

Alessandro Nuvolari

Innovation as economic history: Some reflections on Joel Mokyr's vision and achievement after the Nobel Prize

(doi: 10.1410/120322)

Rivista di storia economica (ISSN 0393-3415)

Fascicolo 1, aprile 2026

Ente di afferenza:

Università Bocconi (unibocconi)

Copyright © by Società editrice il Mulino, Bologna. Tutti i diritti sono riservati.

Per altre informazioni si veda <https://www.rivisteweb.it>

Licenza d'uso

L'articolo è messo a disposizione dell'utente in licenza per uso esclusivamente privato e personale, senza scopo di lucro e senza fini direttamente o indirettamente commerciali. Salvo quanto espressamente previsto dalla licenza d'uso Rivisteweb, è fatto divieto di riprodurre, trasmettere, distribuire o altrimenti utilizzare l'articolo, per qualsiasi scopo o fine. Tutti i diritti sono riservati.

Innovation as economic history: Some reflections on Joel Mokyr's vision and achievement after the Nobel Prize

ALESSANDRO NUVOLARI

Abstract: This paper offers a reappraisal of the contributions of Joel Mokyr to our understanding of the origins of Modern Economic Growth. In doing so, it highlights the specificities of Mokyr's method and provides a critical discussion of the central concepts that structure his interpretative framework. It argues that, taken together, his major works amount to an integrated and insightful «grand narrative». Moreover, the paper contends that Mokyr's scholarship serves not only as a historical interpretation but also as a valuable analytical outline for economics itself, showing how we can approach the study of the sources and drivers of useful knowledge.

Keywords: Useful knowledge; Industrial Revolution; Joel Mokyr; Nobel Prize.

JEL codes: N01, O30, O40

1. INTRODUCTION

Following the 1993 Nobel Prize awarded to Robert Fogel and Douglass North, many economic historians assumed that economic history had received its definitive and final recognition within the economics profession, and that a similar feat was impossible to be repeated in the future. Yet, over the last thirty years, economic history has demonstrated to be a vibrant and diversified field, projecting in the past all the sub-fields and complexities of contemporary economics (micro, macro, finance, labour, industrial organization, etc.), while developing some novelties of its own, including a high variety of innovative methodological tools and creative use of historical sources. In this sense, the assessment of McCloskey (1976) about the significant contribution that economic history can bring to modern economics has been largely fulfilled.¹ The awarding of the Nobel Prizes in 2022 to Ben Bernanke, Douglas Diamond, and Philip Dybvig «for research on banks and financial crises», in

Alessandro Nuvolari, Institute of Economics, Sant'Anna School of Economics, Piazza Martiri della Libertà 33, 56127 Pisa, Italy. Email: alessandro.nuvolari@santannapisa.it.

I would like to thank two anonymous referees and Michelangelo Vasta for their valuable comments. I have also benefited from discussions with Giovanni Dosi, Giovanni Federico and Peter Jones.

¹ In a more recent reprise of the theme, McCloskey (2024) has no qualms in endorsing economic history as the «scientific branch of economics».

2023 to Claudia Goldin «for having advanced our understanding of women's labour market outcomes,» and in 2024 to Daron Acemoglu, Simon Johnson, and James A. Robinson «for studies of how institutions are formed and affect prosperity», recognizes the work of scholars who have drawn extensively in their studies – though in different ways – on economic history and historical sources. These awards confirm the critical role of historical perspectives in contemporary economics research.²

The awarding of the 2025 Nobel Prize to Joel Mokyr marks a further major step in this trajectory.³ Unlike economists who use history primarily as a tool to advance economic theory, Mokyr is a self-conscious and dedicated economic historian, whose central commitment has been to the reconstruction and interpretation of the past. While his work has undeniably yielded insights that refine theory and inform contemporary policy, these outcomes emerge organically from his historical inquiry rather than from any deliberate theoretical or policy agenda. In this sense, his recognition highlights not merely the use of history within economics, but the affirmation of economic history as an autonomous and vital forge for advancing the frontiers of economic research. The economic history community should wax ecstatic. This Nobel prize presents a unique opportunity to further raise the profile of economic history within economics – by strengthening its presence in undergraduate and graduate education, unlocking new avenues for research funding, and inspiring a new generation of young scholars to further push the frontier of the field. *Nunc est bibendum, nunc pede libero pulsanda tellus...*

Economists and scholars of innovation should also rejoice, albeit perhaps with a touch of bittersweet feeling. For the first time, a Nobel Prize has explicitly recognized the connection between innovation and economic growth. This marks the resolution of an often-lamented paradox: the very driver of economic prosperity that has shaped modern economies had long received scant attention from the Nobel committees. In this respect, the awards reflect the discomfort of mainstream economic theory in fully accounting for how innovative processes actually unfold in the real world. At the same time, it is regrettable that the contributions of the «founding fathers» of the modern economics of innovation – Chris Freeman, Richard Nelson, Nathan Rosenberg, and Sidney Winter – will remain unrecognized.⁴ This observation is in

² For two perceptive assessments of the significance for economic history of the Nobel prize awarded to Goldin and Acemoglu, Johnson and Robinson, see respectively Mancini (2024) and Federico (2024).

³ Joel Mokyr has shared the prize 50%-50% with Philip Aghion and Peter Howitt. The overall motivation of the prize is «for having explained innovation-driven economic growth». In particular, the committee highlighted that the motivation for Mokyr is «for having identified the prerequisites for sustained growth through technological progress», while for Aghion and Howitt is «for the theory of sustained growth through creative destruction» (see <https://www.nobelprize.org/prizes/economic-sciences/2025/summary/>, accessed February 10, 2026).

⁴ Dosi and Nelson (2010) argue that the modern economics of innovation emerged from what they term the «Sussex–Yale–Stanford synthesis,» named after the universities where the pioneering scholars and research centers in the field were based: Chris Freeman at the University of Sussex (SPRU), Richard Nelson and Sidney Winter at Yale University, and Nathan Rosenberg at Stanford University. Seminal contributions associated with this tradition include Freeman (1974; with revised editions in 1982 and, with Luc Soete, in 1997), Nelson and Winter (1982), and Rosenberg (1976, 1982). A comprehensive overview of the findings of this research program is provided by the two volumes *Handbook of the Economics of Innovation* edited by Hall and Rosenberg (2010a, 2010b). The first volume contains an important historical

no way meant to diminish the achievements of the 2025 laureates, but rather to highlight the broader profession's continued reticence in acknowledging the groundbreaking work on innovation of some pioneering scholars.

Curiously enough, for a long time, mainstream neoclassical economics – while acknowledging technical progress as the fundamental driver of modern economic growth – treated it as essentially «exogenous», or more precisely, as a phenomenon not fully amenable to explanation within the standard economist's toolkit.⁵ A significant turning point came with the emergence of «endogenous» growth theory in the late 1980s and 1990s. This literature introduced a new class of growth models in which the generation of innovations and investment in technology were explicitly incorporated, while retaining the core assumptions of the neoclassical framework, namely perfect rationality and equilibrium behaviour (Verspagen 1992).⁶ Aghion and Howitt (1992), the contribution recognized alongside Mokyr in the 2025 Nobel prize, belongs to this research trajectory. It represents an attempt to formalize key features of Schumpeterian dynamics, most notably creative destruction, within a standard optimizing framework. Overall, Mokyr's broader perspective, with its closer attention to the historical and institutional realities of innovation processes, appears more aligned with the evolutionary perspectives than with the abstract formalism characteristic of endogenous growth models.

In the remainder of this essay, I will provide a concise critical overview of Mokyr's contributions, focusing mostly on his research on innovation and innovation-driven growth, the work that ultimately led to the Nobel Prize. It is worth noting that, alongside this research, Mokyr has also made important contributions in other areas. However, this essay will not attempt a comprehensive account of his entire body of research.

