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How the ‘Needham Puzzle’ Was Solved in the Early 1990s

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Working Papers # 27

25 June 2020

Institute of Global Dynamic Systems

Canberra

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There are some like me turn gladly home. From the lush jungle of modern thought, to find the Arabian desert of the mind. Hoping, if still from the deserts the prophets come.

A.D. Hope, ‘Australia’ in *Complete Poems, 1930–1965*

1. Introduction

Scholarly ‘puzzles’ about reality are an outcome, not of inherent existential contradictions, but of faulty theories employed by intellectuals. Or by no theory at all. Orthodox histories of the rise and fall of civilisations contain many such ‘puzzles’, which are incorrectly claimed to be unresolved. The neglect of existing solutions to these puzzles is the outcome of the insular attitudes of scholars in the disciplines concerned. Some of these puzzles are outlined in the postscript to this paper.

My purpose in this article is to focus on just one of these historical conundrums—the ‘Needham puzzle’. In what follows, I examine the origin and nature of the Needham Question, the different ways it has been interpreted by subsequent scholars, how my dynamic-strategy theory was employed in the early 1990s to resolve this issue, and why historians are still perplexed. To avoid complicating the narrative, my general dynamic theory is presented in the Appendix, in a highly summarised and simplified form. Readers requiring a fuller discussion may find it useful to consult Snooks (1996; 1997; 1998).

2. Conventional Wisdom on the ‘Needham Puzzle’

All historical puzzles are capable of resolution, provided historians employ the correct models in their work. The problem with the discipline of history is that it turns its back on theory, even on realist theory derived inductively from historical study. I recall a leading scholar in the field of Big History—of all disciplines!—caution against the adoption of Big Theory to explain the patterns of the past. All historical ‘puzzles’ can be solved by developing a general dynamic theory of human society. This was my objective in *The Dynamic Society*, which was written in the early 1990s and published in 1996. From a systematic study of history, I constructed a general dynamic theory—called the ‘**dynamic-strategy theory**’—which I then employed to explain the patterns in global history. And, in *The Ephemeral Civilization* (1997), I applied this theory to explain the institutional dynamics of conquest, commerce, and technological societies. Finally, in *Laws of History* (1998), I derived a set of laws that could account for the patterns observed in the past, and make predictions about the future. In the process of writing this global history trilogy, all the above historical 'puzzles'—including Needham's—were examined and resolved.

2.1 What is the Needham Puzzle, or Grand Question?

Joseph Needham (1900–1995) was a biochemist at Cambridge University who, in the 1940s, became fascinated by China's early achievements in science and technology. The issue that puzzled Needham was why China, given its considerable scientific lead over Western Europe in the Song era (960–1279), missed the opportunity to create the world's first 'scientific revolution'. This has become known as the Needham Puzzle or Grand Question, depending on the intellectual discipline involved.

Needham expressed his famous Grand Question in a number of forms (Needham, *The Grand Titration,* 1969). At its most general, the Question was framed as either:

> "… the essential problem [is] why modern science had not developed in Chinese civilisation (or Indian), but only in Europe"; or:
>
> "Why did modern science, the mathematisation of hypotheses about Nature, with all its implications for advanced technology, take its meteoric rise only in the West at the time of Galileo [but] had not developed in Chinese civilisation or Indian civilisation"

And, more specifically, as:

> "… why between the first century BC and the fifteenth century AD, Chinese civilisation was much more efficient than occidental in applying natural knowledge to practical human needs."

This general question was at the centre of Needham's research into Chinese science and technology over the following half-century. The results of this research have been published by Cambridge University Press as *Science and Civilization in China*—amounting to 27 volumes, of which 15 were written by Needham and his collaborators during his lifetime. It is also the question, in its various forms, that many others have also agonised over, ever since.

Essentially, Needham thought that there were a large number of cultural, social, economic, geographical, intellectual, and ideological 'factors' that led to different scientific and technological outcomes in China and Europe. In the case of China, he documented a number of 'inhibiting factors' that prevented the occurrence of a scientific revolution.

- An inflexible political and social structure, in which the Chinese emperor sought to maximise and maintain his power through centralised bureaucratic control.
- An imperial examination system that underpinned China's central bureaucracy. This system of exacting examinations embodied a Confucian philosophy, which emphasised social harmony, marginalised science, and rejected the disruptive process of technical innovation. Also the examination system was so exacting, he argued, that scholar-administrators had little time for the study of the natural world.
- Chinese religious thought was conservative and restraining, unlike Protestantism in Europe.
- The centralised bureaucratic system in China, unlike mercantile capitalism in Western Europe, had little need of rapid and sustained scientific and technological advancement.

- Nothing like the Renaissance of Western Europe occurred in China.
- China had less flexible attitudes than Europe to matters such as time, language, and the printed word.
- There was a marked difference in motivation between the western and eastern hemispheres. In China, scholarship was the most prestigious career path; whereas in Western Europe it was the accumulation of wealth. Also in the West, wealth did not preclude the ethical life.

