

THE NATIONAL IMPERATIVE: THE STATE, SCIENCE AND TECHNOLOGY, AND POLICY EVOLUTION CIRCA 1400-2000

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Keywords: technological progress, statism, technology transfer, science policy, industrial revolution, economic progress, cultural context, cultural infrastructure, socio-economic base, scientific superstructure, nationalism, patents, reliable knowledge, skills, information diffusion, scientific revolution, public science, military imperatives, European expansion, migration, encyclopaedias, exploration, global development, Japan, climacteric, colonialism, industrialism, industrialisation, economic history, societies and associations, inventions, innovations, appropriate technology, risk-taking, technical education, research and development.

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Summary

This essay surveys the relations between reliable knowledge, technique and the nation-state over a six hundred-year period. In the early years the most important function of the state was probably in the transfer of skilled workers from centers of advancement in Europe to areas of relative technological backwardness. Although some notion of commercial viability was at times present, the overwhelming concern was with the military and civil power of the authorities themselves, and thus state-based modernization centered upon arsenals, docks and capital cities. The expansion of Europe overseas confirmed such a tendency, and was associated with the formation of state-aided associations for the advancement of reliable knowledge and with the development of a conception of the expert as a servant of statist requirements. The eighteenth century represented a genuine breakthrough or watershed in that state-aided formations of reliable knowledge and its dissemination became more formally linked to domestic industry, a process quickened with improvements in intellectual property rights and accelerations of skill migrations between European nations and the Americas. It was probably, therefore, this century that witnessed the departure of Europe from a general global experience, rather than any cultural or commercial advantages forged in earlier centuries. The nineteenth century witnessed three major forces working to create particular patterns of science policy. Within advanced nations, industrialization itself produced new skills and absorbed others from the worlds of intellectual association, the

higher learning, congeries of engineering skills and new artisanal communities of learning, (re)skilling and dissemination. Secondly, a growth of public science in such nations meant that expert pressure groups began to impinge directly on the processes of public policy formation, acting to ensure that science was increasingly seen as an investment rather than a consumption expenditure. Thirdly, the emergence of industrial leaders such as Britain, Germany and the USA, and the associated rise of a large international economy of trade, capital flows, migration, and technology and ideological transfers, combined to ensure that in more industrially backward nations policies to modernize scientific and technological capabilities became central to development programs of authoritarian states, both within Europe and beyond it. Although a subsequent expanded colonialism inhibited the spread of industry and, hence, the global diffusion of scientific and technological assets, the short twentieth century (1914–1970) was dominated by a development paradigm in the ‘third world’ that focused on the gaining of modern knowledge and technologies as the basis for rapid catch-up industrial and commercial development. The modern climacteric since that time has witnessed a greater spread of industrialization and of global science/technology assets for various reasons, a major one being the change in the character of much modern technique, which in the form of biotechnologies, microelectronics, marine applications, and new service and environmental industries, has created some space for the emergence of new centers of advancement beyond the older Atlantic edge. This period has also seen the development of forms of globalism and regionalism that will quite possibly render future national programs of science of lesser relevance to patterns of future prosperity and well being.

1. Introduction: Before the Beginning

Historians are very fond of thinking and writing that there is nothing new under the sun. Of course, this is both sense and nonsense. Although many policy analysts believe that the processes that they address and the problems they seek to redress are novel and contemporary, it seems sensible to emphasize that technological progress has always been sensitive to the more general economic or commercial policies of governments, that technology transfers from other places have always been of great importance in all cases of industrialization and economic growth, and that national competition has usually been at the base of all science policy, however rudimentary that might have been. But it is equally sensible to note the novel aspects of the new millennium. Where statism dominated the long period of modernity circa 1500–1970, in more recent years technological systems have emerged as intrinsic components of global connections and interrelationships that seem to be either entirely without precedent or but weak reflections of the ecumenical civilizations that existed in the ancient world, where nations were yet to solidify as policy-engendering entities.

Again, there has been a clear change in agency, from individuals and their congeries and institutions, to states and their public budgets, to global enterprises and their vast private profits. Within these alterations over time in site and agency there have also been changes in *motif*, from an overriding concern with exploration and domination of nature and foreign places, through the demands for industry and economic growth, to the more subtle, monitoring requirements of welfare, distribution, justice, transparency and environmental sagacity. Indeed, a major historical generalization might be that in its

early years all science policy of states was oriented to commercial competition in some form, but that in more recent years the great empires of policy have shifted from growth in developing nations towards system maintenance in mature economies. Science policy was born long ago in the need for new skills, information, technologies and industries in developing, aggressive national systems. Whilst such a focus remains in many poor societies, amongst the historical ‘winners’ the focus has decidedly moved away from industrial or commercial growth (the province of private enterprise) towards manipulation of a complex, moving equipoise between welfare and growth, society and economy, individual needs and natural constraints.