2. MOKYR'S EARLY CONTRIBUTIONS

Joel Mokyr was born in 1946 in Delft, the Netherlands. Around the age of nine, his family immigrated to Israel, where he grew up in Haifa. He completed his undergraduate studies in History and Economics at the Hebrew University of Jerusalem and went on to pursue a PhD in economic history at Yale University under the supervision of William Parker.

As is common with scholars who have produced throughout their lives a large and influential body of work – such as Marx or Schumpeter – it is tempting to distinguish Mokyr's career into «early» and «later» phases to capture the evolution of his research agenda (Buyst 2018). Mokyr's early contributions were primarily devoted to applying the «new economic history» framework to contexts where it had not previously been used.⁷ His

chapter by Mokyr (2010). Notably, in line with the «founding fathers» of the economics of innovation, Mokyr likewise advocates an evolutionary approach to the study of innovation and technological change.

⁵ This approach is most clearly articulated in the Solow growth model, where technological change is represented by means of an «exogenous» shift of the aggregate production function (Solow 1956).

⁶ For a penetrating critique of «endogenous» growth models, see Nelson (1998).

⁷ For an overview of the «new economic history» or Cliometric revolution, see Cioni, Federico and Vasta (2021). They highlight a key distinction between the Cliometric revolution of the 1960s, which informed

PhD thesis was a major comparative study of early industrialization in Belgium and the Netherlands (Mokyr 1976). This comparative approach allowed him to examine countries with significant cultural and geographical similarities but divergent economic outcomes with Belgium being a leader and the Netherlands a laggard in early European industrialization.

The PhD thesis exemplified the «new economic history» methodology: it combined the formulation of interpretive hypotheses through formal economic models with a systematic effort to retrieve and construct quantitative data from a wide array of historical sources in order to test them. Mokyr offered a sophisticated explanation for the differing trajectories of industrialization, emphasizing the role of real wages. In Belgium, low real wages encouraged higher rates of investment and rapid industrialization, whereas the opposite dynamic occurred in the Netherlands.

The second major contribution of the «early Mokyr» is the book (and the related research) on Irish economic history published in 1983 (Mokyr 1983). Intrigued by the study of the «relative failure» of the Netherlands to industrialize, Mokyr thought that the systematic analysis of the Irish economy – an even more striking case of economic failure than the Netherlands in the first half of the nineteenth century, could yield further insights on the dynamics of European industrialization (Mokyr 2005a). In this case, the main methodological tack was the systematic use of cross-sectional econometrics across Irish counties to unravel the determinants of economic underdevelopment.⁸

To sum up, the «early Mokyr» was an economic historian firmly embedded in the «new economic history» tradition, unbound by specialization in a single theme or country, and adept at moving across diverse sources and methodologies. In this phase of his career, he also wrote the introduction to an influential volume on the British Industrial Revolution (Mokyr 1985). The collection brought together a series of important essays exploring both the causes and the consequences of Britain's industrial transformation. A substantially revised version of this introduction was later published in 1993 (Mokyr 1993). In this piece of research, Mokyr demonstrates his skill in conducting wide-ranging historiographical surveys, which would become a hallmark of his later work. He is able to summarize and effectively compare hundreds of research contributions, producing coherent syntheses and distilling them into original interpretative accounts.

the early work of Mokyr, and the resurgence of historical economics in the 1990s. The earlier movement represented a systematic effort to introduce new frameworks and methodologies for addressing questions in economic history, whereas the later wave focused on using historical cases and evidence either to advance new theoretical perspectives or to uncover some hidden historical roots of contemporary economic and social outcomes, as exemplified in «persistence studies».

⁸ On the side of methodological novelties, Mokyr (1983) introduced in economic history the use of age-heaping as a tool to measure the degree of «quantitative sophistication» in a population (see also Mokyr and Ó Gráda 1982). Following the work of A'Hearn, Baten, and Crayen (2009, in the 2010s this method would become a major trajectory of research for historical studies of human capital. For a discussion of the continuing relevance of Mokyr's original approach, see A'Hearn, Delfino, and Nuvolari (2022).

3. THE ECONOMIC HISTORY OF TECHNICAL CHANGE

The turning point between the «early» and the «late» Mokyr is usually identified with the publication of *The Lever of Riches* (Mokyr 1990a, see Buyst 2018). Mokyr himself recounts that he arrived at the theme of innovation almost by accident, when his colleague F.M. Scherer invited him to write a concise reference survey on the long-run history of technical change (Mokyr 2005a). *The Lever of Riches* grew out of that project.⁹

The book contains a narrative survey of long run technological development which is still today a useful reference point and can stand comparison with similar works by historians of science and technology such as Cardwell (1994). Yet its significance lies not only in its breadth but also in its analytical ambition. Mokyr advances an evolutionary framework to account for the dynamics of technical change – an approach he would subsequently refine and extend in later work. At the core of this framework is an epistemological claim: technology is, in essence, knowledge. The evolution of this body of knowledge is shaped by a specific «selection environment» that determines which techniques are adopted and improved – through mechanisms such as learning by doing and learning by using – and which are rejected and abandoned.¹⁰ Crucially, selection environments differ across societies and civilizations. They reflect geographical, cultural, political, and economic conditions, and some configurations are more conducive to sustained and rapid technological progress than other.

The theme of societal resistance to new technologies is expanded in Mokyr (1992), where Mokyr applies his perspective to the machine breaking riots of the industrial revolution. He observes that, within the contemporary European context, the decision of the British government to side decisively with innovators and to repress the riots was exceptional. In other countries, political elites adopted more accommodating or compromise-oriented responses. In Mokyr's view, the British state's stance may have been an important factor in precipitating and sustaining the Industrial Revolution in Britain.¹¹

In his analysis of the processes that generate new technologies, Mokyr introduces the influential distinction between micro- and macroinventions. In its original formulation (Mokyr 1990a, p. 13), microinventions are defined as «small, incremental steps that improve, adapt and streamline existing techniques», whereas macroinventions are «inventions in which a radical new idea, without a clear precedent, emerges more or less ab nihilo».

Mokyr argues that these two types of invention stem from distinct generative processes. Macroinventions are typically the result of serendipitous breakthroughs and are therefore only weakly responsive to economic incen-

⁹ The compact version was published as Mokyr (1990b).

¹⁰ For insightful observations on evolutionary processes in human creativity within an empirical study of nineteenth-century fiction – observations that resonate closely with Mokyr (1990a) – see Moretti (2000). According to Moretti, literary production contains an in-built mechanism for discarding the majority of novelties, which he famously terms «the slaughterhouse of literature». Focusing retrospectively only on the «survivors» risks producing biased and «whiggish» accounts of literary history.

¹¹ For a critical discussion of the literature on the machine-breaking riots during the Industrial Revolution and of Mokyr's contribution on this theme, see Nuvolari (2002).

tives or changes in relative factor prices. Microinventions, by contrast, are systematic, cumulative, and strongly shaped by economic conditions. They respond to market signals and institutional frameworks, and they account for much of the steady improvement in productivity observed over time. Mokyr's view of technical change shares important affinities with the application of Thomas Kuhn's notions of scientific paradigms and revolutions (Kuhn 1962) to technological development proposed by Constant (1973) and Dosi (1982). In the interpretations suggested by Constant and Dosi, microinventions correspond to inventive activities carried out within the boundaries of a prevailing «technological paradigm» – that is, a shared cognitive framework that guides the search for solutions and is collectively upheld by a community of technological practitioners. Such paradigms define the relevant problems, the acceptable methods, and the directions in which improvement is expected to occur. From this perspective, Mokyr's macroinventions are conceptually akin to the emergence of a new technological paradigm in the sense of Constant and Dosi. Both denote moments of discontinuity, in which established cognitive frameworks are superseded and a new trajectory of problem-solving incremental inventions is set in motion.¹²

The coexistence of two distinct processes in the generation of inventions adds a significant layer of complexity to technological evolution. Technological change is neither fully determined by economic forces nor reducible to pure chance.¹³ By explicitly acknowledging the role of stochastic and random elements in the emergence of macroinventions Mokyr opens his analysis to the issue of historical contingency, emphasizing the interplay between structural forces and random events.