This method—elaborating a list of supply-side factors—is the usual approach taken by historians without an over-arching dynamic theory of human society. I call it the 'great shopping list' approach to explaining history. In part 2.2 below, I demonstrate the fundamental flaw in this method of explanation.

2.2 How Have Other Scholars Interpreted this Grand Question?

The way Needham's Grand Question has been interpreted depends on the discipline in which scholars have been trained. On the one hand, there are the economic historians and development economists, and on the other, there are the historians of science trained either in the natural sciences (like Needham) or in the humanities.

Economists have interpreted this issue as the **Needham Puzzle**. Why, they asked, didn't the Song dynasty forge an early Industrial Revolution, given its technological superiority over Europe, particularly in the basic cotton textile and iron and steel industries that were at the centre of the British industrial breakthrough? As these scholars—Hartwell (1962; 1966; 1967). Elvin (1973), and Lin (1995)—saw a link between the advance of science in Europe after 1600 and the Industrial Revolution after 1780, they focused on China's **lost economic opportunities** rather than its failure to generate a '**revolution in science**'. Their arguments, however, are really no more than the usual 'inhibiting factors' approach, favoured by historians of science, which have been dressed up in the terminology of static economic theory. For example, Elvin advanced a 'high-level equilibrium trap' thesis, which focused on static consumer demand (rather than dynamic strategic demand which transforms institutions and economic variables alike). Whereas Lin claimed that China experienced a 'deficiency of surpluses'—owing to pressure of population on natural resources, particularly land—which he believed severely limited its ability to finance an Industrial Revolution. Both these partial, static arguments fail to solve the puzzle, because they merely compare the normal characteristics of a traditional society with the transformed characteristics of an industrialising society, and assume that the difference is what prevented modernisation. But the difference is merely an artefact of the process of transition. What they fail to see, is that a society in a highly competitive environment will adopt a dynamic strategy that will transform those traditional characteristics. It is a process that begins on the margins of a traditional society, but, if successful, grows exponentially. This is discussed more fully in *The Dynamic Society* (Snooks 1996: 322–24).

Historians of science—such as Sivin (1982), Qian (1985), Lu (2011), and Olerich (2017)—focus on why the so-called '**science revolution**' occurred in Europe and not China, which at the beginning of the present millennium was more scientifically advanced. They see this as a subject in and of itself, and are not interested in explaining the Industrial Revolution. Why? Because of a mistaken belief that, in the right cultural environment (like Western Europe after 1600), science is an independent and self-sustaining entity; and that an industrial revolution inevitably, and uninterestingly, will follow a 'scientific revolution'. Like Joseph Needham, these historians focus on Chinese social and cultural impediments to the achievement of a scientific revolution—particularly on the stultifying role of the centralised bureaucratic system based on the imperial examination system.

One of these historians, however, is critical of the way in which most of his colleagues have approached this subject.

Nathan Sivin (1982, revised 2005) argues that his colleagues in the history of science are not qualified to answer the Needham Question. He provocatively states: "why the scientific revolution did not take place in China is not a question that historical research can answer". He believes that the historical method can only be used to describe and explain the way science actually developed in both China and Europe. He also argues that the 'inhibiting factor' approach is based on the fallacious assumption that such 'factors' were prevalent in China but not in Europe. He points out that Europe had its own version of 'inhibiting factors', but that it was able to transcend them. He concludes that instead of focusing on counterfactual questions, historians of science should do what they are trained to do, namely, to write critical, descriptive accounts of scientific advancement for all countries, within the broad context of their cultural institutions and requirements. More recent historians of science (e.g. Olerich 2017) seemed to have ignored this sensible advice.

Of course, Sivin is right about orthodox historians being unable to answer the Needham Question, but he is wrong about the limitations of the historical method in this respect. As I show elsewhere (Snooks 1996; 1997; 1998), the **historical method** can be used to develop a realist general dynamic theory that can indeed answer the Needham Question. Yet, by answering this Question—by solving this puzzle—it becomes clear that no scholar who understood my dynamic-strategy theory would have bothered to ask it in the first place. In this sense, it is a non-question, because the 'scientific revolution'—or, indeed, the Industrial Revolution—was not even a remote possibility anywhere in the world prior to the late 18th century. Sivin is also wrong when he claims that "we have made very little progress in understanding how Europeans originally came to want that [the scientific] revolution …". The dynamic-strategy theory solved—in 1996—that issue as well.

