

Towards understanding the origins of Industrial Capitalism: a tale of two historical economies

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Abstract

My work toward understanding both successful and failed Industrial Revolution attempts as primarily energy consumption revolutions, and understanding their structure, leads me to a new understanding of the origins of industrial capitalism. This work should be placed firmly in the Historical Materialism tradition.

As social scientists, if we hope to bend the curve of history toward positive institutional change, we must understand the roots of the pervasive institution we call Industrial Capitalism, which continues to influence our personal and collective lives in many ways.

My conclusion is that it is possible to eliminate much of the “bad” of industrial capitalism, but to do so will require a specific development path following Historical Materialism precepts: we need a radical change in the means of production, the technologies we build to meet our material needs and the institutions they imply. Such change must cause a dramatic reduction in the need for accumulated capital; in the language of economics, we must reduce the demand for capital to overcome its negative effects on “the non-invidious recreation of community.”

Describing a technological path that honours revealed economic fundamentals while meeting material needs with reduced capital demand is feasible; to do so without understanding the paths that led to our present state makes that task unnecessarily difficult. I hope to contribute to making the task realistically feasible.

outline

- Historical materialism
- Endogenous institutions. Large and permanent cultural and institutional changes are caused by large and permanent economic changes.
- Industrial revolutions – two main stages – require industrial capitalism
- Demand for capital – coal, steam
- Supply of capital – merchant capitalism, nobility
- Sung China – supply, insufficient demand
- IR England – supply and sufficient demand, an energy revolution
- Future energy revolutions – implications for capital – two possible paths

- describe current state of capitalism (solar farms as an example)
- describe a path which reduces demand for capital, thus causes capitalism to whither

1 Introduction

This paper explores the idea that institutional changes, at least important ones, are primarily endogenous, and especially so to major economic changes. While this a very richly explored area, starting with the Historical Materialism school that Karl Marx fathered, I plan to contribute by extending the apparatus to microeconomic explanations, providing further macroeconomic ideas, and examining historical events. My topic is a large one: the origin of industrial capitalism.

I view industrial capitalism as a mode of production consisting of large, centrally controlled accumulations of capital used to finance the means of production for commodities destined for market, using largely wage-labor, and characterized by large scale production, accumulation, and limited private ownership.

If my basic thesis is to be seen as useful, I must show that the rise of industrial capitalism was caused by a sufficiently large economic change; fortunately, many economic and other historians see as I do that the English Industrial Revolutions (henceforth EIR) was sufficiently large, perhaps the largest economic event in tens of millennia. The contemporaneous timing is further suggestive.

In other work, I claim that the EIR was primarily an energy revolution. As we will see using comparative stories covering England and Sung China I can narrate how the EIR originated in changes in the energy economy, and how those changes led directly to the rise of Industrial Capitalism from the prior regime of Merchant Capitalism. The Chinese started, but failed to complete, this journey.

2 Literature background

2.1 Historical Materialism

I will not extensively review Historical Materialism, except in summary for those who may have never been exposed to the idea. The kernel is that changes in material conditions such as technology and productive capacity are primary in changes to socioeconomic changes and organization. Quoting Marx from “A Contribution to the Critique of Political Economy,”

“In the social production of their existence, men inevitably enter into definite relations, which are independent of their will, namely relations of production appropriate to a given stage in the development of their material forces of production. The totality of these relations of production constitutes the economic structure of society, the real foundation, on which arises a legal and political superstructure and to which correspond definite forms of consciousness. The mode of production of material life conditions the general process of social, political and intellectual life. It is not the consciousness of men that determines their existence, but their social existence that determines their consciousness. At a certain stage of development, the material productive forces of society come into conflict with the existing relations of production or— this merely expresses the same thing in legal terms — with the property relations within the framework of which they have operated hitherto. From forms of development of the productive forces these relations turn into their fetters. Then begins an era of social revolution. The changes in the economic foundation lead sooner or later to the transformation of the whole immense superstructure. In studying such transformations it is always necessary to distinguish between the material transformation of the economic conditions of production, which can be determined with the precision of natural science, and the legal, political, religious, artistic or philosophic — in short, ideological forms in which men become conscious of this conflict and fight it out. Just as one does not judge an individual by what he thinks about himself, so one

cannot judge such a period of transformation by its consciousness, but, on the contrary, this consciousness must be explained from the contradictions of material life, from the conflict existing between the social forces of production and the relations of production.”¹

