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COMMANDING NATURE BY OBEYING HER: A REVIEW ESSAY ON JOEL MOKYR'S A CULTURE OF GROWTH

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ABSTRACT

Why is modern society capable of cumulative innovation? In A Culture of Growth: The Origins of the Modern Economy, Joel Mokyr persuasively argues that sustained technological progress stemmed from a change in cultural beliefs. The change occurred gradually during the seventeenth and eighteenth century and was fostered by an intellectual elite that formed a transnational community and adopted new attitudes toward the creation and diffusion of knowledge, setting the foundation for the ethos of modern science. The book is a significant contribution to the growing literature that links culture and economics. This review discusses Mokyr's historical analysis in relation to the following questions: What is culture and how should we use it in economics? How can culture explain modern economic growth? Will the culture of growth that caused modern prosperity persist in the future?

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Scientia et potentia humana in idem coincident […]. Natura non nisi parendo vincitur.

Human knowledge and human power meet in one […]. Nature to be commanded must be obeyed.

Francis Bacon (1620)

1. The Cultural Roots of Sustained Technological Progress

Modern economic growth is historically unprecedented. Before 1800, no society had ever experienced the sustained growth in productivity, income per capita and living standards that we have enjoyed – and often taken for granted - over the past two centuries.[1] Why are we so much richer than our ancestors?

Earlier economic explanations of modern growth focused on its most visible feature, the accumulation of physical capital in the form of new machines, buildings, railroads, and so on. Later, models of growth have included investment in human capital. However, most economic historians and growth economists agree that neither capital accumulation nor education alone can explain modern economic growth. At the center of modern development is technological progress: faster growth of total factor productivity due to the continuous introduction of better technologies.

Innovation has always been part of human existence, from the control of fire by *Homo erectus* to the transition to agriculture during the Neolithic, from the spread of water mills in Classical antiquity to the introduction of the printing press in fifteenth-century Europe. Before the Industrial Revolution, however, technological improvement was glacially slow, and its impact on income per capita was eventually offset by population growth, leaving the pre-modern world stuck in a Malthusian trap (Galor 2011). In contrast, over the last two centuries a spectacular cascade of innovations has continued to raise productivity and income per capita, generating what Deidre McCloskey (2016) has called "the great enrichment." As Robert Lucas (2002, p.109) remarked: "The novelty of the discovery that a human society has this potential for

[1] Previous phases of high growth, such as in early Song China and Tokugawa Japan, were remarkable but did not last. They were "rises without follow-ons" (McCloskey 2016, p.534).

generating sustained improvement in the material aspects of the lives of all of its members […] cannot be overstressed."

If we want to understand modern development, we must then ask *why* we now live in a world that is capable of cumulative innovation that gradually raises our material standards of living. Joel Mokyr's *A Culture of Growth. The Origins of the Modern Economy* provides an original and persuasive answer to this question.

Mokyr's main argument is that sustained technological progress stemmed from a change in *cultural beliefs about the natural world and the diffusion of knowledge*. The change took place in Europe after 1500 - especially during the seventeenth and eighteenth century. Mokyr's focus is on "the one element in cultural beliefs that economists have so far neglected almost entirely, namely the attitude toward Nature and the willingness and ability to harness it to human material needs." (p.14) He argues that the cultural transformation occurred gradually, starting within a small but influential elite that shared new habits of mind and communication. Those intellectuals formed a transnational and interconnected community known as *Respublica Literaria* or the Republic of Letters. Over time, its members adopted new attitudes toward the creation and diffusion of knowledge that anticipated the ethos of modern science, as characterized by Robert K. Merton (1973). They started to believe that knowledge should be *universal* (not specific to a single group); it should be shared by placing it in the *common* domain; and it should be acquired through *disinterested* and *skeptical* search by researchers whose findings are systematically *verified* by equally disinterested and skeptical peers.[2]

This community shared two fundamental beliefs. First, we *can* understand how the natural world works. Second, we *can* and *should* use such knowledge to improve human production and welfare. In 1620, Francis Bacon - a central hero in Mokyr's story – wrote that "human knowledge and human power meet in one, for where the cause is not known the effect cannot be produced. Nature to be commanded must be obeyed." He meant that the source of human power over nature is a *deep causal knowledge of natural rules*. A premise of this view is that there exists an objective reality, which follows natural rules, independently of human wishes

[2] These cardinal scientific virtues are sometimes summarized as Communalism, Universalism, Disinterestedness, and Organized Skepticism: CUDOS (Pinker 2018, p. xvii).

and feelings. And yet, by understanding and obeying the rules of nature, humans can control the world for their own goals. For example, humans can now fly not because the Wright brothers "negated" or "violated" the law of gravity and the other constraints of physics, but because they *commanded* those natural rules by *obeying* them in a novel and creative way.

