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# Technology and technical knowledge in the debate about the « great divergence »

*Marcus Popplow*[*]

## Résumé

À la recherche des raisons pour lesquelles l'industrialisation apparaît d'abord en Europe plutôt que dans d'autres régions du monde, la technologie est souvent considérée comme un facteur prépondérant. Pourtant, les comparaisons restent souvent centrées sur les inventions spectaculaires et les performances quantifiables, perpétuant ainsi des catégories européocentrées. Cet article critique cette perspective de la recherche. En s'intéressant au problème du savoir technique, il propose d'enquêter sur les multiples aspects de l'expertise technique quelles que soient les régions du monde, plutôt que de poursuivre dans la perspective traditionnelle de l'application de la « science » aux problèmes techniques.



**Mots-clés:** *expertise, européocentrisme, Grande Divergence, industrialisation, savoir technique, science appliquée, technologie.*

## Abstract

*In the search for reasons why industrialization first emerged in Europe and not in other world regions, technology is often referred to as a crucial factor. However, related cross-cultural comparisons still often focus on spectacular inventions and quantifiable performance alone and thus perpetuate Eurocentric categories. The present essay critically discusses this tendency of research. With regard to the issue of technical knowledge, it is proposed to investigate the multitude of aspects of expertise relevant for the realization of technology in any given world region rather than to pursue the traditional focus of the application of « science » to technical problems.*

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Keywords: *applied science, expertise, Eurocentrism, great divergence, industrialization, technical knowledge, technology.*

Why did industrialization first emerge in Britain and thereupon in other European regions? Why not in other world regions like China, India and the Ottoman Empire? This issue is being debated in the social and historical sciences under the heading « Why Europe[1]? » Another label as frequently employed for this controversy is the « great divergence », coined by one of its protagonists, Kenneth Pomeranz, historian of China[2]. The notion « great divergence » conveys the idea that something unprecedented happened in world history towards the end of what historians of Europe call the early modern period. Until then, history on a global scale had repeatedly seen the rise and fall of mighty empires. Periods of « efflorescence » – to use a term suggested by political scientist Jack Goldstone – were followed by economic and cultural decline[3]. The path into industrialisation taken by some of Europe's core regions and subsequently by the United States is seen in this view as a deviation from such continuous ups and downs, in a development into a hitherto unparalleled continuity of economic growth. The « great divergence » thus highlights the uniqueness of European and Western industrialization, in contrast to the paths taken by all other cultures in world history.



But when exactly did Europe's « special course[4] », which is another concept used to describe this same phenomenon, set in? There is yet no consensus on the answer to the question, or indeed if asking this question is a productive way of engaging the past, as will be explained in more detail later. Apart from the few who advocate its beginnings already during the European Middle Ages[5], most agree, however, that this diverging path appeared sometime between 1500 and 1800.

## Technology as a crucial factor for the « great divergence »

In whichever field one seeks the clues for the question « Why Europe? », the reasons must be sought primarily in the early modern period. It is not the aim of this essay to present and discuss all the issues investigated by those involved in discussing this question in different subfield of history focusing on demography or economic institutions, religious beliefs or the availability of natural resources, factors such as the exploitation of colonies in the Americas and others. Economic historians, in particular, who are the most active participants in the debate, have identified a number of core issues, such as wage rates, agricultural productivity, or anthropometric measures for comparing standards of living in regions of Europe, China, and India. Their considerations, based on extensive analysis of the relevant source material, will not be summarized here either, as recent detailed studies have presented the respective data[6]. Within the thematic framework of the present volume, the aim of this essay is rather to take a closer look at how « technology » enters and figures in this debate.

When authors discuss the whole bundle of possible factors that might have set England, in particular, on its way to industrialization, none can avoid mentioning technology. In the long run, machines too clearly appear as indispensable factors for industrialization to be ignored. For the production of textiles, iron and steel, and many other goods; the steam engine as a power generator and the motor in locomotives that accelerated transportation; and the shift to an energy system based on fossil fuels, later supplemented by electricity as a new form of easily available energy.