Attempting to adopt a non-Eurocentric stance, this analytic survey begins with the richness of early science policies as they emerged within national states, to a study of the turning-points of the eighteenth century. It was only in the latter century that overt policy instruments over science and technology began to play a role in the more general process whereby Europe began to overhaul the other great world systems in the movement towards industrialization and the culture of industrialism. From there our survey embraces the growth of policy towards science and technology in the years of industrial transformation, when it becomes clear that primary success was gained by the most open systems, which protected their many interests through increasingly sophisticated legislation and information systems. The next section discusses more formally the historical links between public science and science policy prior to the Great War of 1914–18. The final major section of the chapter takes up the case of the ‘development paradigm’, the form of policy that dominated the planning strategies of the struggling poor nations of the world in the years approximately 1914–1970. We argue, also, that the years since then have seen strategic alterations at the global level that have forced new directions for science policy throughout the nations of the world.

Social historians and, increasingly, their ‘intellectualist’ counterparts, are wont to write of the ‘social context’ or the ‘general cultural environment’ within which science and the scientific enterprise develops. They argue, if only by implication, that formalized and reliable knowledge does not accumulate in a vacuum but by means of a wider infrastructure which supports scientific programs, diffusion of reliable knowledge, skills and technique, or finances careers and institutions. Any public sector activity, any policy of the sovereign, commons or municipality that is directed at such a support structure might, thus, be embraced as an element of science policy. If we disregard for a moment two important historical elements – random inputs from individuals of energy, genius or organising ability who may be ‘culturally misplaced’, together with institutional or ideological influences from outside the immediate national framework – then it would seem appropriate to survey the historical relations between the growth of the *scientific superstructure* of research programs and leading institutions, the growth of a wider *cultural-institutional infrastructure*, and the growth of a *socioeconomic base* of support for scientific and technical activity. All of these levels of support structure may be influenced by the policies of government, at times inadvertently. Thus, even the last, basic level of support, in the form of learned audiences for science in urban densities, in the form of literacy levels, or in the number of skilled professionals who produce and demand reliable knowledge, might be seriously influenced by governments as they wage war, encourage emigration or immigration, seek revenue through internal customs and passport systems, alter education policies, and so on. Until the last century of very

large-scale state financing of science and technology, government policies which promoted our intermediate level, the cultural-institutional infrastructure, might have been of greatest importance in most cases, as shown in sections 2 and 3 below. Here was to be found a broad arena of interests and institutions that is difficult to demarcate and, hence, to evaluate. One premise of this paper is that, over most of early modern and modern history, it was the cultural-institutional infrastructure, influenced by government, which served to mediate the relations between the larger societal base and the narrower scientific and technical superstructure. A classic example of this was surely the Chinese examination system. This has often been seen as a barrier between the talents and energies of the wider population and Chinese culture on one hand, and the production of reliable knowledge on the other, a barrier sufficient to retard the development of Chinese science and technology after a certain high plateau around the fifteenth or sixteenth century. In this argument, the elitism and rigidity of the mandarin and of government policy which sustained it, prohibited the emergence of any significant, mediating cultural-institutional infrastructure, and thus reduced support for progress in science and technology. However, further research questions the simplicity of this vision of a dynamic, urban, institutionally-open European culture, contrasted with a hidebound mandarin Chinese culture forged in public policy. Thus we now find that between AD 1148 and AD 1256, over 50% of the successful higher examination candidates had no direct paternal relative in the bureaucracy. Again, between 1368 and 1496 over half of Chinese degree-holders belonged to families without any record of elite membership. This suggests, then, that the examination system was no impassable frontier between the base and the superstructure of support, that there was room for expansion of a more informal infrastructure, and that if Chinese science and technology indeed became somehow 'retarded', then the reasons must be sought elsewhere. Of course, these may still lie with government – thus the view that the predominance of water and hydraulic engineering in Chinese agriculture forced a system of hierarchy, militarism, corvée labor and the stultification of knowledge in old, proven formulae.

In the years from around 1150 to around 1500 it does seem that Western Europe demonstrated strong technological innovation. But this can not easily be put at the door of nationalism or policy, as much change then centered on the Islamic areas of Spain, emanating outwards from North Africa and the Middle East – thus the new metalworking, mining and architecture, and the general diffusion of printing and paper making and the associated use of the water-wheel in pulping. But by the end of this period, Europe itself was advancing, and this was possibly an outcome of increased statist rivalry and emulation. Such statism was set against the background of the decline of Islamic influence and the relative absence in Europe of natural disasters and setbacks, which together encouraged a measurable increase in trade and communications, in urbanism and new life-styles, and an accelerated transfer of technical knowledge from advanced to backward areas in such industries as glass and paper making.