There are a number of further issues with this **supply-side approach** to historical explanation. Most historians contend that all historical outcomes are the result of the institutional or cultural characteristics of a given society. They claim that two societies—in this case China and Western Europe—will experience different outcomes because they possess different institutional structures and different cultures. I have long held that this is both a superficial and a dangerous argument. First, it is **superficial**, because institutions are only links in a causal chain. In my dynamic-strategy theory, institutions and ideas of all types (including science) are responses to the strategic demand generated by the dynamic strategy pursued by a society. And the dynamic strategy it pursues is the outcome of the strategic environment, which includes location, natural resources, and, particularly, the degree of external competition. Institutions do not just grow out of a primeval culture. They are *no*t, in other words, self-generating entities. (See Snooks, *The Ephemeral Civilization*, 1997; and Snooks, *The Laws of History*, 1998.)

Second, the argument is **dangerous**, because, in the absence of a demand-side theory, how do you explain the institutions existing at any point of time in a given society? As institutions are not self-generating, the supply-side approach begs a series of further Socratic questions. And the answers (**A**) to these questions (**Q**) take institutionalists into deep water. For example:

- **Q 1.** Why are institutions between two countries different? **A 1**. *Because their histories, cultures, and ideas are different.*
- **Q 2.** Why are their histories, cultures, and ideas different? **A 2.** *Because they are different peoples.*

- **Q 3.** Why are they different peoples? **A 3.** *Because they have different genetic backgrounds.*

This is where all supply-side theories end up. **All explanations resulting from the supply-side approach are *unintentionally* of a racial nature.** This serious problem arises from a lack of theoretical vision.

A **demand-side theory**—and my dynamic-strategy theory is the only demand-side general dynamic theory available—not only provides a clear and convincing explanation for institutional differences between societies, but it is also the only theory that cannot be reduced to a racial explanation. As I show in part 3 below, the reason China had different institutions and different attitudes to scientific and mathematical methods is that they were, quite rationally, pursuing a different dynamic strategy, which generated a different strategic demand for different institutions and ideas. And the different dynamic strategies between China (family multiplication/colonisation) and Western Europe (conquest) in the 13th century, were outcomes of different locations, resources, and, particularly, external competition. **They were most definitely *not* the outcome of differences in racial makeup.** Only the superficial exteriors of these institutions emerged from localised artistic expression or ephemeral fashion.

3. Tackling the Needham Puzzle with the Dynamic-Strategy Theory

My **dynamic-strategy theory** explains why neither a 'scientific revolution' nor an Industrial Revolution occurred in China. In Western Europe, both these momentous changes were a response to strategic demand generated by the expansion and, finally (by the mid-18th century), exhaustion of the neolithic (agricultural) technological paradigm, and its replacement after 1800 by the industrial technological paradigm. This occurred first in Western Europe because of the intense competition for over a millennium between warring European states. Owing to its relative isolation, China was not subjected to such intense competition. As a result, it adopted the family-multiplication strategy, rather than the sequence of strategies—of conquest►commerce►technological change—adopted in Western Europe. (Each of these dynamic strategies was roughly 300 years in duration.) While the dynamic strategies of commerce and technological change generated rapid increases in strategic demand for science and technology, the dynamic strategy of family-multiplication required only modest attainments in these respects.

We need to consider the scientific and industrial revolutions separately, because they are very different entities. First, China had no **industrial revolution** because it was in the wrong place at the wrong time. The Song era, when Chinese technology was far in advance of Europe, existed 500 years before the neolithic technological paradigm had been exhausted in frontier strategic societies. No society anywhere in the world around 1300 AD could possibly have generated an industrial revolution, because it just wasn't economically feasible, no matter how relatively advanced they were technologically. Even 500 years after the Song era, China had still not exhausted its family-multiplication strategy or its region's neolithic technological paradigm. It had still not joined the frontier strategic societies of the West.

Second, China had no '**scientific revolution**' for two main reasons.

- First, there is no such thing as a 'scientific *revolution*'—no independent, self-starting, self-generating process of scientific advancement. Science has no internal momentum of its own. It is a response to strategic demand generated by particular dynamic strategies. While science interacts with these dynamic strategies, it is not a prime mover in this relationship. In contrast, the Industrial Revolution embodied the technological strategy that was at the very core of the dynamic mechanism of the West.

- Second, China didn't experience anything like the advances made in Western European science, because of the nature of its dynamic strategy of family-multiplication. The family-multiplication strategy requires only a basic technological achievement to continue indefinitely in an *isolated* location. It certainly doesn't require a sustained increase in 'science'—a system of abstract ideas expressed in mathematical form. The ultimate example of this is Aboriginal Australia, which employed this dynamic strategy with great success, but experienced only slow and steady accumulation of embodied technical ideas, for a period of more than 60,000 years (Snooks 1994a: ch. 3; Snooks 1996: ch. 8).