4. USEFUL KNOWLEDGE, THE ENLIGHTENMENT AND THE INDUSTRIAL REVOLUTION

4.1. *Useful knowledge*

This epistemological perspective on innovation and technology is further developed in Mokyr (2002). Both economic historians and historians of science and technology have long sought to assess the contribution of science – particularly the form of science that matured during the Scientific Revolution of the seventeenth century – to technological progress during the Industrial Revolution. For a long time, the prevailing consensus was

¹² Concerning the generation of macroinventions, Constant (1973) argues that «technological revolutions» are often instigated by «individual provocateurs». He suggests that the question of why one inventor produces a macroinvention while another, with similar training and background, does not, may lie «in the inaccessible personalities of individual men... no conception of paradigmatic change that confines itself to economic factors, however sophisticated its definitions of demand and expected costs might be, would be likely to grasp the full complexity of technological revolution. New paradigms are the progeny of beings, somewhat less, or somewhat more than the “economic man”» (pp. 557, 559). For a similar assessment and a case study of Edmund Cartwright, see also O' Brien (1997). This theme will be rehearsed in the debate between Mokyr and Allen on the origins of the British Industrial Revolution (see Crafts 2011).

¹³ For an empirical study confirming the role of serendipity in the generation of the macroinventions of the Industrial Revolution, see Nuvolari, Tartari and Tranchero (2021).

that scientific insights played a minimal role (Hall 1974).¹⁴ Early industrial technologies were rudimentary and appeared largely disconnected from the «new science» of Galileo and Newton, which focused on «pure» fields such as astronomy. Even in the most celebrated «high-tech» breakthrough of the era, the steam engine, the causal relationship seemed reversed: technology appeared to influence science rather than the other way around, as exemplified by Sadi Carnot's formulation of modern thermodynamics, which followed contemporary debates over the performance of low- versus high-pressure steam engines (Fox 1986). In this view, modern science began to make a substantial contribution to technological change only in the second half of the nineteenth century, with the establishment of industrial research laboratories during the Second Industrial Revolution (Hall 1974).

Within this context, a notable dissenting voice came from Musson and Robinson (1969), who, through detailed historical case studies, argued that scientific insights did, in several instances – chemistry being a prime example – contribute directly to technological innovation. Science also fostered industrialization through a variety of indirect channels: it provided practices and tools for precise measurement, cultivated a culture of experimentation, and enhanced the skills of mechanics and engineers. Nevertheless, the broader scholarly consensus remained skeptical, viewing Musson and Robinson's examples as exceptions rather than indicative of a general pattern.

Mokyr (2002) offered a decisive contribution that cut through this debate. While he acknowledged that the direct impact of the Scientific Revolution's insights to many key innovations was limited, he cautioned that focusing exclusively on «genuine scientific knowledge» was too narrow. Innovations generally draw upon a much broader body of knowledge, which he terms «useful knowledge». In more detail, according to Mokyr:

[...] technology in its widest sense is the manipulation of nature for human material gain. Hence useful knowledge [...] deals with natural phenomena that potentially lend themselves to manipulation, such as artifacts, materials, energy and living things (Mokyr 2002, p. 3).

His perspective therefore situates science as one component within a larger and differentiated body of «useful knowledge» (codified but also tacit) that simultaneously contribute to the generation of innovations.

In more detail, useful knowledge consists both of «propositional knowledge» (know what) and «prescriptive knowledge». Propositional knowledge refers to knowledge about natural phenomena and regularities, while «prescriptive knowledge» or «techniques» consists of executable instructions that exploit natural regularities to achieve practical ends (know how). Because such instructions depend on prevailing understandings of natural phenomena, propositional knowledge maps onto prescriptive knowledge. Importantly, Abraham Flexner's notion of «useless knowledge» – understood as curiosity-driven investigation of natural phenomena – is in fact a significant

¹⁴ Commenting on the textile machines of the Industrial Revolution, Cardwell aptly notes: «[they] incorporated no principles, materials or processes that would have puzzled Archimedes» (Cardwell 1994, p. 186).

component of Mokyr's concept of «useful knowledge» (Flexner 2017), specifically within the category of «propositional knowledge». ¹⁵ Analogously, mathematics, insofar as it «is used to describe and analyze the regularities and orderliness of nature», is similarly encompassed by «propositional knowledge» (Mokyr 2002, p. 5). ¹⁶ Crucially, however, the domain of propositional knowledge extends beyond formal science: it includes experience, artisanal practice, tacit skills, and even folk knowledge.

Within this framework, the epistemological foundation of techniques can be more or less «tight». A tight knowledge base implies that a technique rests on an articulated and accurate understanding of the relevant natural phenomena. A less tight knowledge base characterizes techniques grounded in partial or rudimentary understandings. In the limiting case, a technique may rely simply on the awareness of a regularity in nature, without any explanatory theory accounting for it. ¹⁷

4.2. *The Industrial Enlightenment*

This approach enables Mokyr to re-establish a plausible connection between the Scientific and Industrial Revolutions. The Industrial Revolution did not depend directly on the theoretical achievements of seventeenth-century science; rather, it built on the expansion and diffusion of «useful knowledge» in Europe from the late seventeenth century onward. Mokyr labels this broader transformation the «Industrial Enlightenment». While the Enlightenment more generally denotes a complex cultural movement promoting rational inquiry across domains – politics, law, economics, and beyond – the Industrial Enlightenment refers specifically to the application of rational, systematic inquiry to the expansion of useful knowledge. This expansion was achieved through a strategic set of measures that sharply reduced the costs associated with the generation, storage, and dissemination of useful knowledge (Mokyr 2005b).

¹⁵ Abraham Flexner (1866-1959) was the founder of the Institute for Advanced Study at Princeton University, established on the principle that curiosity-driven, unfettered scientific research is essential for the advancement of human knowledge. Flexner envisioned the Institute as a haven where scholars could pursue fundamental inquiry without the distractions of teaching or administrative duties, enjoying complete intellectual freedom. As he wrote, the Institute was intended to provide «the facilities, the tranquility, and the time requisite to fundamental inquiry into the unknown. Its scholars should enjoy complete intellectual liberty and be absolutely free from administrative responsibilities or concerns» (https://www.ias.edu/about/mission-history?utm_source=chatgpt.com, accessed February 25, 2026).

¹⁶ «Using mathematical skills to apply numerical methods to the interpretation of key words in religious texts to predict the date of the Apocalypse, as Jewish mystical sages tried to do, does not augment useful Knowledge» (Mokyr 2002, p. 249). At the same time, it is important to recognize that the development of mathematics is often driven by practical concerns. For a study of the adoption and use of Indo-Arabic numerals in Western Europe from a perspective informed by Mokyr's framework, see Danna (2026).

¹⁷ Mokyr's example here is the knowledge the fresh fruit (in particular citrus) as suggested by James Lind (1716-1794) in his *Treatise on Scurvy* in 1746 effectively prevents scurvy, without any understanding that the disease is due to a deficiency of vitamin C (Mokyr 2002, p. 186). For a wide-ranging discussion of Mokyr's conceptualization of useful knowledge and its historical relevance, see *History of Science*, 45 (2) featuring contributions of Maxine Berg, Liliane Hilaire-Perez, Larry Stewart, Kristine Bruland, Margaret Jacob and a rejoinder of Mokyr.

