which stresses the difficulty of drawing a line separating skill from knowledge.



A perfect example of this continuous improvement is provided by Kelly and Ó Gráda (2017), who show that in the late seventeenth century, the industry experienced a major technological shock by the invention of the spiral-spring balance in watches.

No discrete macro-invention of similar magnitude occurred over the subsequent century, yet the real price of watches fell gradually by an average of 1.3 percent a year between 1685 and 1810, the result of a gradually finer division of labor and learning by doing by artisan watchmakers.

Very similar results are obtained by Philip Hoffman (2015) in his work on firearms.



Whence the improvement in skills?

Two important points to make here about the market for human capital:

1. In much of Europe the institutional background for training was more effective than elsewhere. Apprenticeship was based on two complementary institutions that enforced what must be “the mother of all incomplete contracts.”
2. How were apprenticeship contracts enforced? The institution enjoyed guild enforcement, and later relied on pure market relations based on a mixture of third-party (legal) enforcement and reputation mechanisms, whether in the shadow of the law or not (Delacroix, Doepke, Mokyr, 2018; Mokyr, forthcoming 2019).



Bridges between savants and fabricants

2. After 1500 the world of artisans and “natural philosophers” began to build bridges across the chasm that separated them, and it was increasingly recognized that they had much to learn from one another and that lines of communications between them held the key to solve technological problems. This was pointed out many years ago by the sociologist Edgar Zilsel (1942).

Collaboration and the exchange of knowledge and skill between savants and fabricants in various forms became the taproot of progress in many industries. This nexus was a main component of the *Industrial Enlightenment*.



Examples are easy to find:

- The French philosopher and logician Petrus Ramus (1515– 1572) wrote proudly that he had visited every mechanical workshop in Paris more than once and advised other philosophers to do the same.
- Robert Hooke, after Newton the most ingenious and talented English scientist of his age, persuaded the Royal Society to write the history of every artisanal occupation, including the makers of counterfeit pearls and precious stones, bugle-makers, book-binders, dancing masters, varnishers and so on [the project failed].



Institutions that helped this communication

These are part of what Larry Stewart has called “Public Science.” They range from informal lectures on natural philosophy in coffee houses and taverns and quasi formal meetings such as the Lunar Society and the London Chapter House, to more formal organizations such as the Royal Society and the Royal Institution and local scientific societies.

On the Continent, various scientific societies and academies emerged from 1600 on, in which such contacts were institutionalized.



Scientific Consultants

Moreover, progressive industrialists hired scientifically-trained consultants.

- The Scottish physician and chemist William Cullen (1710-1790) was retained by Scottish manufacturers to help them solve a variety of problems and worked on issues such as salt extraction, the use of lime in bleaching, and the manufacture of textile dyes.
- The clock and instrument maker John Whitehurst (1713-1788), a charter member of the Lunar Society, was a consultant for every major industrial undertaking in Derbyshire, where his skills in pneumatics, mechanics, and hydraulics were in great demand.
- Joseph Priestley himself worked as a paid consultant for his fellow “lunatics,” Josiah Wedgwood and Matthew Boulton .
- A later but shining example is the Cornwall mathematician Davies Giddy (later Gilbert, 1767-1839) who consulted to the many engineers who tried to weaken Boulton and Watt’s patent-supported stranglehold over the steam engine industry.



When did the belief in this cooperation start?

- It clearly did not erupt suddenly in 1500. Medieval natural philosophers, engineers, and inventors were far from the benighted ignoramuses that subsequent writers have tried to make them seem.
- Yet the notion that useful knowledge was primarily meant, as Bacon famously wrote, to be “a rich storehouse for the glory of the creator and ***the relief of man’s estate***” only fully took hold in the sixteenth and seventeenth centuries, when scientists repeatedly pointed to artisanal knowledge as a source of inspiration.



Could artisans by themselves have brought about an Industrial Revolution ?

Without scientific breakthroughs, purely artisanal-based progress would have run into diminishing returns, as it did in Asia.

This was true to some extent even in the early stages of the Industrial Revolution, but became increasingly true after 1815.



Yet the most important institution was one that supported “propositional knowledge,” i.e., scientific innovation

That institution was critically important because of the well-known failures in the market for ideas.

The production of new ideas is under-incentivized because of the absence of appropriability.

In that sense, the production of ideas can be seen as a “commons tragedy” kind of issue (Ostrom and Hess, 2007).