2.2 Recent institutional endogeneity theory

Perhaps at the complete extreme away from Marx, modern work arising from agricultural economics offers theories of technological and institutional change induced by changes in relative resource endowments and technology. This work is founded in microeconomics. Ruttan and Hayami have a good exposition.²

Whether Marx or Ruttan, macro or micro, sociology or economics, the stories are the same: economic changes cause institutional and cultural changes. There is a very large body of literature, for example the Western exceptionalism literature including Weber, that argues mostly differently. I do not review that work here, simply appealing to the facts that the people involved had no knowledge of what the EIR was and could not therefore have foreknowledge of institutions that would be required. Further, hypothesizing endogenous institutional change ahead of economic changes strains logic.

2.3 Jan de Vries from Early Modern Capitalism

Jan de Vries, in a seminal article in Maarten Prak’s edited volume “Early Modern Capitalism – Economic and social change in Europe, 1400–1800,” clearly defines the great debates among the various disciplines and schools who continue attempting to explain the English Industrial Revolution.

de Vries’ chapter, “Economic growth before and after the Industrial Revolution – a modest

¹Marx, Karl. *A Contribution to the Critique of Political Economy*. Charles H. Kerr, 1904.

²Ruttan, Vernon W., and Yujiro Hayami. “Toward a Theory of Induced Institutional Innovation.” *Journal of Development Studies* 20, no. 4 (1984): 203-223. doi:10.1080/00220388408421914.

proposal,” explains the contours of the debates, and in the end argues for a broad historical approach rather than one dominated by a particular school of thought.

The structure of his thinking is so clarifying that I start with it as an organizing framework in my work here whose goal is to illuminate the rise of industrial capitalism, and investigate its primal cause – institutions (including culture) or economics; of course both happened, but I wish to see if there is a clear primal cause.

2.3.1 general–different modeling schools causing ahistorical approach

de Vries opens his story surveying the problems in past and current approaches: “Coherent accounts of historical economic growth are difficult to achieve only in part because of the venerable jurisdictional boundaries that have for so long governed the training of professional historians.” (p.177). This causes different story tellers for eighteenth (early modern) and nineteenth (late modern) histories, and thus at least the potential for different stories.

de Vries continues: “One might suppose that what historians tear asunder with their conventions of periodization, economists would stitch together with the healing balm of theory.” (p.177). But, before the neo-classical era, economists applied classical models with some binding constraint, usually land, whether the modeller followed Smith, Malthus, or Ricardo in details. Later neo-classical modellers assumed constant returns to scale, substitutability at all margins, and technologies freely available to all, and thus told a story abstracting from all time and space – no history, no geography. And thus he introduces his case for a more integrative approach to fix the rifts in both historical and economic story-telling.

2.3.2 modern economic growth

First, de Vries sketches the contours of modern economic growth, post Industrial Revolution, using the seminal empirical work of Simon Kuznets, Phyllis Deane and W. A. Cole, and Angus Maddison. He supports the empirics with the neo-classical growth theory represented by Robert Solow’s work. These works unarguably describe a structural break from the prior rate of eco-

nomie growth, supported by a growth theory that demands technological change for its growth engine. The facts clearly support this story.

2.3.3 the neo-Malthusian model

Next, de Vries outlines the pre-Industrial Revolution neo-Malthusian models. He cites a large number of contributors including François Simiand, Wilhelm Abel, Ferdinand Braudel, Michael Postan, E. H. Phelps Brown and Sheila Hopkins, B. H. Slicher van Bath, Emmanuel Le Roy Ladurie, and importantly, the team of E. A. Wrigley and R. S. Schofield. The consistent essence of this model is that movement in populations, fuelled by sexual relations, is the dominant economic relationship and is always constrained by a more-or-less fixed supply of land to feed the population and an agricultural technology at its frontier. (p.181).