In Western Europe, it was not until the dynamic strategy of **commerce** began to emerge in the 16th century (replacing **conquest** in England and the Low Countries) that the strategic demand for new production and business techniques increased significantly. These new techniques were required to facilitate the commercial activities of navigation, construction of port facilities, building of better ships, more accurate measurement of time, dimension and mass, and more efficient methods of finance and accounting. And, in turn, these new techniques generated a demand for the accumulation of abstract ideas and knowledge about the natural world—a demand for science. But even this was limited, and would have come to an end when the commerce strategy exhausted itself in Britain in the mid-18th century—if something unprecedented and world shattering had not occurred. And that was the adoption, for the first time in history, of the dynamic strategy of **technological change**.

In the pre-modern world, an exhausted commerce strategy had always been replaced with the conquest strategy—for example Greece around 500 BC, Carthage in the mid-3rd century BC, and Venice in the early-15th century AD. Why? Because the old neolithic technological paradigm still had plenty of excess capacity. So there was no economic incentive to adopt a technological strategy in order to forge an industrial revolution. By the mid-18th century, however, this was no longer the case in Western Europe. In this strategic frontier region, both the neolithic technical paradigm and the commerce strategy coincidentally reached their limits at the same time. This was a period of great uncertainty, during which the demand for scientific ideas stagnated. If conquest had replaced commerce, as evidence suggests was starting to happen in Britain, scientific advancement, along with the Enlightenment, would have been swept aside. *But, for the first time in human history, the technological strategy became the most economical alternative to an exhausted commerce strategy.* And it was the technological strategy that drove the Industrial revolution, which in turn generated a renewed and growing demand for scientific ideas. There was no self-starting, self-sustaining 'revolution' in science. Nor could there be. **The continued development of science depended on the fortuitous and unique strategic sequence of commerce►technological change that occurred in Western Europe between 1500 and the present.**

It is also important to realise that the early stages of the British Industrial Revolution were driven by practical and resourceful men attempting to find new ways to maintain their profits in the face of an exhausting commerce strategy (Snooks 2010a: 215-224; Snooks 2020d). Innovations in the textile, iron and steel, coal-mining, and transport industries were generated by men familiar with the practical aspects of their industries (Snooks 1994b). One of the few *partial* exceptions to this generalisation was the work that James Watt (1736–1819) undertook in developing the modern steam engine. Watt's employment as a scientific instrument maker, rather than his involvement in industry, led to his interest in improving Thomas Newcomen's less efficient atmospheric steam engine. Yet, even in this case, the invention of the steam engine gave more to science, in the form of the theory of thermodynamics, than science gave to steam technology. Not until the pioneering phase of the Industrial Revolution had passed (by 1830) did the reinvigorated and transformed science profession —responding to industrial demand—make a significant contribution to the unfolding of the technological strategy. This was mainly in the fields of alloy steels, chemistry (artificial dyes), electricity, and magnetism (the electric dynamo and motor). Only from the mid-19th century was there a growing interaction—a symbiosis—between science and the unfolding technological strategy. Yet it must be understood that the driving force in this relationship was the motivation underlying the **strategic**, not the **intellectual**, pursuit. The central maxim of *The Dynamic Society*—'desires drive, ideas merely facilitate'—is pertinent here; as much as this may irritate intellectuals.

4. Solving the 'Needham Puzzle' in the Early 1990s

Having reviewed the background to the Needham puzzle, together with the theory needed to solve it, we now consider the arguments I made in the early 1990s. In *The Dynamic Society* (1996: 314), I wrote:

> China has always **puzzled** Western observers. In particular, most have found it difficult to understand either why the Chinese Empire lasted so long—about 2,000 years from 221 BC to the early twentieth century—or why such a vital and technologically advanced society between the eighth and twelfth centuries could have failed to invent an Industrial Revolution before a less advanced Western Europe.

I went on to show that my dynamic-strategy theory—see Appendix—could explain both China's unusual longevity, and the puzzle arising from the apparent failure of the Song dynasty to generate an Industrial Revolution.

There are two strands to my theoretical argument in *The Dynamic Society* about these alleged perplexing aspects of Chinese history. First, during the period 1000 to 1800, while Western Europe was a hotbed of competition, China experienced a relatively low level of external competition. Accordingly, China, quite rationally, adopted the dynamic strategy of family multiplication (procreation and migration) in conjunction with either colonisation (before 1300) or technological and administrative fine tuning (after 1300). (See the appendix for the role dynamic strategies play in my general dynamic theory.) In contrast, the intense competition in Western Europe led to the adoption of the dynamic strategy of conquest. While the conquest strategy is relatively quickly exhausted (hundreds of years at best), the family multiplication strategy under the neolithic (agricultural) paradigm can operate for much longer (thousands of years), provided there is limited external competition, abundant land to colonise, and/or the availability of new techniques to increase the productivity of existing land. This explains, I argued in the early 1990s, the longevity of Chinese civilization before the modern era.