Mokyr argues that this Baconian belief in the practical power of scientific knowledge has been crucial for the long-term development of technology. Many historians believe that formal science had little to do with technological progress during the Industrial Revolution.[3] Mokyr acknowledges that "on the eve of the Industrial Revolution, it was not easy to see the fruits of science translated into practical uses" (p.269). There was no direct impact of Galileo and Newton's Scientific Revolution on major technological advances of the Industrial Revolution, especially in the sectors of textiles and iron. However, other areas benefited from scientific breakthroughs - e.g., Newcome's atmospheric engine, soda-making process and chlorine bleaching, the calculation of the trajectory of a projectile, the determination of longitude at sea, smallpox inoculation and vaccination. In Mokyr's view, those applications greatly mattered not as much because of their immediate economic impact, but rather as impressive *examples* that Bacon was right: science had the potential to improve technology. More broadly, Mokyr rejects the widespread view that formal scientific knowledge was not essential to the emergence of modern growth. Instead, he argues that high-skilled artisans were necessary but not sufficient: "useful knowledge and artisanal dexterity were strongly complementary" (p.273). His central argument is that, in the absence of a deep understanding of the natural principles that make techniques work, technological progress would have eventually slowed down and stopped, as it had happened in all previous instances of rapid innovation. Knowing *why* new techniques worked allowed continuous technological progress that would have been impossible if innovators had to rely only on imitation and learning by trial and error. As Mokyr eloquently states, "when cultural evolution began to involve persuasion regarding the natural principles that make techniques work, the game of innovation was changed forever, and increasingly discrete leaps in technology became increasingly frequent. That is the tale underlying the great enrichment." (p.33)

[3] The book includes a detailed discussion of the role of scientific methods and discoveries in the early stages of the Industrial Revolution (see especially pp.268-280).

A Culture of Growth originates from the lectures that Mokyr gave at the Schumpeter Society in Graz, and builds on a lifetime of path-breaking research on the history of technological progress, including well-known classics such as *The Lever of Riches: Technological Creativity and Economic Progress* (1992), *The Gifts of Athena: Historical Origins of the Knowledge Economy* (2002), and *The Enlightened Economy: An Economic History of Britain 1700-1850* (2010). A common thread in his investigations is that *ideas* are fundamental causes of economic development, or, as he stated at the very beginning of *The Enlightened Economy*: "Economic change in all periods depends, more than economists think, on what people believe." In this book, Mokyr expands on his earlier contributions in two related ways: by digging deeper into the interplay of cultural and institutional changes that led to the gradual formation of an influential community of intellectual innovators, and by linking his sophisticated historical analysis to the broader debate on the role of culture in economics.

In the first part of the book (chapters 1-5), Mokyr presents an extensive discussion of "Evolution, Culture, and Economic History." At first, readers who are unfamiliar with the literature on cultural evolution may find these chapters rather abstract and remote from the central topic of the book. However, their relevance becomes more apparent after reading the core of the historical contribution, which is mostly provided in the third part of the book ("Innovation, Competition, and Pluralism in Europe: 1500-1700" - chapters 9-12), where Mokyr masterfully explains how the Republic of Letters emerged and why it mattered, and in the fourth part ("Prelude to the Enlightenment" - chapters 13-15), which includes an insightful discussion of the relationship between the Enlightenment and economic change. These core parts are preceded by two intriguing and entertaining chapters on Francis Bacon and Isaac Newton, two "cultural entrepreneurs" who played a pivotal role in the emergence of the new culture of growth.

The last part of the book ("Cultural Change in the East and West" – chapters 16-17), discusses why the cultural transformation happened first in Europe rather than in other advanced civilizations, such as China. In the European competitive market for ideas, the "moderns" ultimately triumphed over the "ancients," and society adopted the revolutionary belief that each new generation has the potential to create a better culture and a superior body of knowledge, improving on what has existed until then. In contrast, "the heavy hand of the respect for

'ancients' was felt throughout much of Chinese history" (p.298). Nonetheless, according to Mokyr, the emergence of modern science in European and the triumph of conservative ideology in China were not historically preordained and inevitable, but the results of contingent circumstances and choices that, under slightly different conditions, could have led to different outcomes. An intriguing counterfactual is what might have happened to Chinese history if Mohism, with its focus on scientific thought, logic and impartiality, had not completely vanished in favor of Confucianism, its main intellectual rival (p.299). Even within Confucianism itself, "there was a great deal of heterogeneity and room for flexibility, and surely it allowed for different degrees of openness to innovation" (p.298). And yet, eventually China and Europe followed very different intellectual paths regarding the rise of open science. A key difference was that "China paradoxically lacked a unifying single coordinating mechanism such as a competitive market in which new ideas were tested" (p.318). In contrast, the European "market for ideas worked well enough to allow new entrants to challenge incumbents." Ultimately, what made successful cultural entrepreneurs - such as Newton, Lavoisier, Darwin and numerous others - possible was that "in Europe the market for ideas was not just contestable, but that ideas were actually continually contested. Intellectual sacred cows were increasingly being led to the slaughterhouse of evidence." (p.319)

Mokyr's fascinating historical analysis raises three sets of questions. First, what is culture and how should we use it in economics? Second, how can culture specifically explain modern economic growth? Third, is the "culture of growth" that has fostered modern prosperity likely to persist in the future? In the rest of this essay, I will discuss the book in relation to the first two sets of questions, and will conclude with a few brief remarks about the third question.