To illustrate his argument, Mokyr highlights a wide-range of examples in which a «scientific mentality» shaped technological practice displaying an extraordinary historical erudition. Significantly, the emblematic figure of Mokyr's Industrial Enlightenment is not James Watt (1736-1819) but the lesser-known engineer John Smeaton (1724-1792).¹⁸ In his work on water-wheels, Smeaton adopted a rigorously empirical and pragmatic approach. He conducted systematic experiments, built scale models, and used quantitative calculations to determine which designs performed best under specific conditions. Importantly, he prioritized measurable performance over theoretical explanation: what mattered was establishing which configuration worked most efficiently, not necessarily why it worked (Mokyr 2002, p. 42). This experimental ethos exemplifies the virtues of the Industrial Enlightenment.¹⁹

Mokyr (2002) acknowledges that both the Enlightenment and the Industrial Enlightenment were pan-European phenomena, spanning regions from Scotland to southern Italy to tsarist Russia. This perspective helps explain why industrialization occurred in the eighteenth-century and why it occurred in Western Europe. It is less well suited, however, to explaining why it occurred first in Britain rather than in France or the Netherlands (all three countries have their own version of the Enlightenment). To address this question, Mokyr argues that in Britain emerged a specific version of the Industrial Enlightenment that was particularly effective in precipitating technical progress.

Mokyr develops further his interpretation of Britain's leadership in industrialization in terms of the Industrial Enlightenment in *The Enlightened Economy* (Mokyr 2009).²⁰ He insists on the specificities of the British version of the Enlightenment, which was more «practical and pragmatic» than its French counterpart. He emphasizes the distinctive British focus on the expansion and application of useful knowledge. Britain's advantage lay not primarily in the frequency of «macroinventions» – which Mokyr regards as serendipitous – but in the sustained process of incremental improvement and adaptation that followed initial breakthroughs. British institutions, markets, and social networks provided a particularly favorable environment for such cumulative innovation.²¹ Although the Industrial Enlightenment is central to his analysis, Mokyr also considers complementary factors that reinforced this dynamic. A perceptive coeval reflection on the driving forces of

¹⁸ The historical importance of Smeaton's approach in the accumulation of «engineering» knowledge has been also highlighted by Vincenti (1993) and Cardwell (1994).

¹⁹ It is important to note that, from a sixteenth-century perspective, the value of the experimental approach relative to more deductive methods was far from obvious and remained deeply contested. For a seminal study of the debate between Robert Boyle, who championed systematic experimentation, and Thomas Hobbes, who favored a purely deductive method, see Shapin and Schaffer (1985).

²⁰ Another important account pointing to the specificities of the British version of the Enlightenment in fostering the emergence of the «modern world» is Porter (2000).

²¹ Dowey (2017) provides an empirical assessment of Mokyr's hypotheses. He constructs a catalogue of «knowledge access institutions» (scientific and learning societies, mechanics institutes, public libraries, etc.) and finds that this represents an important determinant of the levels of inventive activities at county level. Jones (2008) provides a highly detailed case study of the Industrial Enlightenment in Birmingham, offering a nuanced analysis of the processes of creation and diffusion of useful knowledge and of the social and cultural environment supporting them.

the Industrial Revolution comes from James Watt himself. Writing about his business partnership with Matthew Boulton, Watt observed that:

[...] these gentlemen [Boulton and Watt] owe much of their success to the accurate philosophy of the last age, to the enterprising spirit of the present age, to the opulence of this country, & to the decline of prejudice & attachment to ancient custom. Had they lived in another age or in some other country, they might have been mere theorists or rubbed through life unknowing and unknown (Watt, letter in Boulton and Watt archives, cited in Jones 2020).

Watt's remark encapsulates neatly Mokyr's argument. Scientific mentality inherited from the seventeenth century Scientific Revolution was a key-factor, but it worked in combination with the commercial dynamism and relative openness of eighteenth-century British economy and society which created an environment conducive not only to invention but, crucially, to diffusion and improvement. Inventive talents and ingenuity might exist elsewhere or in other times; what distinguished Britain was the social and intellectual context that allowed useful knowledge to be systematically expanded, applied, and refined.

An alternative interpretation of British industrialization has been advanced by Robert C. Allen (2009). Allen contends that Britain's distinctive trajectory was shaped less by superior innovative capabilities *vis-à-vis* her European rivals than by a particular configuration of economic incentives that encouraged the adoption and diffusion of new technologies. Compared to much of continental Europe, Britain was characterized by high real wages and relatively cheap energy. This combination made labour-saving and energy-intensive technologies – such as mechanized textile production, steam power, and coke-based iron smelting – economically viable in Britain well before they became profitable elsewhere.

Allen supports this claim with comparative data on real wages and energy prices, as well as quantitative reconstructions of the cost-effectiveness of key technologies across different national contexts. On this account, technological change was driven by relative factor prices: British producers adopted machinery because, given local wage and fuel costs, it paid to do so. Importantly, Allen traces the origins of Britain's high-wage economy to its commercial and maritime success in the late seventeenth and early eighteenth centuries. Expansion in international trade, supported by naval power and imperial networks, increased urbanization and labor demand, thereby raising wages. In this respect, his interpretation connects with earlier scholarship – most notably that of Eric Hobsbawm (1968) – which emphasized the central role of overseas trade and early British imperialism in laying the foundations of industrialization.²²

As Crafts (2011) observes, in the spirit of the «new economic history», both Allen (2009) and Joel Mokyr (2009) have rigorously scrutinized each other's arguments, seeking to identify weaknesses and refine the empirical

²² Throughout his works, Mokyr does not consider that demand factors – particularly the trade boom associated with the rise of British imperial power – could have played a significant role in instigating the Industrial Revolution (see Mokyr 1977; and the exchange between Mokyr 2021; Berg and Hudson 2021 and Zahedieh 2021)

foundations of their respective interpretations.²³ Yet these perspectives need not be seen as mutually exclusive. It is plausible that Mokyr's emphasis on capabilities – rooted in the expansion of useful knowledge and the Industrial Enlightenment – and Allen's focus on incentives – grounded in relative factor prices and profitability – will ultimately be regarded as complementary rather than competing explanations (Crafts 2011; Nuvolari, Tartari and Tranchero 2021).²⁴ Britain's industrialization may have depended both on the capacity to generate and improve techniques and on an economic environment that made their adoption profitable.

4.3. *Upper tail human capital*

In *The Enlightened Economy*, Joel Mokyr (2009, p. 122) introduces – albeit briefly – a concept that he develops more fully in later work: that of «upper-tail human capital» (Mokyr 2021). This notion marks a significant departure from the conventional treatment of human capital in the literature on early industrialization.

Many economic historians have been skeptical about the role of human capital in explaining the onset of the Industrial Revolution. In a well-known contribution, Sandberg (1979) observed that by the late eighteenth century Scandinavian countries had already achieved remarkably high literacy rates, yet they remained peripheral to the First Industrial Revolution. On this basis, Sandberg characterized these economies as «impoverished sophisticates»: societies with comparatively advanced educational attainment but limited industrial dynamism. By contrast, Britain – the pioneering industrial nation – did not stand out in terms of literacy or formal schooling when viewed in a European comparative perspective (Mitch 1993).

Against this backdrop, Mokyr argues that average levels of human capital may be the wrong metric for understanding the relationship between human capital and early industrialization. In the context of an eighteenth-century economy, what may have mattered more than the mean level of educational attainment was the size and density of the «upper tail» of the human capital distribution. In other words, the presence of a relatively large group of highly skilled and exceptionally knowledgeable individuals could have ex-

²³ In line with his earlier research on the industrialization of the Low Countries, Joel Mokyr has strongly rejected Allen's «high-wage economy» thesis, observing that industrialization in Britain frequently began in counties with relatively low wages but abundant endowments of skilled mechanical workers (Kelly, Mokyr, and O'Grada 2023).