Second, the relatively lower level of competitive intensity experienced by China meant that it exhausted the potential of the neolithic (or agricultural) technological paradigm much more slowly than did the more highly competitive Western European societies. By the time of the British Industrial Revolution, China still had excess paradigmatic capacity that it could profitably exploit. That was around 1800. At the end of the Song dynasty in 1279—some 500 years before the British Industrial Revolution—China's unexploited paradigmatic capacity was seemingly limitless. Business as usual for the Song Chinese was immensely more economical and profitable than attempting to forge an

Industrial Revolution. Engineering a new technological paradigm shift was just not economically possible for the Song Chinese at that early date. For China, it was a matter of being in the **wrong place at the wrong time**.

Hence, I argued in the early 1990s, there was no real reason for 20th century scholars—such as Needham (1958), Hartwell (1966), Elvin (1973), and the rest of the China club—to be puzzled about the Song dynasty. Unfortunately, the closed nature of Chinese historical scholarship has meant that, although I solved the Needham puzzle in the early 1990s, it is still referred to reverentially in the 21st century (e.g. Liu 2000; Olerich 2017). In *The Ephemeral Civilization* (Snooks 1997: 467), I wrote:

> But the Song 'economic revolution' was a false dawn. As it did not herald a new technological paradigm shift, it was not the beginning of an industrial revolution. An industrial revolution could occur only once the old neolithic paradigm was exhausted, and only in the face of sustained and intense external competition (Snooks 1996: ch. 12). Neither condition had been met by the late thirteenth century in China, or in any other part of the world. Neolithic exhaustion—the application of best practice neolithic technology to all accessible natural resources—was not evident in Western Europe until the mid-eighteenth century, or in China until the early twentieth century …
>
> … **Some scholars are 'puzzled'** by Chinese failure to develop both the relatively advanced iron industry as the foundation for a process of modern industrialisation (Needham 1958; Hartwell 1962; 1966; 1967) and the existing crude textile technology as a basis for a 'true industrial revolution in the production of textiles over 400 years before the West' (Elvin 1973:198). But it is clear from my model that, as the neolithic technological paradigm had not been exhausted under conditions of intense external and internal competition, there was no strategic demand for this type of technological change.

And in *Ark of the Sun* (2015: 175), tired of continually reading about the 'Needham puzzle' in even the most recent scholarship, I wrote:

> The so-called '**Needham puzzle**' (Needham 1958; Hartwell 1966; 1967) is only a puzzle for historians unfamiliar with my general dynamic theory developed during the early 1990s. New ideas travel slowly in [fortified] communities of conservative scholars.

The exception is the economist Huw McKay (2016: 198–207), who has been prepared to take my dynamic-strategy theory on board and to employ it creatively to analyse longrun industrialisation in China.

5. China's Recurring Missed Opportunities.

The cost of being in the wrong place at the wrong time in the late eighteenth century was, as we have seen, that China failed to participate in the beginnings of the technological paradigm shift called the Industrial Revolution. Consequently it was transformed from a large and relatively wealthy country by international standards, to being a modest sized, and relatively poor, nation. Prior to the Industrial Revolution (1700), China's economy was about as large as that of Western Europe and of India, and about 7.7 times the size of the UK (excluding its overseas territories). After the Industrial Revolution (1913), the UK economy was roughly the same size as those of India and China, despite the fact that

China's population was over 10 times larger than the UK's. And in terms of economic resilience, while prior to the Industrial Revolution, UK's GDP per capita was already twice that of both China and India, after the Industrial Revolution it was 9 times greater than China's and 7 times greater than India's. China failed to catch the great technological wave of the late eighteenth century.

The burning question today is: Will Chinese history repeat itself in the 21st century? See my recent paper "Can China overtake America? Or will it fail to catch the great technological wave once again?" (Snooks 2020b). History shows that China is not too big to fail.

6. Conclusion

When scholars reach impasses in their research, they invariably invoke the phrase 'enduring puzzle'. It is assumed that if they are unable to solve the conundrum, then future generations will experience the same problem—that it will remain an 'enduring' issue. It rarely occurs to them that someone working outside the confines of their fortified community or discipline might already have solved their historical 'puzzle'—might have cut their Gordian knot. While lip-service is usually paid to the multidisciplinary approach in academic circles, few take it seriously—few look beyond their own clearly-marked discipline boundaries. And when someone does appear from beyond the pale, bringing new methodological techniques, they are usually ignored; particularly if they come from unexpected quarters. But, then, as the poet A.D. Hope once wrote: 'from the deserts the prophets come'.

7. Postscript: A Plethora of Historical 'Puzzles'

History is crowded with scholarly 'puzzles', owing to a failure to employ a realist general dynamic theory. Here are a few examples that were resolved in my global history trilogy—in *The Dynamic Society* (1996), *The Ephemeral Civilization* (1997), and *The Laws of History* (1998a).