It would be a gross mistake, however, to identify the factor « technology » as a special characteristic of Europe or the West in the time period considered here. It is one of the central lessons of recent research on a global scale to have provided much detailed information about technologies used in various world regions in pre-industrial times. The debate on the « great divergence » and respective cross-cultural comparisons usually focus predominantly on the seventeenth and eighteenth centuries. Somewhat implicitly, most authors thus agree that, towards the end of the European Middle Ages, Eurasian cultures were disposing over roughly comparable technological equipment and technical competences. At that point of time, it is argued, it would thus not have been possible to foresee which of them was better prepared for industrialization: Chinese regions had thriving economies and coal, ores and other resources in abundance. Zheng He had, just some decades earlier, successfully completed his famous exploratory voyages which even led him to the eastern shores of Africa. Asian coastlines were dotted with smaller and larger harbours, which served to exchange a multitude of goods, among them precious wares like silk garments or Chinese porcelain, over large distances to the Arab peninsula – in Europe, too, these luxuries were long being appreciated[7]. Textiles were produced all over Asia in great variety and number, and by refined techniques. In Arab regions, refined artisanship and complex hydraulic systems formed the basis of intense commercial networks across Eurasia as well as far into Africa. It fits into this picture that, up to around 1500, Europe had been an importer of a wide array of technologies and goods from Asian regions as far as China: examples range from the compass to gunpowder and complex automata, silk and paper. In early modern Europe, authors were well aware of these origins and often mentioned them in their writings[8].

## Chronology and protagonists of the debate on the « great divergence »

Before looking in more detail at how early modern technology has been discussed in recent decades in the controversy over the « great divergence », it might be appropriate to sketch briefly two of the central features of that debate. This section will survey how the debate unfolded over time and the academic profiles of its protagonists.

It is surely not new to compare differences in economic performance of diverse high cultures in world history. Contemporaries of industrialization in the nineteenth century already highlighted European or « Western » superiority as part of colonial and often racist arguments, for example, in the context of the widely discussed presentations of material culture on world fairs, starting with the famous exhibition in London in 1851. As Michael Adas has shown, references to advanced technologies became more and more frequent among the arguments offered by nineteenth-century authors for the cultural dominance of the West[9]. In scientific discourse, authors in the early twentieth century like the German sociologist Max Weber discussed in detail different developmental paths of various regions of the world and sought cultural explanations for Europe's particular path to industrialization. Much later, in the 1980s and 1990s, a growing awareness of globalization processes led to renewed interest in historical explanations for different developmental paths taken by the various world regions. Since then, the centre of gravity of this debate has shifted away not unlike the swing of a pendulum. The first bestsellers included Eric Jones' *The European miracle* (1981) and David Landes' *The wealth and poverty of nations* (1998). Their authors supported the idea of Western dominance by often unduly clear-cut arguments[10]. A wealth of studies emerged in the rise of global history since the 1990s that pointed out the many blind spots in publications such as those by Jones and Landes. Now, they argued, it was urgently necessary not just to back the discussion about the « great divergence » with more solid data from economic history. In particular, the issues at stake must also be considered on the basis of well-informed research on Asian. The title of André Gunder Frank's book, *Re-Orient* (1998), symbolizes this approach well[11]. Particularly the « California school », named as such because its writers taught at Californian universities, synthesized studies specifically on the economic history of premodern China, to enable a more nuanced comparative analyses.

Despite all this contention, most of these debaters shared the conviction that Europe's « special course » into industrialization was to some extent contingent. British industrialization is not seen as a necessary outcome of some particular characteristics that had evolved over centuries, but as a result that emerged somewhat arbitrarily out of a convergence of factors, among them the availability of coal and ores, the financial means to invest in large technological projects, and advanced forms of technical expertise.