2. What is Culture and How Should It Be Used in Economics?

Cultural beliefs and mechanisms are at the center of Mokyr's analysis, even though, traditionally, economists have been reluctant to use culture as an explanation for economic outcomes. One reason for such reluctance is that culture is an elusive concept, with multiple meanings in everyday language and among academics. In an often-cited study, the anthropologists Alfred Kroeber and Clyde Kluckhohn (1952) listed 164 definitions of culture.

The word's etymology reflects this complexity. The English *culture* comes from the Latin *cultura*, which meant cultivation, as in agri*culture* (cultivation of the soil), from the verb *colere*, "to till" the soil, in turn coming from the Indo-European root $k^{w}el$-, meaning "to move around" and therefore also to "change" and "improve."[4] Roman writers extended this idea of improvement to the areas of knowledge and values (*cultura animi*, cultivation of the soul), from where we get the normative concept of culture as "development or improvement of the mind by education and training."[5] Later, the meaning of culture was extended to encompass all traits that are transmitted through learning and imitation across generations, independently of their quality. Voltaire (1756) used "culture" to denote the customs of different populations, so that different cultures produced "different fruits," in contrast with "nature," which he viewed as common among all human beings. This more general and neutral meaning is the source of the concept of culture as "the total ways of living built up by a group of human beings and transmitted from one generation to the other,"[6] which is central in anthropology and other social sciences.

Building on this contemporary meaning, Peter Richerson and Robert Boyd (2005, p.5), two leading scholars of cultural evolution, provide a comprehensive definition of culture as "information capable of affecting individuals' behavior that they acquire from other members of their species through teaching, imitation, and other forms of social transmission." Echoing Voltaire's observation that different cultures produce "different fruits," contemporary students of human evolution view cultural transmission as a first-order source of differences across human societies. For instance, Joseph Henrich and Richard McElreath (2003, p.123) write that "while a variety of local genetic adaptations exist within our species, it seems certain that the same basic genetic endowment produces arctic foraging, tropical horticulture, and desert pastoralism [...]. The behavioral adaptations that explain the immense success of our species are cultural in the sense that they are transmitted among individuals by social learning and have accumulated over generations. Understanding how and when such culturally evolved adaptations arise requires

[4] $k^{w}el$- is also the root of the English word *wheel*. Thus, the words for culture and for one of humanity's major inventions are etymologically related – although this may tempt some critics to quip that economists who use culture to explain technological progress are reinventing the wheel.
[5] *Webster's Encyclopedic Unabdidged Dictionary*, meaning 4.
[6] *Webster's Encyclopedic Unabdidged Dictionary*, meaning 6.

understanding of both the evolution of the psychological mechanisms that underlie human social learning and the evolutionary (population) dynamics of cultural systems."

Richerson and Boyd (2005) play a deservedly prominent role in Mokyr's methodological discussion of culture and evolution at the beginning of *A Culture of Growth*. Following their approach, he formulates a useful definition of culture as "the set of beliefs, values, and preferences, capable of affecting behavior, that are socially (not genetically) transmitted and that are shared by some subset of society" (p.8). Methodologically, the whole book is about the relevance of this concept of culture for understanding modern economic growth.

A prominent and explicit role for human choice is central to economists' approach to culture. For example, in their seminal work on the economics of cultural transmission (discussed by Mokyr in chapter 4), Alberto Bisin and Thierry Verdier (2000, 2001) have gone beyond mechanical models of transmission that mirrored genetic mechanisms - such as those studied by Luigi Luca Cavalli Sforza and Marcus Feldman (1981) - and explicitly introduced choice by the relevant economic agents. In general, when it is studied with the tools of economic analysis, cultural transmission can best be understood as the outcome of a complex set of purposeful decisions, whereby choices inside the family across generations (vertical transmission) interact with social imitation and learning outside the family, occurring both horizontally (from peers and media) and obliquely (from teachers and role models). Therefore, the study of cultural transmission is closely related to the growing field of economics that studies social interactions and social learning.[7]

Because of the interplay between vertical transmission and horizontal transmission, deeply-rooted similarities and differences across groups and societies may matter when studying economic development, but not necessarily in the direct and deterministic way that proponents of simple causal links from the past to the present have proposed. Rather than *directly* affecting comparative performance, cultural and historical differences may create *barriers* to communication and exchange across populations. Conversely, people who are historically and

[7] Discussions of the economics literature on social interactions are provided by Durlauf and Ioannides (2010) and Ioannides (2013). Contributions on culture and economics are surveyed by Bisin and Verdier (2010), Nunn (2012), Spolaore and Wacziarg (2013), Spolaore (2014), and Alesina and Giuliano (2015).