- If there are, as some claim, no laws of history, how do we account for regular patterns in the past?
- Why did hunter/gatherer societies on the world's strategic periphery resist, for so long, the agricultural techniques at its strategic core? More specifically, why did Australian Aboriginals remain hunter/gatherers for over 60,000 years?
- Why did a commercial/democratic Athens, after flourishing for 300 years, transition into a conquest/authoritarian state?
- How was Rome, reeling under Hannibal's attack, finally able to defeat and destroy Carthage?
- Why did Rome, which had endured for 800 years, fall in the mid-fifth century AD?
- Why did the civilisations of Egypt and China last thousands of years, while other civilizations collapsed more quickly?
- Why did Venice abandon commerce for conquest in the early 15th century?
- Why did both modern democracy and the Industrial Revolution emerge first in Great Britain?

- How could a small military expedition from Spain defeat the mighty Aztec empire in the early 16th century?
- How do we account for the sudden demise of the powerful USSR in 1991?
- Will China become the world's next superpower, or will it fail to catch the great technological wave once again?
- Will the world fall victim to the ravages of climate change, or to the more insidious internal corrosion of metaphysical interventionism?
- And, finally, the '**Needham puzzle/question**', which, as we have seen, takes the form of either: Why did Song China (960–1279 AD) fail to generate an Industrial Revolution, despite its achievements in technology and science? Or: Why did China not invent a 'scientific revolution'?

It is curious that only the last of these 'puzzles' is known by name. Is it because Needham was more perplexed than other historians; is it because Chinese scholarship is particularly inward looking; or is it because China is regarded, quite wrongly, as being too big to fail?

Finally, those interested in how this theory can be employed to solve 'puzzles' in the **natural world**, the **world of the human mind**, and the **future world**, may wish to consult Snooks (2003), Snooks (2006), and Snooks (2010b; 2015) respectively.

APPENDIX: GENERAL DYNAMIC THEORY AND GLOBAL HISTORY

To provide a solid foundation for my discussion of the 'Needham puzzle', in this appendix I briefly outline my general dynamic theory, and sketch the global historical context. `

The Theory

The realist general dynamic theory used in this paper is called the '**dynamic-strategy theory**'. It first appeared in fully developed form in my book *The Dynamic Society* (1996) in order to explain the rise and fall of societies and civilizations on the one hand, together with the great economic revolutions, or technological paradigm shifts, on the other. The great economic revolutions include the paleolithic (hunting) 2 million years ago, the neolithic (agriculture) 10,600 years ago, and the modern (industrial) 1780–1830. Since then, I have employed this theory to also explain biological transition (Snooks 2003), the emergence and role of the human mind and consciousness (Snooks 2006), and the role of religion and scientism (Snooks 2010a), and to make predictions about the future (Snooks 2015). This general dynamic theory was constructed inductively from a close and systematic observation (over a number of decades) of living systems in the human and non-human worlds. Very briefly, the dynamic-strategy theory consists of four endogenous, interrelated elements and one exogenous and random force (including disease). They include:

- *The endogenous driving force*—which arises from the need of all organisms, including humans, to survive and prosper—provides the theory with its self-starting and self-sustaining nature. This force, which is called 'strategic desire', is the drive to survive and prosper.

- *The set of four universal 'dynamic strategies'*—technological change, family-multiplication (procreation and migration), commerce, and conquest—that are employed opportunistically by individual organisms or 'strategists' to achieve their material objectives. While each of these dynamic strategies unfolds over *roughly* a 300 year period, they consist of a series of sub-strategies that operate over *roughly* a 50 year period. External shocks disrupt these great waves of progress.

- *The 'strategic struggle'*, which is the main political method by which established individuals or societies ('old strategists') attempt to maintain control over sources of survival and prosperity, and by which emerging individuals or societies ('new strategists') attempt to usurp such control. Throughout history, this strategic struggle has led to political and social transition. Where it has been hijacked by metaphysical interventionists (or antistrategists), these transitions have turned into bloody revolutions (French revolutionary terror, the USSR, and Maoist China). In modern democratic society this struggle takes the form of competing political parties.

- *The constraining force* operating on the continuing dynamics of a society is the eventual exhaustion, not of natural resources, but of the dominant dynamic strategy; or at a higher level in the dynamic process, of the technological paradigm. The operation of this constraint leads to the emergence of internal and external conflict, environmental crisis, collapse, and even extinction.

- *Exogenous shocks*, both physical (continental drift, volcanic action, asteroid attack, climate change) and biological (disease such as the plague and various viruses together with unforeseen invasion), impact randomly and marginally on this endogenously driven and shaped life-system, or strategic *logos*. In the past, only internally exhausted life systems (or *logoi*), that would have collapsed anyway, are terminally affected; viable ones manage to shrug off these external shocks, but bear the scars of these encounters. The last century has witnessed three different types of metaphysical interventionists—those activists driven by ideas unrelated to reality—namely, Marxists, radical environmentalists, and technical experts (Snooks; 1996; 1997; 2010b; 2020a).