Most recently, this line of research followed by the « California school » is being supplemented by increasingly specialized studies of non-Western economic development, providing a more solid basis for comparative studies[12]. Some core arguments of the California school have be questioned, most prominently by the economic historian Peer Vries. He argues that during the early modern period Britain accumulated a wealth of factors on the economic level that allowed its transition to industrialization whereas those possibilities were not available to China[13]. At first sight this position seems to mark the pendulum's swing back to the positions taken by Jones and Landes decades ago, albeit based on substantial amount of research results and data which became available since, in particular on Asian economies.

Even if the debate on the « great divergence » clearly has an interdisciplinary character, its most visible protagonists are economic historians and social scientists with a historical interest. It would be hard to over emphasise that despite the large number of publications that in one way or another are contributing to the debate, many experts, particularly those on non-Western cultures, are refraining from engaging in the debate even if tacitly, although their research experience is highly relevant to its core issues. There are surely good reasons for this choice: an inherent problem in the debate on the « great divergence » is that a presupposition of « Western » categories can hardly be avoided as its starting point – most prominently, industrialization and economic growth as the crucial events seeking explanation. Such Eurocentric presuppositions have, however, in principle long since been overcome in the large community of global historians. For many of them global history, by definition, must not presuppose « Western » categories, but must devise categories apt for the study of diverse world regions on an equal level. This position is connected with a more general suspicion concerning « comparisons » of regions or cultures as such – they have too often resulted in highlighting what « the West » had and what « the Rest » did not have. As one of the ways out of this trap, it is usually proposed to focus instead on concrete interactions and networks, shifting the attention to processes of exchange and to personalities who served as brokers between cultures.

As convincing as this position is, one might also regret its consequences on the debate about the « great divergence ». The puzzling issue « Why Europe? » easily stirs interest and stimulates discussion in broader audiences of historical research among the well-informed public. It is thus somewhat deplorable when historians refrain from explicitly incorporating their positions into the controversy, even if they may have good reasons for taking a fundamentally critical stance on this debate as such. Such silence quite necessarily results in a lopsided assemblage of arguments and a lack of relevant issues in historical expertise within the debate. As will be argued in what follows, a related problem also holds true for the factor of interest here, namely early modern technology.

## Ways to deal with the factor « technology » in the debate on the « great divergence »

As has already been stressed, technology is perceived as a crucial factor by nearly all the authors in the debate on the « great divergence ». They agree that it was by far the only aspect of relevance to the development of sustained economic growth. It was, however, an indispensable one, insofar as without advanced machinery and the abundant energy resources provided by fossil fuels, the rising output of goods, increase in productivity and drop in prices would not have been possible. This focus on quantifiable factors has, however, led to a somewhat lopsided treatment of technologies in the debate. Today, the history of technology is no longer seen predominantly as a history of spectacular inventions and innovation processes. Historians of technology pay attention to a whole range of other factors such as the social and cultural settings in which diverse technologies are produced and used. The debate on the « great divergence » is still characterized by a much more schematic perspective on technology, however. One traditional strain compares the technologies of premodern Europe, China, India, and the Ottoman Empire only in terms of who first invented what, the performance of certain artefacts or simply regarding sheer size, as is the case of comparing the ship sizes of Zheng He's fleet with those of the European colonial powers. It has to be stressed that this focus is as characteristic of proponents of European superiority as well as of proponents of the superiority of Asian civilizations in the pre-industrial era. Just as Jones and Landes, repeatedly highlighted the superiority and ingenuity of Western technology, John Hobson, a most fervent advocate of Asian technological superiority in the same period, used the same yardstick: innovation and large-scale technologies[14]. A second line of thought, as part of well-established approaches in economic history, stresses the role of technological artefacts in achieving productivity gains, for example as a response by entrepreneurs to the high wage rates during British industrialization[15]. For example, one line of inquiry recently gaining momentum seeks to examine the role of macro- or micro-inventions in the productivity gains. To be sure, this is just one way of approaching the role of technology in a society. It is only one of a multitude of issues nowadays under debate among historians with expertise in the history of technology, in particular when it comes to reflections about how societies employ and evaluate technologies.