As is often the case with commons issues, if there is a welfare-improving solution it is something like a private-order local community.

The issue is more complicated because the institution had to solve two kinds of incentive problems.



These incentives were of two kinds:

1. Increase *positive* incentives by finding ways in which intellectual innovators could be rewarded.
2. Reduce *negative* incentives by weakening the forces that would suppress innovation and persecute heretics and “black magic.” Often these were driven by incumbents protecting their rents.

Against all odds, between 1500 and 1700 Europe produced an institution that did all that and made the market for ideas work far better than anywhere else.



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The Solution found: a unique institution

Europe was not the first and only place to create a market for ideas. But it was the first and only one to stumble upon an institutional solution supporting the market for ideas that actively encouraged intellectual innovation and led to an exponential growth in useful knowledge.

What emerged between ca. 1500 and ca. 1700 was an institution that solved the problem in a largely novel way. In so doing, it laid the foundation of a more efficient market for ideas in Europe and to all that that entailed.



In an Ostrom framework, in which institutions resolve the intellectual commons problem, this was especially unlikely, because in her work the kind of institutions that solve the commons problems she was concerned with are mostly *local* communities.

But Europe was very fragmented and decentralized.



The “Republic of Letters”: an early “virtual community”

Within Europe, the “intellectual commons resource” was organized after c. 1500 through a transnational (and later transreligious) network of scholars, which referred to itself as the *Respublica Literaria*.

This community included the European educated elite, the intellectual *crème de la crème*: scientists, physicians, philosophers, mathematicians (as well as theologians, astrologers, and mystical and occultist writers). By construction they were relatively homogeneous: they were all educated, literate, polyglot, religious-but-open-minded, and they subscribed to a common ideology or culture.



It was an international network of European scholars and intellectuals of various stripes who shared and distributed new ideas and findings.

They did so through personal correspondence, publications, and (more infrequently) personal meetings. Most of it was a virtual network.

No conferences and very few brick-and-mortar institutions, except universities and a few scientific societies.



The Republic of Letters

Earliest mention of the term is in 1417, but came into its own in the first half of the sixteenth century with the work of Erasmus of Rotterdam and his friend Juan Luis Vives, and reached a peak in the Age of Enlightenment.

It was an institution that was *ex post* efficient, even if it was not *designed* to be that way and its efficiency does not explain its longevity.

It was a classic *emergent property*, a complex phenomenon resulting from much simpler interactions with aggregate characteristics that were quite different from its individual components.

What is clear is that it was uniquely European and that no other civilization came up with a similar arrangement though other networks of information diffusion of course existed.



It was most certainly *not* a construct of historians or “an imagined past.”



Pierre Bayle, the French Huguenot philosopher who lived in exile in Rotterdam and who began publishing in 1684 his newsletter named *Nouvelles de la République des Lettres*, wrote that

“The Commonwealth of learning [= the Republic of Letters] is a State extremely free... the Empire of Truth and Reason is only acknowledged in it... everybody is both sovereign and under everybody’s jurisdiction... the laws of of the society have done no Prejudice to the Independency of the State of Nature as [much as to] Error and Ignorance”

(Bayle, [1694], 1734, Vol. II, p. 389, essay on *Catius*).



Two contemporary views:

“The Republic of Letters. . . embraces the whole world and is composed of all nationalities, all social classes, all ages and both sexes . . . All languages, ancient as well as modern, are spoken. The arts are joined to letters, and artisans also have their place in it . . . Praise and honor are awarded by popular acclaim.”

Noel Bonaventure d’Argonne (1634-1704)
Mélanges d’Histoire et de Littérature, 1699

“During the Age of Louis XIV, a Republic of Letters was established, almost unnoticed, despite the wars and despite the difference in religions...all the sciences and arts received mutual assistance this way...True scholars in each field drew closer the bonds of this great society of minds, spread everywhere and everywhere independent... this institution is still with us, and is one of the great consolations for the evils that ambition and politics have spread through the earth”

Voltaire, *Age of Louis XIV, (1751)*



What was the Republic of Letters ?

It was a private order institution, not controlled by any formal authority and transcended national boundaries.

It was the institution in which the overriding concept of *open science* emerged (David, 2008).

It was a classic “weak ties” network (Granovetter, 1983): its members did not know each other very well. Levels of trust were relatively low, so that ideas had to be backed up by evidence and proof (e.g., Shapin and Schaffer, 1989). But the information tended to be less redundant than in strong-ties communities.