linguistically closer to each other may be more likely to adopt each other's cultural and institutional innovations through social influence and social learning. For example, Romain Wacziarg and I have found that the Industrial Revolution initially spread to populations that were more closely related to the English, and only later to more distant societies (Spolaore and Wacziarg 2009, 2018). We have also found (Spolaore and Wacziarg 2019) that new social norms about fertility control, pioneered by the French in the eighteenth and early nineteenth century, percolated to the rest of Europe along linguistic and cultural lines. In the initial phases of the demographic transition, only populations that were closer to the French reduced their fertility, while over time all other European populations gradually adopted the new fertility behavior. These findings suggest that cultural distances from the English and the French are not capturing the direct impact of "deep" differences between populations (a persistent effect of "Englishness" on industrialization or "Frenchness" on fertility behavior), but a temporary *barrier effect*: populations that were at a higher *social distance* from the innovators took longer to adopt modern norms and behaviors. Generally, horizontal transmission and vertical transmission tend to *interact* – so that new ideas and attitudes emerge and spread horizontally across different individuals and groups, but the patterns and dynamics of diffusion may be affected by pre-existing vertically-transmitted connections between them.

Mokyr places the mechanisms of cultural transmission and cultural change at the center of his narrative. The fact that cultural beliefs are not "immutable for life" but a matter of choice is crucial in his analysis. As he points out (p.36), "the degree to which people deviate from their default and adopt new cultural features is the critical variable that allows for dramatic cultural change."[8] In fact, Mokyr belongs to a small but prominent group of scholars of economic history who have suggested *changes* in culture and ideology as fundamental causes of modern development. Others in this line of research include Margaret Jacob (1997, 2014), Jane Jacobs (1992), Jack Goldstone (2009), and Deidre McCloskey (2006, 2010, 2016).

[8] This does not necessarily imply that all decisions are taken under perfect rationality. As Mokyr remarks (p.44), "the rational or even boundedly rational optimization process often assumed by economists does not seem terribly helpful when people make once-in-a-lifetime very rare choices." He prefers Samuel Bowles's approach, whereby people are "adaptive agents," who learn when they are exposed to cultural variants and decide whether or not to adopt them (Bowles 2004, p.60).

And yet, the use of ideas, beliefs and values to explain economic outcomes has often been met with skepticism in the economics profession. Are cultural phenomena too vague to satisfy the rigorous methodological standards required for proper causal analysis? Mokyr is well aware of these objections, and cites (p.5) a well-known line by Robert Solow (1970), who said that all attempts to explain national differences in economic performance and growth using non-economic factors "end up in a blaze of amateur sociology."

Solow's original comment, however, was not against cultural explanations. On the contrary, Solow was arguing *for* bringing such factors into the picture, but in a rigorous way. The context of his comment was an article on "Science and Ideology in Economics," published in *National Affairs* in 1970 and written in response to Robert Heilbroner's (1970) criticism of the "limited relevance" of economics. The words "culture" or "cultural" were never used by either Solow or Heilbroner in their articles, but Solow mentioned several "social forces" that economists had suggested to explain the relatively slow growth of the British economy compared to Continental economies after World War II. Those included, for example, "the slowness of English management to adopt new products or new processes or new ideas" and "the style of English education and the attitudes it imprints on graduates." The "blaze of amateur sociology" occurred when economists brought up all those factors (and many others) in an undifferentiated and confused way. Nevertheless, Solow recognized that those non-economic forces were relevant to explain national differences in growth performance, because "the identifiable purely economic factors do not account for the full difference between the growth of productivity in Britain and in, say, Germany or Sweden" (Solow 1970, p.103). Solow was not against the use of social and cultural variables themselves, but was arguing for a more scientific approach, noting that "it is a fair, if very complicated, problem in social science to measure the other social forces that operate on the level of output per man and the growth of output per man" (Solow 1970, p.103). His hope was that the social sciences would become interdisciplinary in a practical and research-motivated way, as it happened in the natural sciences, where "biochemistry and biophysics got started not because someone thought that biology should be interdisciplinary but because concrete research problems arose on the borderline of the biological and the chemical or physical" (Solow 1970, pp.101-2).

In fact, the main goal of Solow's article was countering what we might now call "post-modern" critics, who questioned a scientific approach to economic phenomena on ideological grounds: "The modern critics of economics and the other social sciences rarely seem to do any research themselves. One has the impression that they don't believe in it, that the real object of their dislike is the idea of science itself, especially, but perhaps not only, social science. […] The critics […] do not criticize on the basis of some new discovery of their own, but on the basis that […] anything that is discovered is likely to interfere with their own prescriptions for the good society. My own opinion is that the good society is going to need all the help it can get […]. A society that wants to be humane […] should be looking for clever, unhurtful, practical knowledge" (Solow 1970, p.107).