The question is thus whether such a quantitative approach to the factor « technology » suffices to understand the role technology had in societies in China, India, the Ottoman Empire and European's core regions between c. 1500 and c. 1800 and the relevance this factor thus might have had to the « great divergence ». One might well argue that a merely quantitative perception of the issue of technology rather obstructs a more substantial discussion of the qualitative aspects of this factor. Along this line of thought, the discussion about technological issues in the controversy on the « great divergence » could in the future be brought to a different level. One could, for example, explicitly turn away from comparing the mere performance of technical artefacts and from using yardsticks like efficiency and productivity gains, in order to develop non-Eurocentric categories instead which might better serve to compare technologies in different world regions. Such categories might comprise the ways technologies were adopted and adapted to local economic, social, and environmental conditions; how respective decisions were influenced by political or religious structures; and which symbolic functions such artefacts had as part of the material culture of a given place or region. So far, however, a discussion about the standards by which one might compare pre-industrial technologies in different regions of the world with such rather qualitative categories has hardly even begun[16].

One thing quite clear is that utilization of the most intricate machinery is not an appropriate yardstick of our reflection on the ways technology is part and parcel of a change over time in any society. An often cited example of the problems connected to this frequently adopted approach is the employment of milling machinery in Europe and China. While the basic elements of this technology had been known in both cultures since about the time of Christ's birth, and various forms of mills were being employed for various purposes in China for centuries, China did not experience a similar application density of grain mills as did Europe, where mills were found in a range of places throughout the early modern period. One of the basic reasons is that, in China, the milling of rice was simply not necessary or adequate. All the same, when it comes to agrarian output, Chinese rice farming produced more calories per area than European grain production. To use the number of mills employed as a yardstick for technological superiority is thus as misleading. Similarly misleading is the argument that the renunciation of carts in Arab regions since late Antiquity in favor of camels marks a technological regression in transportation. Research has shown that because the climatic and environmental circumstances in which they technical choice was made, camels were simply much more apt to fulfil transportation purposes than carts.

Another such doubtful comparison regards the employment of complex pumping technology for irrigation purposes as a symbol of technological progress. Hydraulic systems such as those in China or in the Islamic world and Persia, to a great extent without relying on such mechanical devices, fulfilled comparable functions and were sometimes executed on a considerably larger scale than their European counterparts.



To be sure, mechanical technology remains highly relevant to the study of Western industrialization. Yet the argument advanced here is that it would be productive to discuss pre-industrial technology on a global scale without necessarily presupposing Eurocentric categories. There is surely enough material to do so. In recent years a number of pioneering studies have been published that take a closer look at Ottoman artisans, cotton production in Asian regions, the employment of gunpowder weapons across Asia, or the employment of technical and scientific illustrations and technical treatises in China[17]. However, these path-breaking studies seem to have not been taken comprehensively into account in scholarship on the « great divergence ». An attempt to take a closer look at « technology », below the only skin-deep quantitative approaches, could also be directed at the study of technical knowledge, along the lines discussed in the following section.

## Applied science or technical knowledge?

Interestingly, « science » is only rarely discussed as a relevant factor in the debate over the « great divergence ». By now, there seems to be an agreement that major achievements in the natural sciences in Europe, even those by such outstanding characters as Galileo and Newton, did not directly influence technological achievements in the early stages of the industrial revolution and are thus not of relevance to Europe's « special course ». This aspect is connected to the insight that technology in the early modern period and, as many researchers now argue, even far into the nineteenth and twentieth centuries, was definitely not some kind of « applied science ». Therefore it cannot be said that scientific reasoning was in some way « adapted » to technological needs and thus helped to realize artefacts, procedures or machines that artisanship alone would not have succeeded in producing. To be sure, many technical experts in early modern Europe increasingly attempted to analyse pressing technical problems with mathematical and geometrical tools, in particular in civil and military engineering. In the overwhelming majority of cases, however, they succeeded in describing in mathematical language what they had perceived before, rather than developing new technical solutions on the basis of scientific reasoning. For the debate on the « great divergence », it is quite clear that it was definitely not scientific reasoning that put early modern Britain on the path toward industrialization.