²⁴ The debate on the «high-wage economy» versus the Industrial Enlightenment interpretations of the British Industrial Revolutions has unfolded along several complementary lines: *i*) the link between the Industrial Enlightenment and the inventors of the British Industrial Revolution using quantitative prosopographical methods (Allen 2009, pp. 238-271; Meisenzahl and Mokyr 2012); *ii*) the reconstruction of the goals of inventions using the analysis of patent specifications (MacLeod 1988; Nuvolari, Tartari, and Tranchero 2021); *iii*) the investigation of the factor bias of technical change by the estimation of production functions (Otojanov, Fouquet, and Granville 2023); *iv*) the study of the connection between real wages and the geography of early industrialization (Kelly, Mokyr, and Ó Gráda 2022). In parallel, a related debate has questioned the characterization of eighteenth century Britain as a «high-wage economy» as proposed by Allen. Key contributions to this discussion include Stephenson (2018), Ridolfi (2019), Humphries (2013), Humphries and Schneider (2019), and Allen himself (2015, 2020).

erted a disproportionate influence on technological progress, precipitating innovations and their diffusion even at the aggregate level.²⁵

Mokyr (2018) further suggests that this upper tail consisted of two distinct but complementary groups. The first comprised «intellectuals» – natural philosophers and early scientists – whose primary activity was the expansion and diffusion of «propositional knowledge» (knowledge of natural phenomena and regularities). The second consisted of «artisans», a broad category including engineers, millwrights, instrument makers, and other highly skilled practitioners engaged in the development and refinement of «prescriptive knowledge» (practical techniques and know-how).²⁶ Industrial progress, in this view, depended not on mass literacy alone but on the interaction between these two segments of the upper tail, and on the institutional and cultural conditions that facilitated their communication and collaboration. Again Mokyr (2021) emphasizes that Britain provided a particularly felicitous environment for such interactions. The country's networks of learned societies, workshops, coffeehouses, and informal associations created channels through which intellectuals and skilled artisans could exchange knowledge, test ideas, and refine techniques. Additionally the apprenticeship system that emerged in Britain was particularly apt in fostering the accumulation and refinement of mechanical skills at least in a key segment of the population (Ben Zeev, Mokyr and van der Beek 2017; Mokyr 2022).²⁷ In contrast, in many other European countries, these two spheres – propositional and prescriptive knowledge – remained more segregated, limiting the diffusion of insights and the cumulative development of innovations. Britain's distinctive social and institutional environment thus amplified the productive potential of its human capital upper tail, helping to convert useful knowledge into technological progress. Overall, in the most recent contributions – in particular in those in collaboration with Morgan Kelly and Cormac Ó Gráda, it is possible to identify an increasing emphasis by Mokyr on the accumulation and development of mechanical skills in a selected segment of the workforce as a crucial component for early industrialization (Kelly, Mokyr and Ó Gráda, 2014, 2022

²⁵ In his discussion of «upper-tail human capital,» Joel Mokyr (2018, p. 1004) cites approvingly Robert Hooke (1635-1703), who argued that the investigation of useful knowledge should be undertaken by means of «a Cortesian army, well-disciplined and regulated, though their numbers be but small», alluding to Hernán Cortés (1485-1547) and his subjugation of the Aztec Empire by a small expeditionary force of Spanish conquistadors.

²⁶ An interesting corroboration of Mokyr's upper tail human capital hypothesis (in the version of «intellectuals») is provided by Squicciarini and Voigtlander (2015). Their study considers the case of France in the eighteenth and nineteenth century. Their proxy for «upper tail human capital» is the number of subscriptions to the *Encyclopedie* at department level. A recent comparative discussion of the different distribution of artisans and intellectuals in the upper tail human capital in Britain and France is in Nuvolari, Tortorici and Vasta (2023). A recent important paper by Kelly and Ó Gráda (2022) highlights, particularly in Britain, the crucial role of an emerging group of applied mathematicians and instrument makers who progressively forged significant connections between the worlds of intellectuals and artisans.

²⁷ For a major study of the evolution and the functioning of the apprenticeship system in Britain, see Wallis (2025). Macleod and Nuvolari (2009) show the importance of apprenticeships for the creation of the most important engineering firms of the early phase of the Industrial Revolution. For quantitative appraisals of the role of millwrights and engineers in line with Mokyr's account, see de Pleijt, Nuvolari and Weisdorf (2020) and Hanlon (2025).

and 2023).²⁸ It is worth noting, however, that for Mokyr, this accumulation of mechanical skills is not exclusively the outcome of «uneducated» empirical processes of learning by doing and by using, but remains fundamentally imbued in the «scientific mentality» of the Industrial Enlightenment.

4.4. *The Republic of Letters and the origins of the Enlightenment*

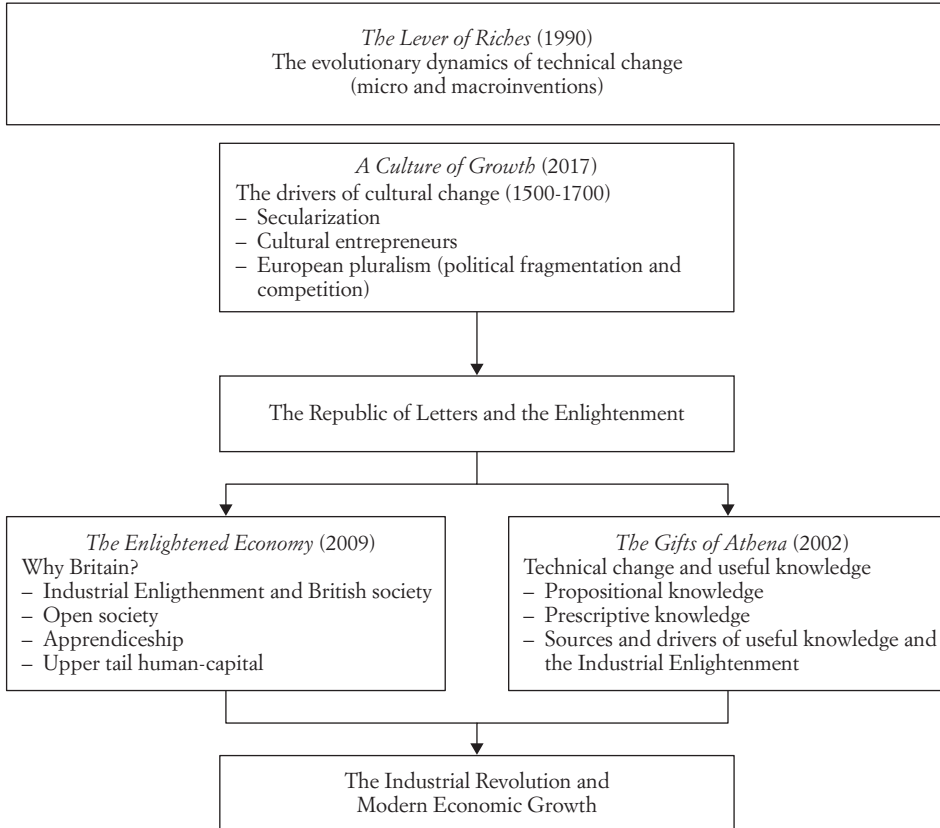
One important critique of the Industrial Enlightenment interpretation of the Industrial Revolution is that it may simply push the explanation one step back. Accepting that the Industrial Revolution was fueled by the Industrial Enlightenment raises a deeper question: what accounts for the emergence of the Enlightenment itself across Western Europe in the eighteenth century? This issue is addressed in Mokyr (2017). Taking a comparative perspective, Mokyr examines Europe alongside other regions of the world, particularly China, and applies again an evolutionary perspective – this time not to technological or scientific innovations per se, but to cultural novelties more broadly, that is, «ideas».