By the fifteenth and sixteenth centuries there are some clues as to the impacts of officialdom. Specific skilled sites develop, for instance German potters, stone ware, salt glaze, Dutch canal building, Portuguese navigation and ship building, English military technologies, which are closely allied to the needs of the state and to policies of skill migration, guild membership and so on. Property rights begin on knowledge

applications – from the 1421 legislation of the Republic of Florence to the English Statute of Monopolies in 1623. (It should be noted that the Italian city state patents covered only that region. The first of the greater territorial patent systems was that instituted by Queen Isabel of Spain in 1478 – with a patent for improved grinding – which gave rights in all areas of the Hispanic monarchy, including America from the 1490s). Thirdly, the struggle towards reliability and accurate reportage was closely linked to navigational and military needs, focussed on time, place and cartography. A well-known example was that of the Portuguese prince, Henry the Navigator (1394–1460), who set up an observatory and school of navigation on the south coast at Sagres, where there gathered pilots, cartographers, philosophers and shipbuilders, all aiming at the exploitation of the mysterious west coast of Africa and generating improvements in the astrolabe, the compass and other techniques and instruments. The Iberian explorations required improved compasses, geometric quadrants, and astrolabes, advances in ship technology, including piston pumps for draining (notably improved in 1545 by the Spaniard Vicente Barroso) and diving equipment. It might be remembered that Raleigh's first colony in the New World in the 1580s included a smelting laboratory designed to test ores for gold and silver. The effective exploitation of the Americas involved advances there in water milling generally and grain grinding and sugar crushing in particular. Finally, for every state which rejected skilled minorities, more than one other instituted policies for their reception and reward, from grants of land and property-rights to membership of guilds and fraternities. From the Jewish diasporas of the South (particularly the impact of the expulsion from Spain in 1492), to the later Huguenots of the North, such movements were through social networks which encoded values and awarded status to those with skills and new knowledge.

With all this, we might also remember two things. First, the European state was an active if usually ineffectual suppressant of knowledge and technique. From the *Index librorum* of 1559 to threats of execution by the Grand Duke of Florence for any brocade worker leaving town, authorities prohibited the development and diffusion of useful knowledge and its applications. But of greater importance, most such development was independent of the policies of the state anyway, and thus difficult to apprehend. Europe-wide techniques of clock making or cast iron production, or the use of the spinning wheel, diffused through communities and markets, not via bureaucracies. Much knowledge was invented with circumstance or depended on a reevaluation of technical classics such as Ptolemy's *Geography*, translated into Latin in 1406, or Conrad Mendel's publication during 1423-29 of the so-called *Mendel Book*, which depicted 355 mediaeval crafts. Again, the explosion of publication owed little directly to any state. By the end of the fifteenth century some 35,000 different books had been published in Europe, possibly around 20 million copies, of which perhaps only 40% dealt with moral and religious matters. By the early 1600s the first European newspaper was published in Antwerp, and in 1691 one of the first technical journals specifically for artisans was published in England, the *Collection for Improvement in Husbandry and Trade*. None of this owed much to officialdom, and little of this could be found elsewhere in the world.

We might conclude that, prior to the eighteenth century, government influenced the generation of reliable knowledge and its applications mostly through military demands, migration and skilling legislation, providing havens for minorities, and instituting

something of a system of intellectual property rights. The European scientific revolution, if such may be identified validly, depended for its emergence on places of experiment and trust and avenues of knowledge articulation, expansion and diffusion. Its principal elements, of measurement, experiment, classification and physical modeling, depended on but required moving far beyond old patterns and norms of craftsmanship. Techniques were spurred by increases in demand, but also by the invention of the associated institutions of the market, of plantations and factories, and by a background radiation of divisions of labor based on better use of existing techniques. In great 'other places' such as China or India, this configuration appears not to have worked so intensively – trust and civil living, increased domestic and military demand, places of experiment, acceleration of the media of communication and knowledge articulation, together with altered imperatives stemming from the need to exploit new areas of the globe in a system of national commercial, naval and military competitiveness, did not appear conjuncturally elsewhere in the world at this time. Although much of this lay beyond any European state or policy regime, we might conclude that the principal function of the state at this time was to provide base and infrastructural support (or environmental facility) to the emergent scientific endeavor, rather than to interfere in the workings of science itself, the certifying of experiments or the codifying of what was good in the new.

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