E. A. Wrigley models this world with useful components; he describes the world in, among other references, “People, Cities and Wealth.” The main components of the Wrigley model include living standards (most often represented as Gross Domestic Product per capita), nuptiality (marriage) rates and ages, and fertility rates. In the neo-Malthusian world, before about 1880 in England, there is a strong positive correlation between living standards and nuptiality rates, and subsequently a very strong positive correlation between nuptiality rates (and age at first marriage) and fertility rates. In this world, as living standards fluctuate upward due typically to exogenous factors such as better weather and crops, more women marry at a younger age, and therefore increasing fertility rates drive up population levels.

Wrigley (and Schofield’s)(p.237) major correlations for his neo-Malthusian model for England are:

Factor 1	Factor 2	Sign of correlation
Population increase	Food prices increase	Positive
Food price increase	Real income decrease	Negative
Real income decrease	Nuptiality decrease	Positive
Nuptiality decrease	Fertility decrease	Positive
Fertility decrease	Population decrease	Positive

Thus rising population caused lower living standards and retarded fertility through the nuptiality mechanism. Wrigley claims a different mechanism for China's version of a neo-Malthusian model as in:

Factor 1	Factor 2	Sign of correlation
Population increase	Food prices increase	Positive
Food price increase	Real income decrease	Negative
Real income decrease	Mortality increase	Negative
Mortality increase	Population decrease	Negative

Wrigley summarizes the "Chinese" version of his model this way: "Here to balance the books[,] nature audits with a red pencil." (p.236). This neo-Malthusian variant was not the most pleasant of existences.

The fundamental importance of Wrigley's theories is that they fit the historical data that we know describes the millennia preceding the Industrial Revolution in terms of population and living standards, and suggest how radically that changed post-Revolution. The history is of increasing total final demand because of gradually rising population and, cyclically, rising living standards. But the rising final demand eventually ran into some constraint or set of constraints that caused living standards to fall. Only in the later eighteenth century was this perpetual cycle interrupted, allowing simultaneous increases in both population and living standards. Total final demand started marching inexorably upward and the supply revolution that was the Industrial Revolution was able to match the population's rising desires and incomes.

de Vries further covers, de rigueur, the contributions of Michael Postan and Emmanuel Le Roy Ladurie. These are important contributions; Wrigley, however has both the theory and data that is convincing.

2.3.4 the Industrial Revolution

Returning to de Vries' history, I summarize his account of the Industrial Revolution.

Commenting on the commonly-held neo-classical model's "bookends" of the EIR, meaning the neo-Malthusian model that preceeds it, and the Kuznetsian model of modern economic growth that follows it, a unitary growth model with a single long term trend, de Vries accepts the revisionist criticisms from many including, Mokyr ((993), Eric Jones (1988:26), and Crafts and Harley (1992). The revisionists claim the EIR covered a longer period, and a slower rate of growth than Kuznet's version. But he does not fully dismiss his bookends, instead appealing to the complexity of the event and saying that we must revise those models. I agree. Along they way, de Vries dismisses as un-historical and un-empirical the neo-classical "Solow" convergence models.

2.3.5 re-thinking economic growth

2.3.6 from two models to one

Next, I develop the very basic theory of the EIR which applies also to China, and perhaps to other pre-modern industrialization attempts such as the Dutch Republic during the sixteenth and seventeenth centuries.

3 Industrial revolutions

In other work, I provide a theory for industrial revolutions, centered on the EIR. There I claim and demonstrate empirically that the EIR was essentially an energy revolution in the strong sense that without the energy revolution there would not have been an event which has come to be

called the EIR.

Elements of this theory are in the Technical Appendix, section 8.

Summarized, the story unfolds this way. There was an up-welling of income and populations during the Middle Ages; this is temporally related to the Medieval Warming Epoch which increased (likely globally) agricultural yields and influenced institutions and culture. Increased goods and services demand led to increased production in heat-consuming industries such as smelting, metal working, salt making, dyeing, and brewing. Heat consuming industries used mainly wood (sometimes as charcoal) as their energy source. The wood demand deforested regions and countries. Wood prices rose dramatically, for example in sixteenth century England. This also affected household uses of wood for heating and cooking.