This, however, does not mean that far-reaching transformations of technical expertise during the early modern period were irrelevant to technological change right from the start. Much better than describing these transformations in terms of (applied) science, they might be described as a whole set of interrelated developments that resulted in the fact that technical knowledge was no longer nearly exclusively embodied in an artisan, in the form of personal expertise accumulated over the course of years or decades. Since the late Middle Ages, in addition to that common form of expertise, representational media such as technical drawings and treatises had become part of standard practice. Towards the end of the early modern period, such formalized technical knowledge was collected, discussed, and taught in institutions such as scientific academies, economic societies, and engineering schools[18].

To what extent this development which indeed influenced technical practice in early industrialization is still a matter of debate. However, it seems evident that, it was related to practices like the usage of scaled-down models and measuring instruments in engineering, to field trials in agriculture, to learned correspondence, and to privileges for inventions, patents, and prize contests. Authors including Joel Mokyr and Margret Jacob have recently identified this cluster of media, institutions and practices, with regard to the eighteenth century, as part of an « industrial enlightenment », to which they attach considerable relevance to the onset of British industrialization[19]; Other authors have questioned the top-down approach inherent in this argument and have opted for a broader analysis of technical knowledge that does more justice to a broad array of various forms of artisanal knowledge that undoubtedly produced viable economic effects in early modern Europe[20].

## Conclusion

For future studies on the « great divergence », this shift of focus from highlighting « science » as a factor of cross-cultural comparisons to investigating instead various bodies of formalized knowledge in different parts of the world fits well into more recent developments in a global history of science. Studies that explore – even without directly contribute – to the issue of the « great divergence » tend to look at « science » from the perspective of the « natural sciences » according to European standards, to an encompassing variety of bodies of formalized knowledge[21]. Such approaches converge well with recent trends in studies at the intersection of early modern history of science and history of technology in Europe that increasingly tend to overcome this binary opposition with the aim rather of writing an overarching history of expertise in that period[22].

Due to their somewhat restricted focus on technological invention alone, the protagonists of the debate on the « great divergence » thus far have not taken much note of these transformations of early modern technical knowledge. A research project headed by Patrick O'Brien at the London School of Economics mainly introduced this perspective into reflections on the « great divergence » by studying the generation and application of « useful and reliable knowledge » in various world regions before the onset of industrialization. Karel Davids, in his recent contribution to the debate, has discussed the relation between religion and technology in pre-modern Europe and China, with extensive reference to such newer methodological approaches[23]. He thus demonstrated that an in-depth consideration of these media, institutions and practices is one of many possibilities to bring the discussion of technology in this controversy to a level transcending its study as a factor exclusively for the generation of economic growth.

The « cultural turn » that the history of technology as a historical sub-discipline has witnessed in recent years offers many such possibilities for the study of how societies in various world regions not only employed technologies as an economically relevant factor, but also as an inherent part of their material culture within which technology served a multitude of cultural and symbolic functions. The study of technical knowledge, in this panorama, shifts the focus away from some sort of « applied science » toward studying the wealth of knowledge formations that characterized, in particular, the expertise with which artisans produced viable economic effects in all regions of the world. Historians of science and technology might profit from future insights into an extended study of these levels of the « great divergence » to the same extent as representatives of other scientific disciplines and the interested public.