Central to Mokyr's argument is the role of individuals he terms «cultural entrepreneurs». These figures introduced new cultural outlooks that displaced established ones, echoing Schumpeter's concept of creative destruction: for new ideas to take hold, they must dislodge established ones. Mokyr identifies Francis Bacon (1561-1626) and Isaac Newton (1643-1727) as the key cultural entrepreneurs whose work laid the foundations for the eighteenth-century Enlightenment. Bacon, in particular, articulated a persuasive program for the systematic generation, diffusion, and practical application of useful knowledge in the interest of human prosperity – the so-called «Baconian program» – which Mokyr sees as pivotal for the emergence of the Industrial Enlightenment.

Mokyr further emphasizes that the social environment for cultural novelties is often highly selective, as societies tend to maintain stable beliefs and knowledge over time. In contrast to China, Europe's relative fortune lay in its political fragmentation, a configuration that emerged in the Middle Ages. Fragmentation created spaces where new ideas could be tested, survive, and migrate across borders. If some novelty did not take root in one country, it could still emerge in another. In this context, the emergence of a transnational «Republic of Letters» during the sixteenth century is especially significant: while Europe remained politically divided, it became increasingly culturally interconnected, with ideas circulated, debated, and critiqued across countries, within a self-organizing community of «scholars» or *savants*. It was precisely this combination – fragmented political authority and transnational intellectual networks – that created the fertile ground in which the Enlightenment could originate and expand during the eighteenth century. Here Mokyr cites approvingly a perceptive assessment of Edward Gibbon (1737-1794) linking political fragmentation to tolerance and expansion of knowledge:

Europe is now divided into twelve powerful, though unequal, kingdoms, three respectable commonwealths, and a variety of smaller, though independent, states:

²⁸ On the role of mechanical skills, see also Ó Gráda (2016).

Figure 1. Mokyr's «grand narrative» of the origins of Modern Economic Growth.

the chances of royal and ministerial talents are multiplied, at least, with the number of its rulers [...] The abuses of tyranny are restrained by the mutual influence of fear and shame; republics have acquired order and stability; monarchies have imbibed the principles of freedom, or, at least, of moderation; and some sense of honour and justice is introduced into the most defective constitutions by the general manners of the times. In peace, the progress of knowledge and industry is accelerated by the emulation of so many active rivals; in war, the European forces are exercised by temperate and undecisive contests (Gibbon, *The History of the Decline and Fall of the Roman Empire*, 1789, cited in Mokyr 2017, p. 168).

4.5. Synthesis

Figure 1 provides a synthetic overview of Mokyr's research agenda since *The Lever of Riches*. The central question guiding his work is the explanation of Modern Economic Growth and its origins in the Industrial Revolution. In *The Lever of Riches* (Mokyr 1990), he introduced a general evolutionary framework for the study of technological change, emphasizing the distinction between micro- and macroinventions. This framework is fur-

ther elaborated and applied to the origins of the Industrial Revolution in *The Gifts of Athena* (Mokyr 2002), where he examines the epistemological foundations of innovation by introducing the notion of «useful knowledge» and identifying the Industrial Enlightenment as a crucial prerequisite for sustained economic growth. According to Mokyr, without the synergistic interaction between «propositional» and «prescriptive» knowledge fostered by the Enlightenment, growth was bound to remain sporadic. In *The Enlightened Economy*, he analyzes the Industrial Enlightenment in action in industrializing Britain, exploring its broader economic and social ramifications and its interplay with other historical processes. Finally, in *A Culture of Growth* (Mokyr 2017), he traces the origins of the Enlightenment itself, highlighting its roots in political fragmentation and the intellectual networks of the «Republic of Letters». Collectively, these works complement each other forming an impressive «grand narrative» or «fresco» highlighting the key role of the evolution of knowledge, in dynamic interaction with other cultural, economic, social, and institutional forces in the emergence of Modern Economic Growth.

5. CONCLUSION

Joel Mokyr's Nobel prize signals, above all, a renewed acknowledgment of the indispensable role of economic history within economics itself. Mokyr's work demonstrates that some of the discipline's most fundamental questions – why sustained growth emerged, why it proved durable, and why it remained geographically uneven – cannot be answered alone through theoretical modeling or econometric analysis alone. They require deep immersion in historical processes, attention to context, and sensitivity to how ideas, institutions and social practices change over time. In this perspective, economic history is not a subordinate field tasked merely with supplying «data». It is an autonomous domain of inquiry in which interpretive hypotheses are formulated, scrutinized, and refined – often reshaping the very questions economists ask.²⁹

Another central lesson of Mokyr's scholarship is that the development of knowledge and ideas must occupy a more prominent place in economic explanation. His work rests on wide-ranging and intensive engagement with the scholarship of historians of science and technology. Crucially, he does not treat their findings in isolation. Rather, he situates them within their broader historical setting, drawing on insights from other fields of history. Mokyr's historical erudition is proverbial, yet it is far from ornamental. His command of historical detail is integral to the formulation of his interpretive hypotheses. This genuinely multidisciplinary outlook is a defining methodological feature of his approach. It offers an important lesson not only to econo-

²⁹ In this respect, it is worth emphasizing that Mokyr's broader approach fosters a more substantive and genuinely reciprocal dialogue between economic history and economics than that underlying the recent vogue of «persistence studies», in which economic history tends to play a more subordinate role (see Cioni, Federico and Vasta 2023).

mists, but also to economic historians, who too often confine their reading to the boundaries of their own field rather than engaging more fully with the wider historical scholarship. This approach has not been without critics. In his review of *The Enlightened Economy*, Clark argued that Mokyr's historically rich narrative – its attention to detail and openness to multiple causation – actually amounted to a «re-embrace ... of [an] earlier casual mode of history ... [that] puts us on the wrong path» (Clark 2012, p. 93). This criticism, however, misses the mark. Mokyr's method begins with comprehensive historiographical surveys from which he derives interpretive hypotheses, often introducing novel conceptual tools in the process. In subsequent research – whether by Mokyr himself or by others – these concepts are operationalized and the hypotheses subjected to empirical scrutiny using the available evidence (often stimulating the exploration of new sources and the construction of new data). His narrative, therefore, is not a retreat from «testable scientific history» (Clark 2012, p. 93) but a precondition for it. It should be understood as a generative canvas that opens new and challenging research agendas, rather than an impressionistic historical account.

Finally, it is worth emphasizing that, on a personal level, Joel Mokyr has consistently embodied the virtues of the Industrial Enlightenment that he has so eloquently described in his scholarship. Throughout his career, he has been an indefatigable mentor to PhD students and has served in editorial and leadership roles within various economic history associations and societies.³⁰ He edited a major Encyclopedia (Mokyr 2003) and, as editor of the book series *Princeton Economic History of the Modern World*, has overseen the publication of seminal works that have greatly advanced the frontier of the research in the field.³¹ Remarkably, despite the demands of his work, he has always been generous with his time in support of the broader international community of economic historians. This human dimension – manifest in generosity, mentorship, and dedication – forms an integral part of the remarkable career that culminated in the Nobel Prize.

References

- Aghion, P. and Howitt, P. (1992), «A model of growth through creative destruction», *Quarterly Journal of Economics*, 60(2), pp. 323-351.
- A'Hearn, B., Baten, J. and Crayen, D. (2009), «Quantifying quantitative literacy: Age heaping and the history of human capital», *Journal of Economic History*, 69(3), pp. 783-808.

³⁰ Even a selective list of his principal honors and positions shows that Joel Mokyr's achievements are coupled with a sustained dedication to scholarly institutions. He served as editor of the *Journal of Economic History* from 1994 to 1998 and as President of the Economic History Association in 2002-2003. Mokyr was elected a foreign member of the Royal Netherlands Academy of Arts and Sciences and of the Accademia Nazionale dei Lincei. He is a Fellow of the British Academy and of the Econometric Society, and a Distinguished Fellow of the American Economic Association. He has also been awarded the prestigious Dr A.H. Heineken Prize and Balzan Prize for his contributions to historical research.