Solow's 1970 article is relevant to the arguments in Mokyr's book for two reasons. The first reason is that Solow, far from opposing the use of culture in economics, was in favor of introducing social and cultural forces into the picture, as long as the analysis was not vague or ideologically motivated. The second reason is that Solow's conclusion is an eloquent statement of the Baconian ethos that upholds a scientific approach to reality, so that we can achieve practical knowledge and improve human welfare. In the social world as well as in the physical world, we can only "command nature" if we "obey her." Thus, quite fittingly, Robert Solow - the creator of the most influential growth model - was himself a cultural heir of the Baconian beliefs and values that are at the center of Mokyr's narrative about the emergence of modern economic growth.

Consistent with Solow's prescriptions, Mokyr's *A Culture of Growth* uses culture in a concrete and research-driven way. He introduces cultural variables and mechanisms because he has concluded that we cannot explain modern economic growth without them. And his use of culture is not generic but very precise. In his view, only a *specific change* in cultural beliefs about nature and the diffusion of knowledge can satisfactorily explain why modern economic growth occurred when it occurred (and not at some other times) and why it happened in Europe (and not elsewhere). In the next section, I will discuss Mokyr's claim in more detail, in the context of the broader literature on culture, institutions, and development.

3. How Does Culture Explain Modern Economic Growth?

As modern economic growth is historically unique, we observe its onset only once. Hence it is extremely difficult to explain why it happened. Several potential "causes" proposed in the literature can be viewed at best as necessary conditions for prosperity, but they are inadequate to explain the exact timing, location, and spectacular size of the "great enrichment."

Among those preconditions is geography. Jared Diamond (1997) famously argued that some regions of the world had geographical and biological characteristics that were more favorable to the domestication of animals and plants and the spread of agricultural innovations.[9] These factors can help explain why complex civilizations emerged earlier in Eurasia than in other continents, but cannot explain why modern economic growth started in Western Europe rather than in China (a topic that Mokyr addresses in chapters 16 and 17 of his book, as we have already seen).

Another set of important preconditions is institutions associated with protection of property rights, enforcement of contracts and laws, executive constraints, and participation in political decisions (North 1981, 1990; Acemoglu, Johnson, and Robinson 2005; Acemoglu and Robinson 2012). There is extensive evidence that societies with extractive and anti-market institutions have worse economic outcomes than similar societies with relatively better institutions. As Mokyr remarks (p.11), an "almost hackneyed example" is the different development of North and South Korea, while another recent case is the contrast between Venezuela and Colombia. But if "bad institutions" can too easily kill prosperity, there is no guarantee that "good institutions" by themselves can foster a great enrichment. In fact, for millennia societies have enforced property rights and even adopted pro-market institutions without experiencing major economic progress (McCloskey 2010, p.316). According to Mokyr, the Industrial Revolution "does not seem to have been a response to any obvious institutional stimulus" (pp.5-6). Inclusive institutions and well-functioning markets may be a necessary component for sustained growth, but they do not appear to be sufficient.

[9] An overview of empirical tests of the Diamond's hypotheses and other long-term approaches to comparative development is provided in Spolaore and Wacziarg (2013).

If geography and market-friendly institutions are not enough to explain modern economic growth, is culture *the* cause of the great enrichment? As already noted, culture is a broad concept, encompassing all information that is transmitted non-biologically across generations – including technological knowledge itself. Thus, technological progress is by definition a cultural phenomenon, and it would only be natural – and almost tautological - that cultural variables and mechanisms should affect it. The question is not whether culture in general matters for economic growth (of course it does), but what *specific* cultural traits played a key role in the great enrichment and why. A great virtue of Mokyr's analysis is that it provides precise and testable hypotheses about such factors. In his view, the central changes associated with modern economic growth were the *new belief in the power of humans to understand nature*, and the creation of a *new system to acquire and diffuse such knowledge*, adopted by a transnational community of scholars (the Republic of Letters).

Cultural change was the driving force. It took place over time through intellectual innovation, persuasion, and cultural diffusion. Specifically, culture changed as the result of individual choices and social interactions, whereby cultural entrepreneurs came up with new ideas, and other intellectuals were persuaded by those entrepreneurs and adopted their new beliefs and attitudes. Over time, this cultural revolution affected technology not only directly, by changing attitudes towards the natural world, but also indirectly, by creating social rules and habits that stimulated and supported the accumulation and diffusion of useful knowledge. Those new social norms included tolerance of heterodox views, rigorous standards based on proofs and reproducible experiments, and positive attitudes towards openness, collaboration and disclosure. They provided the cultural and institutional foundations for a community of scholars that continuously exchanged new ideas and discoveries: the *Republic of Letters* in the seventeenth century and its successor, the *Republic of Science*, in the eighteenth and nineteenth century. *Cultural change* was therefore accompanied by a strongly complementary form of *institutional change*. However, the novel institutions that Mokyr highlights in this book are not government-enforced rules about protection of property rights in standard markets for rival goods, which are generally emphasized in the institutional literature. Rather, he stresses the role of social norms and informal rules that helped create a *well-functioning market for non-rival goods*: a market for ideas, discoveries, and innovations.