## Notes

1. A useful basic introduction to this debate is Jack A. Goldstone, *Why Europe? The Rise of the West in World History, 1500-1850*, New York, McGraw-Hill, 2009.

2. Kenneth Pomeranz, *The Great Divergence. China, Europe and the Making of the Modern World Economy*, Princeton/Oxford, Princeton University Press, 2000.

3. Jack A. Goldstone, « Efflorescences and Economic Growth in World History: Rethinking the "Rise of the West" and the Industrial Revolution », *Journal of World History*, 13, p. 323-389.

4. Rolf Peter Sieferle, *Der Europäische Sonderweg. Ursachen und Faktoren*, Stuttgart, Breuninger Stiftung, 2003.

5. These authors comprise Joel Mokyr, *The Lever of Riches. Technological Creativity and Economic Progress*, Oxford, Oxford University Press, 1990; David Landes, *The Wealth and Poverty of Nations. Why Some Are So Rich and Some So Poor*, New York, W.W. Norton, 1998; Michael Mitterauer, *Warum Europa? Mittelalterliche Grundlagen eines Sonderwegs*, Munich, C.H. Beck, 2003.

6. See, for example, Bishnupriya Gupta, Debin Ma, « Europe in an Asian mirror: the Great Divergence », in Stephen Broadberry, Kevin H. O'Rourke (eds), *The Cambridge Economic History of Modern Europe, Vol. 1 (1700-1870)*, Cambridge, Cambridge University Press, 2010, p. 264-285. With ample references to previous studies, Peer Vries, *Escaping Poverty. The Origins of Modern Economic Growth*, Göttingen, V&R unipress, 2013; Roman Studer, *The Great Divergence Reconsidered. Europe, India, and the Rise to Global Economic Power*, Cambridge, Cambridge University Press, 2015.

7. Maxine Berg (ed.), *Goods from the East, 1600-1800. Trading Eurasia*, Basingstoke, Palgrave Macmillan, 2015.

8. Frances Gies, Joseph Gies, *Cathedral, Forge, and Waterwheel. Technology and Invention in the Middle Ages*, New York, Harper Collins, 1994, p. 82-104.

9. Michael Adas, *Machines as the Measure of Men. Science, Technology, and Ideologies of Western Dominance*, Ithaca/London, Cornell University Press, 1989.

10. Eric Jones, *The European Miracle. Environments, Economies and Geopolitics in the History of Europe and Asia*, Cambridge/M., MIT Press, 1981; David Landes, *The Wealth and Poverty of Nations. Why Some Are So Rich and Some Are So Poor*, London, Little/Brown, 1998.

11. André Gunder Frank, *Re-Orient: Global Economy in the Asian Age*, Berkeley, University of California Press, 1998.

12. One among many examples is Prasannan Parthasarathi, *Why Europe Grew Rich and Asia Did Not. Global Economic Divergence, 1600-1850*, Cambridge, Cambridge University Press, 2011.

13. P. Vries, *Escaping Poverty*, *op. cit*. See also his *State, Economy, and the Great Divergence. Great Britain and China 1680s-1850s*, London, Bloomsbury Academic, 2015. The arguments by Pomeranz and Vries are summarized at an earlier stage in Kenneth Pomeranz, « Repenser le changement économique de longue durée : la Chine, l'Europe et l'histoire comparée », dans Jean-Claude Daumas (dir.), *L'Histoire économique en mouvement entre héritages et renouvellements*, Villeneuve-d'Ascq, Presses Universitaires du Septentrion, 2012, p. 293-310, and Peer Vries, « Un monde de ressemblances surprenantes? », dans *id*., p. 311-340.

14. John Hobson, *The Eastern Origins of Western Civilization*, Cambridge, Cambridge University Press, 2004.

15. For this approach see, for example: Robert C. Allen, *The British Industrial Revolution in global perspective*, Cambridge, Cambridge University Press, 2009.