Producers and households naturally sought alternative energy sources. In England and China, that source was coal. Using coal for heating was not an easy technological transition for many reasons; the full transition was on the order of centuries. In the Dutch Republic, the energy source was peat. The Dutch ran out of peat supplies and their industrialization attempt stalled.

In pre-modern eras, this was the path to an industrial revolution, the transition from an inherently limited energy source, trees, to an essentially unlimited source, coal. Both England and China did this, and further research should show that other areas did as well. But this is only the first step on the path.

The main leap to an industrial revolution, exemplified in the EIR, was learning to substitute the new energy source not just for the heating industries, but through the application to steam-powered devices to supplant human and animal power. This invention unleashed the enormous productivity gains that are the hallmark and legacy of the EIR.

Of course, I still need to explain what was unique about England, but this is sufficient background to delve into the foundations of industrial capitalism, which was not uniquely English at its roots.

4 The rise of demand for capital

4.1 Transition from wood to coal for heating - England

In the “real” story of the previous section, we have clues that explain how the demand for capital arose, which when paired with the capital supply story, will give us a picture of the economic foundations for that institution. First the demand side, and first for England.

John Nef plays an important role in this story. Nef, a University of Chicago historian, produced in 1932 a two-volume work titled “The Rise of the British Coal Industry.” This is a little-cited work in recent scholarship; scholars should seek it out – this is as definitive a work as one could hope for.³

In Volume I, Part IV, Chapter I, Nef lays out the case for the necessity of the development of capitalism to support the level of investment needed in the nascent coal industry. Nef dates the start to the mid-sixteenth century, along with the rise of using coal as a heating fuel. He discusses that the division of labor in the mining and transportation of coal was great, calling a mine, or colliery, “a Jack of all Trades shop” (1932, p.348). And most of this labor was wage-labor from workers who depended entirely on wages for their living, a signature feature of capitalism. I will quote Nef as he captures the state of capitalism across the continent as well as in England.

“There was no other British industry of equal importance which had advanced so far on the road to modern capitalism. This observations leads naturally to the question : How far does the expansion of the coal industry in Great Britain at an earlier period than in any other part of the western world account for the fact that the new capitalistic order, which, before the reign of Elizabeth, had found more fruitful soil in Italy, Flanders, and southern Germany than in England, should have obtained, during the seventeenth and early eighteenth centuries, a tighter hold on the economic life of England than on that of any continental country? How far, in other words, is the growth of modern capitalism as the dominant form of economic organization related

³Nef, John Ulric. The Rise of the British Coal Industry. 1st Edition. George Routledge & Sons, 1932.

to the rise of the coal industry?” (1932, p.349)

Now I would prefer from Nef a clearer separation in this discussion between the demand for capital and the supply of capital; as he progresses, he clearly is developing the case for demand for capital in what I call the first step of the EIR, the transition from wood to coal heating.

Good enough, in the following pages he relates the large costs of exploratory drilling, deep structural requirements (up to 36 fathoms), and drainage requirements, sums far beyond the resources of a few workers to supply on their own. He relates many cases of individual investments (capital supply), and concludes the section on the capital requirements of coal mining by saying “For the first time in western Europe, in connection with an industry employing a considerable portion of a country’s population, large capitals had become the rule” (1932, p.380).

To summarize, this effect begins in the sixteenth century and grows dramatically in the seventeenth and eighteenth centuries, preceding the dating many other estimates claim for such a beginning. Are we yet at what we might recognize as industrial capitalism? No, but we have in coal mining an engine of demand for capital that leads inexorably to nineteenth century institutions.

To further bolster the case, Nef elaborates on the even higher capital requirements for transporting mined coal; after all the early mines were in north east England, far from London and other consumption centers. This required capital investment in boats, wharves, warehouses, wagons, and roadways.