Interestingly, open science did not become the "central institutional principle of the intellectual world of early modern Europe" by conscious design. Rather, "it was an emergent property, the unintended consequence of a different phenomenon: scholars trying to build reputations among their peers in order to gain various advantages, including the much-hoped-for financial security, freedom, and time to do undisturbed research through patronage position" (p.183). As a result of the behavior of people who were responding to those incentives, useful knowledge became much more accessible and could eventually affect technology and productivity. As Mokyr explains, this is an important instance of how institutions are eventually "internalized" and "fed back" into cultural beliefs. Ultimately, "open science and free access to knowledge as a social method of organizing knowledge became itself a value, something to be savored and protected" (p.183). Consequently, culture and institutions are not alternative explanations for modern economic growth. Instead, cultural beliefs and institutional arrangements *coevolve*, whereby culture form "the foundation of institutions, in that it provides them with legitimacy" (p.10). In this respect, Mokyr's work is a significant contribution to the growing literature that studies the interplay and joint evolution of culture and institutions from an economics perspective (Greif 1994, 2005; Tabellini 2008, 2010; Alesina and Giuliano 2015; Bisin and Verdier 2017).

Mokyr's emphasis on cultural change helps dispel the common error that cultural explanations for economic development should only refer to *persistent* traits, passed without much variation from one generation to the next over the long run, and inexorably leading to foreordained outcomes for different societies. In other words, an evolutionary approach focused on cultural change is an antidote against the misconception that the effects of "culture" could *only* be interpreted in terms of "deep" characteristics that deterministically continue to affect contemporary outcomes. Modern economic growth "was not the ineluctable culmination of Western history, nor a sign of the greater dynamism of Western culture, but the unintended and unanticipated result of a set of circumstances that affected the culture of some parts of Europe and through them the institutions that set the parameters of intellectual development. Neither the classical world, nor the medieval church, nor the Renaissance made the material successes of the West inevitable." (p.33)

Consistent with an evolutionary approach to culture, Mokyr argues that the cultural mutations that actually took place were only some among many possible mutations that could have occurred. When we deal with cultural innovation and cultural choices, we face an inherent element of contingency and unpredictability, whereby similar circumstances can lead to different outcomes. It is generally erroneous to assume that "since what happened did happen it must have been inevitable," as Deidre McCloskey (2016, p.376) remarks when she criticizes David Landes's claim that "one could have foreseen the postwar economic success of Japan and Germany by taking account of culture" (Landes 1998, p.517).

And yet, evolutionary innovation is not the outcome of pure randomness. The Scientific Revolution and the Enlightenment did not happen in a vacuum, but arose and spread because cultural mutations took place in an environment that was favorable to them. As Mokyr writes, "historical circumstances were conducive to the sprouts of the seeds that were already present in the soil." (p.32)

Mokyr's book contains an extensive discussion of the historical and political circumstances that set Europe apart from other regions of the world, ultimately allowing the cultural innovators to defeat intellectual conservatism. In particular, the collapse of the Roman Empire in the West had led to the development of a unique situation in medieval Europe, whereby *political fragmentation* - the existence of a system of numerous independent states, polities and other self-governing entities in competition with each other - coexisted with substantial *cultural and intellectual unity*, derived from a shared classical heritage, the Christian Church, and the use of Latin as the lingua franca of scholars. Thus, cultural innovators could communicate with each other and spread their ideas, while political fragmentation and interstate competition limited rulers' ability to suppress cultural heterodoxy. This exceptional combination of political fragmentation and cultural unity played a key role in Europe's intellectual development, especially starting in the sixteenth century, when "heterodox cultural variants" emerged in every area of knowledge. Hence, political and institutional developments that took place in medieval times, such as the resurgence of the Latin Church and the formation of self-regulating communes and states, mattered not only because of their direct impact on economic

growth (which is more typically emphasized by economic historians[10]), but because they created favorable conditions to the emergence and diffusion of cultural innovation - an indirect and unintended effect which turned out to be even more important in the longer run.

The view that European political divisions may have been economically beneficial in the long run because they fostered competition and imposed limits on rulers has a long pedigree, going back to David Hume (1742), who famously noted that "the divisions into small states are favourable to learning, by stopping the progress of authority as well as that of power." As Mokyr notes (pp.167-168), contemporary scholars have often interpreted the systemic benefits of political fragmentation in terms of fiscal and administrative constraints, but Hume's focus was much more on cultural advantages ("freedom of thought and examination") than on taxation. On the other hand, political fragmentation and competition among European states obviously entailed significant costs because they were often associated with violent interstate wars and protectionist policies. Nonetheless, Hume's argument, strongly supported by Mokyr's historical analysis, suggests that those costs might have been offset by large indirect cultural benefits from political divisions. However, for those benefits to emerge, political fragmentation was necessary but not sufficient. As already mentioned, it had to be accompanied by substantial cultural unity, embodied by a pan-European community of transnational scholars who could take full advantages of the mobility of people (especially intellectuals) and ideas across political and linguistic borders. In this respect, according to Mokyr, European national and regional borders did *not* translate into significant cultural barriers to the spread of modern science. The essential cultural unity of European elites, developed during medieval times, persisted during the long critical period when the Republic of Letters emerged in the sixteenth and seventeenth century, and turned into the Republic of Science during the eighteenth and nineteenth century (even though the transnational network of scientists and intellectuals was disrupted by the French Revolution and the Napoleonic wars, it was reconstructed after 1815).