- Like any Northian institution, the Republic of Letters set the **rules of conduct** for the “knowledge commons” in the age of Enlightenment. These rules specified *incentives*, payoffs for those who did well, penalties for those who broke the rules.

- What were these rules?



The rules of the RoFL:

1. Knowledge and data should be open and *shared*. (When someone refused, e.g., John Flamsteed, this could create a scandal.)
2. Priority conveyed property rights in the sense of “credit” and reputation but not in the sense of exclusionary rights. Many priority fights.
3. It was an *open* community: anyone (within reason) could enter.
4. It was in principle egalitarian and non-hierarchical (although Newton became a bit of an idol, and birth and wealth may have counted for more than they liked to admit).



The rules of the RofL (cont'd)

5. All knowledge, both new and old, was contestable (“*in nullius verba*”). No sacred cows.
6. All new propositions were to be reproduced, checked, tested and evaluated (making the new knowledge more reliable to outsiders).
7. It was a *transnational* community: “The sciences are never at war”.



What explains its success?

1. The Republic of Letters could thrive because it was to a considerable extent independent of political or religious organizations. This was true even for France, where the state meddled more than elsewhere. As a result, cooperation and exchange could take place across national and religious boundaries thus realizing the Polanyi (1962) ideal of a collaborative community of scholars.
2. It could do so because its “citizens” took advantage of the political fragmentation of Europe by limiting rulers and organized religion from intervening in or controlling knowledge creation, and when needed, by its footloose members moving from one nation to another and playing one power against another.



The Rise of Positive Incentives:

Competitive patronage:

As other scholars (Westfall, 1985; Dasgupta and David, 1993) have pointed out, the market for ideas became a *reputation* game in which the payoff for leading intellectuals was fame and respect among their peers through their scholarly writings. Reputation was the main incentive mechanism that spurred creative people to make advances in knowledge.

Reputation was correlated with ***patronage*** (though many wanted reputation for its own sake). Patronage itself was not new, but a highly competitive market in it was only possible in Europe's "states system."



The market for ideas was a competitive market:

On the demand side: the buyers, that is, the courts, wealthy aristocrats, universities, and academies who extended patronage to the top scientists and competed among themselves to attract the best and the brightest “citizens” of the Republic of Letters. Patronage was the “price” that cleared this market.

Attracting famous learned people was partially a matter of prestige, signaling, and ostentation. But powerful and rich rulers also wanted cutting-edge medical care, top-of-the-line tutoring for their children, and information and advice on topics such as ballistics, navigation, engineering, and astrology from the smartest and best-informed people in Europe.



- **On the supply side:** Most sellers (i.e., intellectuals) wanted patronage. Some worked hard to get it (Galileo, Leibniz), others accepted it when it came their way (Newton). A few did not need it (Boyle) or were uninterested (Spinoza).
- Patronage provided intellectuals with economic security, a comfortable if not opulent lifestyle, social standing (Westfall, 1985) and legitimization (Biagioli, 1991).



The Republic of Letters and the Market for Ideas

The concept of a *competitive market* combines in a special way the coexistence of competition and cooperation. Participants on both the supply and the demand side competed fiercely, and the intellectual world between 1500 and 1700 was riven with conflicts, jealousy, skullduggery, and personal animosities and grudges.

At the same time, because the game was repeated, people followed the rules and norms set by the institution that “governed” it.

Like all markets, it combined these aspects of conflict and harmony.



The decline of “negative” incentives

Notwithstanding some famous cases such as Galileo’s notorious trial of 1633, the cases in which intellectual innovators were effectively suppressed declined to a trickle after 1650. It became little more than window-dressing in the eighteenth century.

Radical thinkers were still strongly denounced, their books sometimes burned, but they were no longer persecuted in a serious way. Even in Italy, where Jesuit influence was strong, revolutionary scientists such as Francesco Redi (1626-1697) could work freely and were respected.

In part this was because of a change in beliefs and a decline in intolerance, but the political fragmentation and competition between polities and religions were also central factors here.



Because the Republic of Letters provided people with international reputations, the intellectual stars always had the option to go abroad. This made for a highly competitive continent-wide market for the best and the brightest.

The significance of competition and mobility was that European rulers and patrons were limited in their ability to force their clients to accept their views, much less to prosecute them (and knew it). This severely limited the ability of reactionary elements to pursue or silence “heretics” and thus weakened “negative incentives.”

The basic argument here is that Europe advanced because of a coordination failure among reactionary powers.