The demand story is straightforward for Nef. The capital supply required came mainly from wealthy merchants and nobility. Thus the story of the rise of merchant capitalism that had, relatively, low capital demand and high capital accumulation (supply) is important. Eric Mielants, in his “The Origins of Capitalism and the ‘Rise of the West’,” makes the strong case for a rise in merchant capitalism among the western European city-states between A.D. 1000 and 1500.⁴ I will accept his results without further analysis as supporting my claim for the sufficient supply of

⁴Mielants, Eric. *The Origins of Capitalism and the “Rise of the West”*. Philadelphia: Temple University Press, 2007.

capital.

This first phase of the EIR has given us, then, two critical pieces of infrastructure – the physical infrastructure for the mining and transportation of coal, and a financial institution, merchant capitalism, capable of supplying the comparatively large capital needs of the physical infrastructure.

4.2 Transition from wood to coal for heating - China

The story emerging from Sung China is not yet as rich or well-documented as that of England. But it is sufficient to detect similar mechanisms at work. The story is mainly told by John Hartwell, a student of Nef, and a sinologist.

I will ask Hartwell to start our story with the following:

“From about 750 to 1100, China experienced a series of economic changes roughly comparable to the subsequent patterns of European growth from the Crusades to the even of the French Revolution. The spread and use of money, development of new credit and fiscal institutions, increase in interregional and international trade, and colonization of hitherto marginal land which took place in the Occident during the half-millennium preceding the Reformation was paralleled by an earlier era of progress in East Asia during the two-hundred-fifty years from the rebellion of An Lu-shan (755) to the treaty of Shan-yüan (1004). And the achievements of late sixteenth- and early seventeenth-century England, which John Nef terms an ‘early industrial revolution,’ were in many respects even exceeded by the impressive expansion of mining and manufacturing in eleventh-century China.” (1966, p.29) ⁵

Supporting his hypothesis of rising per-capita incomes, Hartwell notes about the eleventh-century, “... alum making, salt processing, quicksilver and cinnebar production, shipbuilding, papermaking, and printing were all businesses in which the scale of operation and the absolute

⁵Hartwell, Robert. “Markets, Technology, and the Structure of Enterprise in the Development of the Eleventh-Century Chinese Iron and Steel Industry.” *The Journal of Economic History* 26, no. 1 (March 1, 1966): 29-58.

level of physical output were greater than was common in any other national economy before the last decades of the eighteenth century. But progress in the extraction and refining of metallic ores was even more astonishing ..." (1966, p.32). Hartwell continues by describing the high state of Chinese iron-making technologies using blast furnaces fueled both by anthracite coal and coke. Wood and thus charcoal became increasingly scarce as population and industry expanded.

So we have a similar story in China about the first step of an industrial revolution – the transition from wood to coal for heat-using industries facing rising aggregate demand, especially iron and steel making in the Sung dynasty, driven by increasing lack of wood availability through deforestation (1966, p.50).

Hartwell clearly shows that the mining and metallurgical industries were private, and the thirty-six large mining and iron and steel operations during the Sung were owned by thirty-six wealthy families. Here, the demand and supply of capital were controlled by the same entities. Hartwell claims a lack of evidence on the source of the wealth of these families, but provides evidence that most of these families were landed gentry (1966, p.47); he does speculate that some of the capital supply may have been through wealthy merchant capitalists. If so, this is a similar supply and demand story as in England, with the capital supply called forth by the demand from the mining of coal, and in the Sung case, applying that to large-scale production of iron and steel.

To summarize, both early-modern England and Sung China before the Mongol invasion experienced an energy revolution – the transition from wood to coal to fuel heat-consuming industries – causing structural changes in the economies. Large capital supplies were needed to support the large and centralized infrastructures required to mine and transport coal. That demand for capital was met by both landed gentry and merchant capitalists. This may mark an important transition toward industrial capitalism – the large-scale application of accumulated capital toward economically productive investments driven by an energy revolution; this marked the first step towards industrial capitalism.

Next, I will briefly examine the second step of industrial revolutions.

5 Industrial revolutions – step two

In other work I claim that the second step of an industrial revolution is the transition from animal power, largely human, to mineral power. This is exemplified during the EIR by the increasing substitution of steam power for animal power for both production and transportation. This allows a great increase in labor productivity, and, given distribution, living standards. A key invention is, of course, the steam engine. While China knew of steam engines by at least the seventeenth century (Wang 2010, p.36) ⁶, they did not apply them to practical applications until the nineteenth century.