In emphasizing the pan-European origins of the Scientific Revolution, Mokyr is within the mainstream historical literature, which has generally rejected claims that scientists from specific national groups, such as the British or the French, played a dominant role in that process.

[10] For example, see Greif (2006) and Campbell (2016), reviewed by Cheney (2018) in this journal.

Mokyr acknowledges that different national versions of scientific research evolved during the seventeenth and eighteenth centuries, but "they constantly interacted and influenced one another, freely mixing and exchanging cultural beliefs across national boundaries." (p.242). Multiple "national styles" did not prevent intense collaboration across political and religious boundaries. On the contrary, Mokyr believes that a multinational diversity of approaches and viewpoints fostered cultural innovation and intellectual progress.

In an in-depth and fascinating discussion of the religious (Puritan) origins of "British Exceptionalism" (chapter 13), Mokyr remarks that eighteenth-century British science might have differed from Continental (and specifically French) science in ways that made it more suitable to the Industrial Enlightenment: an "increasingly pragmatic and empirical orientation and interest in prescriptive knowledge, and its diffusion to a wide circle through mostly private and spontaneous mechanisms." (p.231). Stemming in part from the specific beliefs of the Puritans about the relationship between God and nature, British science had embraced a deeply empirical and experimental methodology, grounded on careful observation and examination of facts, rather than on the Cartesian use of logically rigorous derivations, which dominated in France and other parts of the Continent. Mokyr agrees with Margaret Jacob (1997) that there is a complex but clear intellectual lineage going from Francis Bacon to the Industrial Enlightenment and the Industrial Revolution via Puritan Science, Anglican Science (during the restoration), and Newtonian Science. And yet, Mokyr does not believe that British leadership in the Industrial Revolution was due to a cultural divergence between British Science and Continental Science. While he acknowledges that, on the Continent, cultural evolution "took slightly different routes from that of England and Scotland" he expects that, even without Britain's leadership, the other countries in Western Europe would "eventually have found the path from the Republic of Letters to economic growth" (p.244). This bold counterfactual prediction may surprise the reader, especially in light of Mokyr's convincing arguments elsewhere that modern economic growth was not preordained, and that even relatively small differences in shocks and contingencies could have led to different outcomes. And yet, he expects that, even without the ability to observe and learn from the spectacular success of the British Industrial Revolution, innovators and entrepreneurs in other European countries would have eventually adopted the technological and institutional innovations required for modern economic growth. Mokyr's optimistic assessment

of Europe's long-term perspectives for growth, independently of anything that happened in Britain, seems to be founded on his conclusion that the central cause for sustained growth is the belief in the "transformative powers, social prestige and virtuousness of useful knowledge" (p.267). Mokyr is confident that such belief would have eventually impacted the European economies, because it was already shared by the European elites and institutionally embodied in a "well-functioning market for ideas" at the time of the Enlightenment. Thus, the fundamental catalyst for growth was already in place before the Industrial Revolution took off in Britain, and it would have ultimately led to modern economic growth in other European societies even without the British example.

While it is obviously impossible to observe what would have happened in the rest of Europe in the absence of British leadership, it is reasonable to wonder whether Mokyr's analysis may underplay the role of British influence in the actual development of the modern economy. Mokyr does provide a strong argument about the existence of a common ethos of science and empiricism shared by a pan-European elite of scholars and intellectuals. Nonetheless, in the absence of the British example, it is not fully clear *how* that ethos would have percolated across larger segments of society and influenced substantial numbers of entrepreneurs and innovators, leading to actual technological progress and economic growth over time. As Mokyr himself points out in his discussion of British exceptionalism, an important difference between British science and Continental science was that the British version had already reached a much *wider circle* of connected individuals during the seventeenth and early eighteenth centuries. Plausibly, such broader social diffusion of empiricist attitudes was connected to the spread of ethical ideas about the "dignity and liberty" of the *bourgeoisie* (middle class), as extensively argued by Deidre McCloskey (2006, 2010, 2016). According to McCloskey (2010, p. 366), it was the coming of a "business-respecting civilization" that reduced social distance between classes, whereby "the longstanding traditional barriers between upper-class philosophers, market-driven entrepreneurs, large-scale industrialists, and skilled craftspeople and technicians dissolved, so that all these groups came together to initiate a culture of innovation" (Goldstone 2009, p. 134). Therefore, ethical and rhetorical changes that happened within British society seem to have contributed to lowering the barriers to the diffusion of new ideas on how to produce, which Mokyr views as essential for growth. Mokyr is right to point out that an entrepreneurial or bourgeois culture