The History

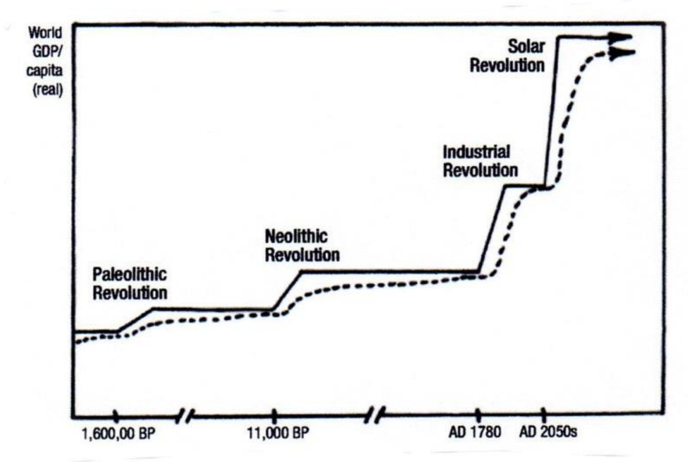
The dynamic-strategy theory needs to be placed within the context of the history, present, and future that it was developed to explain. Figure A.1 illustrates the four great economic revolutions, or technological paradigm shifts.

- The Paleolithic (hunting) Revolution from 2 myrs BP.

- The Neolithic (agricultural) Revolution from 10,600 years BP.

- The Modern (Industrial) Revolution from AD 1780.
- The future revolution—the Solar Revolution—which can be expected from middle decades of the twenty-first century.

Figure A.1: **Four Great Economic Revolutions—Past and Future**



Source: G.D. Snooks, *Ark of the Sun* (2015)

The outcome these great revolutions of human society is a step-like progress of economic activity over the past 2 million years. Each giant step forward, which was facilitated by a technological revolution, made possible mankind's more intensive access to natural resources. In turn this enabled a higher level of economic activity (in terms of GDP and GDP per capita) to be achieved. It resulted not only in a rapid increase in human, domesticated animal, and plant populations, but also an exponential increase in human living standards, particularly concerning the consumption of services and nonperishable commodities. The major discovery I made in *The Dynamic Society* (1996: 79–81) concerning this process of economic and technological transformation is its **exponential nature.** In fact, it is part of a continuum that goes back to the beginning of life on Earth. It is what I call the **logological constant**—a measure of the dynamics of the progress of the dynamic system that I call the 'strategic *logos*'—which can be mathematically described by a simple algorithm:

$y = a\ (3^{t-1})$

where y is global biomass/world GDP generated by genetic/technological change over the past 4,000 million years, and t is time. What this tells us is that biomass/real GDP is accelerating at a constant rate—namely, that **the transformation of each epoch in history is taking place three times more quickly than the last epoch**. In other words, history is getting faster. Yet, while this function is exponential in arithmetic terms, it is linear in logarithmic terms. The logological constant has also been called the 'Snooksian algorithm' to distinguish it from the more recent, but fantastical hyper-exponential algorithms concocted by the 'singularitists' (Panov 2005 and Kurzweil 2005), which, bizarrely, predict infinitely rapid growth rates in the near future. This is economically impossible (see Snooks 2019). As I explain elsewhere, the logological constant in life systems plays a similar role to that of the cosmological constant in the Universe (Snooks 2015: ch. 3). This analogy is not possible for the singularity-ists—imagine, if you can, a universe expanding at a hyper-exponential pace!

The reason for the step-like profile of real GDP per capita is that with each technological revolution there was a quantum leap in *potential* access to natural resources owing to the occurrence of a major innovation or cluster of innovations. The *actual* utilization of this potential, however, is a gradual and wave-like process driven by the 'strategic desire' of 'materialist man' in pursuit of their *non*-technological strategies. But in order to achieve this potential, it was usually necessary to develop add-on technological devices, such as newly conceived war machines to further Rome's conquest strategy, or new and better ships and maritime facilities to further Venice's commerce strategy. The relationship between potential and actual outcomes is represented diagrammatically in Figure A.1.

In Figure A.1 the *actual* curve (dotted line) represents the development path of global economic activity, measured by real GDP per capita. Once a particular technological paradigm has been exhausted (where the potential is fully realized), the *actual* curve presses persistently against the *potential* curve and reduces living standards as population increases. The resulting technological paradigm exhaustion leads to the adoption of a new economic revolution, or technological paradigm shift. The modern era was ushered in by the Industrial Revolution about 250 years ago. Currently we are approaching the end of the resulting industrial technological paradigm. As the technological potential of this paradigm is exhausted, global and national growth rates decline, eventually stagnate, and finally collapse under pressure from growing population. This provides the economic pressure and incentive to introduce costly new technology.