I further claim that the English had strong economic motives to apply steam technology as a substitute for high-wage English labor throughout much of the early-modern era. The Chinese had no such incentive – wages are thought to be low during the relevant historical periods.

This application of economic incentives is sufficient, I claim, to explain why England completed their industrial revolution and China did not.

In any case as England proceeded down the path toward the EIR, the demand for capital increased. Capital was now required for building the new steam-powered factories and the steam-powered land- and water-transportation systems. So, again, we have an energy revolution causing the derived demand for capital to increase dramatically. By this stage in English history (eighteenth century and later), financial systems were increasingly participating in creating credit to supply the inventors and entrepreneurs with needed capital.

6 Summarizing the story

First-step energy revolutions, the transition from wood to coal for energy consuming industries, required substantial capital to build mining and transportation infrastructures. Before this, there was likely no large scale demand for capital, and the scale of industrial capitalism was not re-

⁶Hsien-Chun Wang. “Discovering Steam Power in China, 1840s-1860s.” *Technology and Culture* 51, no. 1 (2009): 31-54. doi:10.1353/tech.0.0388.

quired to meet market needs. This type of energy revolution occurred at least in China during the Sung dynasty (ninth-, tenth-, and eleventh-centuries), and in early-modern England.

England built upon their first-step infrastructure, using steam power to dramatically increase labor productivity. China did not. Until the modern era, this was the only known complete industrial revolution, was accompanied by greater demand for capital, and led directly to the institution we now call industrial capitalism.

This paper seeks to identify a prime-mover in the explanation of what is a very complex social system, industrial capitalism. Following the suggestions of Historical Materialism and endogenous institutional theory that depend on economic causes, the seminal change in demand for capital was the energy revolution that required replacing wood with more capital-intensive coal for heating, and then, with ever more sophisticated technology, replacing labor power with coal power. Thus, I suggest these energy revolutions are the prime-mover in the rise of industrial capitalism.

7 Brief speculation on future energy revolutions

The coal and steam revolutions required large investments in centralized structures. Current energy extraction, processing, generation, and transportation investments remain large and highly centralized. Should a future energy revolution result in highly distributed and very inexpensive energy sources, the need for large capital investments will be diminished. Whether that will be sufficient to diminish the rentier power of industrial capitalism remains to be seen, but at least is an intriguing possibility.

8 Technical Appendix

8.1 Importance of energy for growth and development

Period	Pearson Correlation Coefficient: energy and GDP
England 1300-1873	0.998
World 1980-2008	0.993

Table 1: Energy/GDP correlations – the case for energy revolutions

8.2 Cross-country history of energy consumption

Year	England	China	Netherlands	India
1650 ^a			0.63	
1820	0.61			
1840 ^a			0.33	
1870	2.21			
1970 ^a			8.07	0.33
1973		0.48		
1998 ^b	6.56	1.18		
2008 ^b	5.99	2.56	9.86	

Table 2: Per-Capita Primary Energy Consumption, annual Tonnes of Oil Equivalent. *Source:* Angus Maddison, ^ade Zeeuw, ^bUS DOE EIA

8.3 Theory of industrial revolutions

$$\frac{\text{Marginal Product}_{\text{wood Joule}}}{\text{Price}_{\text{wood Joule}}} \ll \frac{\text{Marginal Product}_{\text{coal Joule}}}{\text{Price}_{\text{coal Joule}}} \quad (1)$$

First energy revolution: China 900 – 1200 (Northern Sung);

England 1590 – 1700

$$\frac{\text{Marginal Product}_{\text{labor Joule}}}{\text{Price}_{\text{labor Joule}}} \ll \frac{\text{Marginal Product}_{\text{steam Joule}}}{\text{Price}_{\text{steam Joule}}} \quad (2)$$

Second energy revolution: England 1700 – 1873,

but not in China

The RHS of (2) was so large, it induced a major positive aggregate supply shock and large income effects.

This is intended to be didactic, not ideological, i.e. not supporting marginalism in general. Note that replacing Neo-classical marginal pricing with more general average pricing will not change this theory.