Two examples:

Tommaso Campanella (1568-1639)

Accused of heresy by the Inquisition, he was sentenced to life imprisonment in 1599 (for anti-Spanish activity rather than for heresy) and spent twenty seven years in a Neapolitan jail. However, his conditions there were sufficiently benign (thanks to the protection of Emperor Rudolph) that he could write seven books in jail, including his celebrated *City of the Sun* (1602) as well as a pamphlet defending Galileo during his first trial in 1616.



Mobility and footloose-ness were the best defenses against intolerance

Jan Amos Comenius (Komensky) (1592-1670)

Famous progressive philosopher and follower of Francis Bacon and educational reformer. One of the most footloose European intellectuals of all times, he escaped religious intolerance and benightedness by moving from his native Moravia to Poland, England, Sweden, and Hungary, and died in Amsterdam.



“The best of all possible worlds.”

The Republic of Letters constituted a unified, pan-European institution that allowed intellectuals to enjoy a much larger constituency than they would have in their often small home-countries. Thus it helped realize economies of scale.

In that sense Europe had the *best of all possible* worlds between political fragmentation and intellectual unification. It was diverse and pluralistic, yet it was intellectually “integrated” in that there was a more or less unified market for ideas.

New knowledge and discoveries diffused rapidly over the entire Continent, and what seemed to be demonstrably superior ideas were eventually adopted widely.



The net result was a growth in science; whether we want to call it a “scientific revolution” or not, it is not doubted by anyone that in 1700 European intellectuals knew a great deal more about natural phenomena and regularities than they did in 1500. [Whether they knew *enough* to trigger an Industrial Revolution remains a matter of dispute].

What is less often stressed is the changes in the way people did science:



Changes in how people “did science”

- The value of “experimental philosophy” in scientific research (Bacon etc.) and the persuasiveness of experimental results.
- The importance of mathematics and quantification as tools of the investigation of nature (Copernicus, Galileo, Newton), aided by the emergence of infinitesimal math.
- The importance of the systematic collection of facts, artefacts, and data, and classifying and organizing them in accessible forms looking for “empirical regularities” (purely inductive science).
- The religious virtuousness of research into natural philosophy (Merton, 1938), and the (eventual) separation of science from metaphysics (“*Sire, je n'avais besoin de cette hypothèse*”)



So what?

It is not at all clear that the growth of science in the period 1500-1700 (“the scientific revolution”) led directly to eighteenth-century technological change. Maybe all that science did not matter to the Industrial Revolution (Mathias, 1979; McCloskey, 2010)?



This underestimates the importance of science and scientific progress which affected technology in all kind of unexpected ways.

Water power had been known since antiquity yet advanced painstakingly slowly, through trial and error until about 1700. Its accelerated improvement was due to a combination of better experimental techniques (e.g. Smeaton) and the systematic use of formal science in its analysis (e.g., Parent, Borda, Coulomb).

Longitude: while the Harrison clock was itself the classic work of a supremely skilled artisan, the idea of using two clocks (and a host of other tricks) to measure longitude depended on advances in astronomy and mathematics (starting with Gemma Frisius, 1508-1555)



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Gaslighting, one of the paradigmatic inventions of the Industrial Revolution, was supported by the development of the concepts, materials, experience and apparatus of pneumatic chemistry (Tomory, 2012, pp. 13-36).

Chlorine Bleaching: critical work by professional scientists, Scheele and Berthollet.

Coal Mine prospecting and safety (“miner’s friend” invented by Humphry Davy)

Pottery and its uses of best-practice chemistry by Wedgwood.



Moreover, this takes a very narrow view of what the Industrial Revolution was about. The mechanisms by which the Republic of Letters affected technological progress are deeper and more complex than the banal question of “how much science was needed to build a spinning jenny.”

Science (broadly defined) plays an ever-growing role in the post-1815 history of industrialization in Europe (Mokyr, 2009).

In some parts of technology, especially engineering: scientific culture and a belief in open source knowledge and the sharing of technical information (“Collective Invention”).



Could there have been an Industrial Revolution without a Culture of Growth?

There might have been an industrial revolution in Europe without the Republic of Letters and the changing agenda of science, but it would have been short-lived and fizzled out after 1815 or so, another technological “efflorescence,” a temporary flourishing of innovation much like the fifteenth century that eventually peters out.

Waves of invention and technological progress had occurred before in Europe, and before in the Islamic world and China.

But this time it was different.



- Thank you





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