³¹ The book series is notable for its remarkable breadth and intellectual pluralism, featuring contributions that explicitly challenge Mokyr's findings and interpretations. Prominent examples include Allen (2003), Clark (2007), Gordon (2016), Paglayan (2024) and Pomeranz (2000).

- A'Hearn, B., Delfino, A. and Nuvolari, A. (2022), «Rethinking age heaping: A cautionary tale from nineteenth century Italy», *Economic History Review*, 75(1), pp. 111-137.
- Allen, R.C. (2003), *Farm to Factory, A Reinterpretation of the Soviet Industrial Revolution*, Princeton University Press, Princeton.
- Allen, R.C. (2009), *The British Industrial Revolution in Global Perspective*, Cambridge University Press, Cambridge.
- Allen, R.C. (2015), «The high wage economy and the Industrial Revolution: A re-statement», *Economic History Review*, 68(1), pp. 1-22.
- Allen, R.C. (2020), «Spinning their wheels: A reply to Jane Humphries and Benjamin Schneider», *Economic History Review*, 73(4), pp. 1128-1136.
- Ben Zeev, N., Mokyr, J. and van der Beek, K. (2017), «Flexible supply of apprenticeship during the Industrial Revolution», *Journal of Economic History*, 7 (1), pp. 208-250.
- Berg, M. and Hudson, P. (2021), «Slavery, Atlantic trade and skills: A response to Mokyr's "Holy Land of Industrialism"», *Journal of the British Academy*, 9, pp. 259-281.
- Buyst, E. (2018), «"A Culture of Growth" situated in Joel Mokyr's *scientific oeuvre*», *European Journal of the History of Economic Thought*, 25(6), pp. 1495-1499.
- Cardwell, D. (1994), *The Fontana History of Technology*, Harper, London.
- Cioni, M., Federico, G. and Vasta, M. (2021), «The two revolutions in economic history» in A. Bisin, and G. Federico (eds.), *Handbook of Historical Economics*, Elsevier, Amsterdam, pp. 17-40.
- Cioni, M., Federico, G. and Vasta, M. (2023), «Is economic history changing its nature? Evidence from top journals», *Cliometrica*, 17(1), pp. 23-48.
- Clark, G. (2007), *A Farewell to Alms. A Brief Economic History of the World*, Princeton University Press, Princeton.
- Clark, G. (2012), «A review essay on *The Enlightened Economy: An Economic History of Britain 1700–1850* by Joel Mokyr», *Journal of Economic Literature*, 50(1), pp. 85-95.
- Constant, E.W. (1973). «A model for technological change applied to the turbojet revolution», *Technology & Culture*, 14(4), pp. 553-572 .
- Crafts, N. (2011), «Explaining the first industrial revolution: Two views», *European Review of Economic History*, 15(1), pp. 153-168.
- Danna, R. (2026), *The Craft of Indo-Arabic Numerals. How Practical Arithmetic shaped Commerce and Mathematics in Western Europe, 1200-1600*, Harvard University Press, Cambridge (MA).
- De Plijt, A., Nuvolari, A. and Weisdorf, J. (2020), «Human capital formation during the First Industrial Revolution: Evidence from the use of steam engines», *Journal of the European Economic Association*, 18(2), pp. 829-889.
- Dosi, G. (1982), «Technological paradigms and technological trajectories: A suggested interpretation of the determinants and directions of technical change», *Research Policy*, 11(3), pp. 147-162.
- Dosi, G. and Nelson, R.R. (2010), «Technical change and industrial dynamics as evolutionary processes», in B. Hall, and R. Rosenberg (eds.), *Handbook of the Economics of Innovation. Vol. 1*, Elsevier, Amsterdam, pp. 51-127.
- Dowey, J. (2017), *Mind Over Matter: Access to Knowledge and the British Industrial Revolution*, The London School of Economics and Political Science (LSE) Ph.D. thesis.
- Federico, G. (2024), «A Nobel Prize for economic history?», *Rivista di Storia Economica / Italian Review of Economic History*, 40(3), pp. 329-341.
- Flexner, A. (2017), *The Usefulness of Useless Knowledge*, Princeton University Press, Princeton (1st edition 1939).

- Fox, R. (1986), «Introduction.», in S. Carnot, *Reflections on the Motive Power of Fire. A Critical Edition with the Surviving Scientific Manuscripts*, Manchester University Press, Manchester, pp. 1-57.
- Freeman, C. (1974), *The Economics of Industrial Innovation*, Penguin, Harmondsworth.
- Gordon, R.J. (2016), *The Rise and Fall of American Growth: The U.S. Standard of Living since the Civil War*, Princeton University Press, Princeton.
- Hall, B. and Rosenberg, N. (eds.) (2010a), *Handbook of the Economics of Innovation. Vol. 1*, Elsevier, Amsterdam.
- Hall, B. and Rosenberg, N. (eds.) (2010b), *Handbook of the Economics of Innovation. Vol. 2*, Elsevier, Amsterdam.
- Hall, R.A. (1974), «What did the Industrial Revolution in Britain owe to Science?», in N. McKendrick (ed.), *Historical Perspectives. Studies in English Thought and Society*, Europa Publications, London, pp. 34-57.
- Hanlon, W. (2025), «The rise of the engineer: Inventing the professional inventor during the Industrial Revolution», *Economic Journal*, 135(670), pp. 1749-1781.
- Hobsbawm, E. (1968), *Industry and Empire*, Weidenfield and Nicolson, London.
- Humphries, J. (2013), «The lure of aggregates and the pitfalls of the patriarchal perspective: A critique of the high wage economy interpretation of the British Industrial Revolution», *Economic History Review*, 66(3), pp. 693-714.
- Humphries, J. and Schneider, B. (2019), «Spinning the Industrial Revolution», *Economic History Review*, 72(1), pp. 126-155.
- Jones, P.M. (2008), *Industrial Enlightenment. Science, Technology and Culture in Birmingham and in the West Midlands, 1760-1820*, Manchester University Press, Manchester.
- Jones, P.M. (2020), «James Watt and the steam engine. A Calvinist path to Enlightenment and creativity», in M. Dick, and C. Archer-Parre (eds.), *James Watt, 1736-1819. Culture, Innovation and Enlightenment*, Liverpool University Press, Liverpool.
- Kelly, M. and Ó Gráda, C. (2022), «Connecting the Scientific and Industrial Revolutions. The role of practical mathematics», *Journal of Economic History*, 82(3), pp. 841-873.
- Kelly, M., Mokyr, J. and Ó Gráda, C. (2014), «Precocious Albion: A new interpretation of the British industrial revolution», *Annual Review of Economics*, 6, pp. 363-389.
- Kelly, M., Mokyr, J. and Ó Gráda, C. (2022), «Could artisans have caused the Industrial Revolution?», *Rivista di Storia Economica / Italian Review of Economic History*, 38(1), pp. 11-28.
- Kelly, M., Mokyr, J. and Ó Gráda, C. (2023), «The mechanics of the Industrial Revolution», *Journal of Political Economy*, 131(1), pp. 59-94.
- Kuhn, T.S. (1962), *The Structure of Scientific Revolutions*, University of Chicago Press, Chicago.
- MacLeod, C. (1988), *Inventing the Industrial Revolution. The English Patent System, 1660-1800*, Cambridge University Press, Cambridge.
- MacLeod, C. and Nuvolari, A. (2009), «“Glorious Times”: The Emergence of Mechanical Engineering in Early Industrial Britain, c. 1700-1850», *Brussels Economic Review*, vol. 52(3/4), pp. 215-237.
- McCloskey, D. (1976), «Does the past have useful economics?», *Journal of Economic Literature*, 14(2), pp. 434-461.
- McCloskey, D. (2024), «Economic history as humanomics: The scientific branch of economics» in C. Diebolt, and M. Hauptert (eds.), *Handbook of Cliometrics*, Springer, Berlin, pp. 109-122.
- Mancini, G. (2024), «Women, economic history and the Nobel», *Rivista di Storia Economica / Italian Review of Economic History*, 40(1), pp. 115-124.