16. A good example of a more balanced treatment of the history of technology in a particular epoch of Chinese history is Francesca Bray, *Technology and Society in Ming China (1368-1644)*, Washington D.C., American Historical Association, 1997. For an attempt to contextualized technological developments better in various world regions during the Middle Millennium, see Dagmar Schäfer, Marcus Popplow, « Technology and Innovation within Expanding Webs of Exchange », in Benjamin Z. Kedar and Merry E. Wiesner-Hanks (eds), *Expanding Webs of Exchange and Conflict, 500 CE-1500 CE*, Cambridge, Cambridge University Press, 2015, p. 309-338.

17. Surayia Faroqhi, *Artisans of Empire. Crafts and Craftspeople under the Ottomans*, London, Tauris, 2009; Giorgio Riello, Prasannan Parthasarathi (dir.), *The Spinning World. A Global History of Cotton Textiles*, Oxford, Oxford University Press, 2009; Iqtidar Alam Khan, *Gunpowder and Firearms. Warfare in Medieval India*, Oxford, Oxford University Press, 2004; Gábor Ágoston, *Guns for the Sultan. Military Power and the Weapons Industry in the Ottoman Empire*, Cambridge, Cambridge University Press, 2006; Peter Lorge, *The Asian Military Revolution. From Gunpowder to the Bomb*, Cambridge, Cambridge University Press, 2008; Francesca Bray, Vera Dorofeeva-Lichtmann, Georges Métailié (eds), *Graphics and Text in the Production of Technical Knowledge in China. The Warp and the Weft*, Leiden/Boston, Brill, 2007; Dagmar Schäfer, T*he Crafting of the 10000 Things. Knowledge and Technology in Seventeenth-Century Chin*a, Chicago, University of Chicago Press, 2011.

18. Marcus Popplow, « Formalization and interaction. Towards a comprehensive history of technology-related knowledge in early modern Europe », ISIS 106, 2015, p. 848-856.

19. Joel Mokyr, *The Enlightened Economy. An Economic History of Britain, 1700-1850*, New Haven, Yale University Press, 2009; Margaret C. Jacob, *The First Knowledge Economy. Human Capital and the European Economy, 1750-1850*, Cambridge, Cambridge University Press, 2014.

20. Liliane Hilaire-Pérez, « Technology as a public culture in the eighteenth century: The artisans' legacy », *History of Science*, 45, 2007, p. 135-153.

21. See, for example, Francesca Bray, « Science, technique, technology. Passages between matter and knowledge in imperial Chinese agriculture », *British Journal for the History of Science*, 41, 2008, p. 1-26. See also the « focus section » entitled « Global histories of science » in ISIS 101, 2010, p. 95-158, in particular Sujit Sivasundaram, « Sciences and the global: on methods, questions, and theory », p. 146-158. For a reconsideration of the notion of « science » as employed in Joseph Needham, *Science and Civilisation in China*, Vol. I-VII, Cambridge, Cambridge University Press, 1954-2008, see David de Saeger and Erik Weber, « Needham's Grand question revisited: On the meaning and justification of causal claims in the history of Chinese science », *East Asian Science, Technology, and Medicine*, 33, 2011, p. 13-32. Furthermore Jürgen Renn (ed.), *The globalization of knowledge in history*, Berlin, Édition Open Access, 2012; Dagmar Schäfer, « Technology and innovation in global history and in the history of the global », in Maxine Berg (ed.), *Writing the history of the global. Challenges for the 21st century*, Oxford, Oxford university Press, 2013, p. 147-164.

22. Such approaches are cited and discussed, for example, in the contribution to the « focus section » entitled « Bridging concepts: Connecting and globalizing histories of science, history of technology, and economic history » in ISIS 106, 2015, edited by Karel Davids.

23. Karel Davids, *Religion, Technology, and the Great and Little Divergences. China and Europe Compared, c. 700-1800*, Leiden, Brill, 2013. See also his contribution in this volume.