What of the situation today? Over the next generation, human society will need to invest massively in the development of new infrastructure for directly accessing the energy of the Sun. This will lead to the rapid and sudden emergence of the Solar Revolution, because history is speeding up (as shown by the logological constant). Initially this huge effort will place pressure on living standards, just as did the early stages of the British Industrial Revolution, but, once successfully completed, this great breakthrough will provide endless supplies of energy and lead to an unimaginable growth of prosperity—at least for the next 600 million years, after which the Sun will begin a deadly process of expansion, making life on Earth untenable.

This technological transition, however, will not be without its dangers. Global conquest and collapse—possibly even extinction—could theoretically occur in human society, if we were determined and able to eliminate growth-inducing technological change in the mistaken belief that this will save the environment or reverse climate change. This scenario was initially discussed in the early 1990s in my book *The Dynamic Society* (1996: ch.13) and developed further, in relation to climate change, both in *The Coming Eclipse* (2010b: ch.5) and *Ark of the Sun* (2015: ch.3).

References

Elvin, M. (1973). *The Pattern of the Chinese Past*. London: Eyre Methuen.

Hartwell, R. (1962). "A revolution in the Chinese iron and coal industries during the Northern Sung, 960–1126 AD", *Journal of Asian Studies*, 21 (2): 153–62.

Hartwell, R. (1966). "Markets, technology, and the structure of enterprise in the development of the eleventh-century Chinese iron and steel industry", *Journal of Economic History*, 26(1): 29–58.

Hartwell, R. (1967). “A cycle of economic change in imperial China: coal and iron in northern China, 750–1350”, *Journal of the Economic and Social History of the Orient*, 10: 102–59.

Liu, D. (2000). “A new survey of the Needham question”, *Studies in the History of the Natural Sciences*, 19 (4).

McKay, W.H. (2016). Longrun Industrialisation in China: A Strategic Perspective. PhD, Australian National University (March).

Needham, J. (1954–1980). *Science and Civilization in China*, Cambridge: CUP.

Needham, J. (1958). *The Development of Iron and Steel Technology in China*. London: Newcomen Society.

Needham, J. (1969). *The Grand Titration: Science and Society in East and West*, Toronto: University of Toronto Press.

Olerich, R. (2017). An examination of the Needham question: Why didn’t China have a scientific revolution considering its early scientific achievements? MA thesis, CUNY.

Sivin, N. (1982). “Why the scientific revolution did not take place in China—or didn’t it?”, *Chinese Science*, 5. [Revised 2005, online].

Snooks, G.D. (1993). *Economics Without Time. A Science Blind to the Forces of Historical Change.* London: Macmillan

Snooks, G.D. (1994a). *Portrait of the Family within the Total Economy: a study in longrun dynamics, Australia 1788–1990*. Cambridge: CUP.

Snooks, G.D., ed. (1994b), *Was the Industrial Revolution Necessary?* London & New York: Routledge.

Snooks, G.D. (1996). *The Dynamic Society.* London & New York: Routledge.

Snooks, G.D. (1997). *The Ephemeral Civilization.* London & New York: Routledge.

Snooks, G.D. (1998). *The Laws of History*. London & New York: Routledge

Snooks, G.D. (2010a), *Dead God Rising. Religion & Science in the Universal Life-System*. Canberra: IGDS Books.

Snooks, G.D. (2010b). *The Coming Eclipse. Or the Triumph of Climate Mitigation Over Solar Revolution*. Canberra: IGDS Books.

Snooks, G.D. (2015). *Ark of the Sun: the improbable voyage of life*. Canberra: IGDS Books.

Snooks, G.D. (2019). “Is singularity a scientific concept or the construct of metaphysical historicism? Implications for Big History”, Institute of Global Dynamic Systems, *Working Papers* # 17 (February); subsequently published in Korotayev, A.V. & LePoire, D.J. (eds) (2020). *The 21st Century Singularity and Global Futures.* Switzerland: Springer.

Snooks, G.D. (2020a). “Fight the virus, not the economy! How to avoid the ‘interventionist storm’”. Institute of Global Dynamic Systems, *Working Papers* # 19 (March).

Snooks, G.D. (2020b). "Can China Overtake America? Or will it fail to catch the great technological wave once again?". Institute of Global Dynamic Systems, *Working Papers* # 25 (June).

Snooks, G.D. (2020c). "Plato's cave of shadows and the Chinese political system". Institute of Global Dynamic Systems, *Working Papers* # 26 (June).

Snooks, G.D. (2020d). "The rise of science: a new strategic explanation." Institute of Global Dynamic Systems, *Working Papers* # 28 (July).

NOTE: All the above working papers by G.D. Snooks are available on his *Researchgate* and *Academia* sites.