- Meisenzahl, R.R. and Mokyr, J. (2012), «The rate and direction of invention in the British Industrial Revolution: Incentives and institutions», in J. Lerner, and S. Stern (eds.), *The Rate and Direction of Inventive Activity Revisited*, University of Chicago Press, Chicago, pp. 443-479.
- Mitch, D. (1993), «The role of human capital in the first Industrial Revolution», in J. Mokyr (ed.), *The British Industrial Revolution: An Economic Perspective*, Westview Press, Boulder.
- Mokyr, J. (1976), *Industrialization in the Low Countries, 1795-1850*, Yale University Press, New Haven.
- Mokyr, J. (1977), «Demand vs. Supply in the Industrial Revolution», *Journal of Economic History*, 37(4), pp. 981-1008.
- Mokyr, J. (1983), *Why Ireland Starved. A Quantitative and Analytical History of the Irish Economy, 1800-1850*, Allen and Unwin, Boston.
- Mokyr, J. (1985), «The new economic history and the Industrial Revolution», in J. Mokyr (ed.), *The Economics of the Industrial Revolution*, Rowman & Littlefield, Totowa, pp. 1-84.
- Mokyr, J. (1990a), *The Lever of Riches. Technological Creativity and Economic Progress*, Oxford University Press, Oxford.
- Mokyr, J. (1990b), *Twenty-five Centuries of Technical Change. A Historical Survey*, Harwood, New York.
- Mokyr, J. (1992), «Technological Inertia in Economic History», *Journal of Economic History*, 52(2), pp. 325-338.
- Mokyr, J. (1993), «The new economic history and the Industrial Revolution», in J. Mokyr (ed.), *The British Industrial Revolution. An Economic Perspective*, Westview, Boulder, pp. 2-126.
- Mokyr, J. (2002), *The Gifts of Athena. Historical Origins of the Knowledge Economy*, Princeton University Press, Princeton.
- Mokyr, J. (ed.) (2003), *The Oxford Encyclopedia of Economic History*, Oxford University Press, Oxford.
- Mokyr, J. (2005a), «An interview with Joel Mokyr», *Newsletter of the Cliometric Society*, 20(3), pp. 4-9.
- Mokyr, J. (2005b), «The intellectual origins of modern economic growth», *Journal of Economic History*, 65(2), pp. 285-351.
- Mokyr, J. (2009), *The Enlightened Economy. An Economic History of Britain*, Yale University Press, New Haven.
- Mokyr, J. (2010), «The contribution of economic history to the study of innovation and technical change», in B. Hall and N. Rosenberg (eds.), *Handbook of the Economics of Innovation. Vol. 1*, Elsevier, Amsterdam, pp. 11-50.
- Mokyr, J. (2017), *A Culture of Growth. The Origins of the Modern Economy*, Princeton University Press, Princeton.
- Mokyr, J. (2018), «Bottom-up or Top-down ? The origins of the Industrial Revolution», *Journal of Institutional Economics*, 14(6), pp. 1003-1024.
- Mokyr, J. (2021), «“The holy land of industrialism”: Rethinking the Industrial Revolution», *Journal of the British Academy*, 9, pp. 223-247.
- Mokyr, J. (2022), «Incentives, institutions and industrialization: A prelude to modern economic growth», *Rivista di Storia Economica / Italian Review of Economic History*, 38(2), pp. 127-146.
- Mokyr, J. and Ó Gráda, C. (1982), «Emigration and poverty in pre-famine Ireland», *Explorations in Economic History*, 19(4), pp. 360-384.
- Moretti, F. (2000), «The slaughterhouse of literature», *Modern Language Quarterly*, 61(1), pp. 207-227.
- Musson, A.E. and Robinson, E. (1969), *Science and Technology in the Industrial Revolution*, Manchester University Press, Manchester.

- Nelson, R. (1998), «The agenda for growth theory: A different point of view», *Cambridge Journal of Economics*, 22(4), pp. 497-520.
- Nelson, R. and Winter, S. (1982), *An Evolutionary Theory of Economic Change*, Belknap Press of Harvard University Press, Cambridge (MA).
- Nuvolari, A. (2002), «The “Machine Breakers” and the Industrial Revolution», *Journal of European Economic History*, 31(3), pp. 393-426.
- Nuvolari, A., Tartari, V. and Tranchero, M. (2021), «Patterns of innovation during the Industrial Revolution: A reappraisal using a composite indicator of patent quality», *Explorations in Economic History*, 82, article 101419.
- Nuvolari, A., Tortorici, G. and Vasta, M. (2023), «British-French technology transfer from the Revolution to Louis Philippe (1791-1844): Evidence from patent data», *Journal of Economic History*, 83(3), pp. 833-873.
- O’Brien, P. (1997), «The micro foundations of macro invention: The case of the reverend Edmund Cartwright», *Textile History*, 28(2), pp. 201-233.
- Ó Gráda, C. (2016), «Did science cause the Industrial Revolution?», *Journal of Economic Literature*, 54(1), pp. 224-239.
- Otojanov, R., Fouquet, R. and Granville, B. (2023), «Factor prices and induced technical change in the Industrial Revolution», *Economic History Review*, 76(2), pp. 599-623.
- Paglayan, A.S. (2024), *Raised to Obey: The Rise and Spread of Mass Education*, Princeton University Press, Princeton.
- Pomeranz, K. (2000), *The Great Divergence: China, Europe and the Making of the Modern World Economy*, Princeton University Press, Princeton.
- Porter, R. (2000), *Enlightenment. Britain and the Creation of the Modern World*, Penguin, Harmondsworth.
- Ridolfi, L. (2019), «Six centuries of real wages in France from Louis IX to Napoleon III: 1250-1860», *Journal of Economic History*, 79(3), pp. 589-627.
- Rosenberg, N. (1976). *Perspectives on Technology*, Cambridge University Press, Cambridge.
- Rosenberg, N. (1982), *Inside the Black Box: Technology and Economics*, Cambridge University Press, Cambridge.
- Sandberg, L.G. (1979), «The case of the impoverished sophisticate: Human capital and Swedish economic growth before World War I», *Journal of Economic History*, 39(1), pp. 225-241.
- Shapin, S. and Shaffer, S. (1985), *Leviathan and the Air Pump. Hobbes, Boyle and the Experimental Life*, Princeton University Press, Princeton.
- Solow, R. (1956), «A contribution to the theory of economic growth», *Quarterly Journal of Economics*, 70(1), pp. 65-94.
- Squicciarini, M. and Voigtlander, N. (2015), «Human capital and industrialization: Evidence from the Age of Enlightenment», *Quarterly Journal of Economics*, 130(4), pp. 1825-1883.
- Stephenson, J. (2018), «“Real” wages? Contractors, workers and pay in London building trades, 1650-1800», *Economic History Review*, 71(1), pp. 106-132.
- Verspagen, B. (1992), «Endogenous innovation in neoclassical growth models: A survey», *Journal of Macroeconomics*, 14(4), pp. 631-662.
- Vincenti, W.G. (1993), *What Engineers Know and How the Know It*, Johns Hopkins University Press, Baltimore.
- Wallis, P. (2025), *The Market for Skill. Apprenticeship and Economic Growth in Early Modern England*, Princeton University Press, Princeton.
- Zahdieh, N. (2021), «Britain’s Atlantic slave economy, the market for knowledge and skills, and early industrialisation: A response to Joel Mokyr’s *Holy Land of Industrialism*», *Journal of the British Academy*, 9, pp. 283-293.