alone, without innovations and productivity growth, would not have been enough for sustained economic growth (p.122). However, the converse may also be true: an ethos of science that is not accompanied by an entrepreneurial and inclusive ethic is likely to remain confined to an aristocratic and military elite (as it happened in France during most of the eighteenth century), therefore failing to turn into technological progress and sustained growth. Hence eighteenth-century British society might have been exceptional after all, insofar as it enjoyed the unique combination of *two* cultural innovations: a new culture of knowledge (thanks to its prominent participation in the Republic of Letters) *and* a new bourgeois ethic (which the English had learned from the Dutch, and then modified and developed throughout their turbulent religious and political history during the seventeenth century). That unique combination of cultural traits might be a reason why the Industrial Revolution first took off in Britain, and only later diffused to other societies in Europe and the rest of the world.

4. Conclusions

The spread of modernity is a complex phenomenon, likely to be the result of multiple factors, possibly with different historical origins and following different diffusion processes.[11] As Landes (2000, p.3) wrote, "Economic analysis cherishes the illusion that one good reason should be enough, but the determinants of complex processes are invariably plural and interrelated. Monocausal explanations will not work."

Mokyr's analysis is very far from being monocausal. On the contrary, his book is a sophisticated and nuanced study of a vast set of factors and mechanisms that interacted and coevolved, often leading to unintended and unpredictable consequences. And yet, Mokyr is not shy about singling out what he views as the ultimate causes for modern economic growth: the Baconian belief in the human ability and duty to "command nature by obeying her," and its institutional embodiment in a community of innovators devoted to the cardinal scientific virtues: Communalism, Universalism, Disinterestedness, and Organized Skepticism (CUDOS, Pinker 2018, p. xvii).

[11] For example, as already mentioned, the spread of modern industrialization and the diffusion of modern norms about fertility control took place along different cultural and linguistic lines, reflecting their origins in different European societies (Spolaore and Wacziarg 2009, 2018, 2019).

Mokyr's story is a wonderful tale of achievement and enrichment, and yet the reader may wonder whether economic growth will continue for the foreseeable future or eventually stop, as it always happened in previous instances. On the one hand, Mokyr gives us reasons for optimism. If the ultimate engine of growth is the existence of a large transnational network of scientists and innovators who share the values of scientific inquiry and operate in a politically fragmented but culturally unified world, we should be in a pretty good shape when compared to previous historical periods. As Mokyr remarks (p.42), "a prediction of this model is that the veritable explosion of communication technology in the late twentieth century will lead to an acceleration of technological progress as social interactions and information exchanges have become essentially costless regardless of distance." Thus, as long as we continue to practice the scientific virtues of CUDOS within today's dense network of social interactions, there is no reason to fear that the flow of new ideas and innovations will dry up. Or is there?

In light of Mokyr's historical analysis, a key question is whether contemporary societies will continue to support innovators who embrace the ethos of science. Mokyr's own discussion of cultural evolution highlights how cultural beliefs can change quite rapidly and unpredictably. New cultural variants can quickly spread through populations, and the changes can be maladaptive in terms of genetic fitness or physical health (Richerson and Boyd 2005, chapter 5). The development of science was a lucky occurrence in the history of cultural evolution, as it "scotched many harmful superstitions by making the adaptive component of content biases more powerful" (Richerson and Boyd 2006, p.190). But there is no guarantee that future generations will continue to believe in the idea of science, founded on careful observation, logic and experimentation, which we have inherited from the Republic of Letters and the Enlightenment.

In fact, the scientific method has never been very popular among large sectors of modern society, including influential intellectuals and opinion-makers. In his eloquent and passionate defence of the values of the Enlightenment (reason, science, humanism, and progress), the psychologist Steven Pinker laments that many students today are taught that "science is just another narrative like religion and myth, that it lurches from revolution to revolution without

making progress" (Pinker 2018, p.401). Pinker also argues that the "stigmatization of science is […] jeopardizing the progress of science itself."[12]

Whether science is currently under threat or not, Mokyr's historical analysis helps scientific progress for two reasons. The first reason is intellectual. This book is a substantial contribution to the progress of scientific knowledge, as it sheds invaluable light on the causes of an important social phenomenon, modern economic growth. The second reason is ethical. Mokyr, by explaining how the scientific ethos emerged and caused economic prosperity, provides his readers with persuasive arguments that go a long way towards strengthening our own commitment to scientific inquiry as a force for human betterment.

[12] For instance, Pinker (2018, p.402) cites a medical researcher who contends that the current constraints imposed on scientific research would have prevented former scientific breakthroughs that we take for granted, such as X-rays, cardiac catheterization, and general anesthesia.

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