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The Mantra of Efficiency: From Waterwheel to Social Control

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It is said that ‘efficiency is doing better what is already being done’, although the word in English derives from the Latin *efficere*; simply, to accomplish. In its crudest sense then, regardless of culture or nationality, the vast majority of humanity engages in efficiency at a personal level on a daily basis. The lowest common denominator from this perspective is that life presents material challenges – the perpetual need for food, shelter and protection from harm – and from the birth of civilisation this has entailed individuals learning to accomplish certain tasks and improving upon their own methods for doing so throughout their lives. The briefest delving into the archaeological history of tool-making shows that separated societies have often stumbled upon similar technical solutions to shared material dilemmas (especially in hunting and agriculture). In this narrow sense the pursuit of efficiency is at least as old as humanity itself and has been a key dynamic at the individual and societal level through to the present. However as most historians concerned with modernity will accept, there is something special about modern forms of efficiency. In all its various guises it has flourished in the 20th century, remaining among the most discussed issues around the world and an important idea in most walks of life. Efficiency is fundamental in everything from waging war, through all forms of logistics, to perfecting speed cycling. For many the word is aspirational, for others oppressive. It can be synonymous with ideals of perfection, expansion and progress or it might denote balance, equilibrium or the absence of disruption. Since the enlightenment the word has been formalised as a concept, increased in sophistication and its 20th-century variants have been utilised in such diverse and complex ways – both subtle and extreme, and in the service of all imaginable ideologies – as to almost defy coherent understanding. As Jennifer Alexander explains at the beginning of her book, *The Mantra of Efficiency: From Waterwheel to Social Control*, efficiency ‘belongs’ to the epoch of industrial modernity (p. 3).

In *The Mantra of Efficiency*, Alexander, based at the University of Minnesota's Department for the History of Science, Technology and Medicine, has produced a thought provoking study underwritten by a wide range of secondary literature and no small amount of primary research, including much conducted in London, Paris and Berlin. Her book is a brief but ambitious attempt to understand efficiency as an article of intellectual history in Europe and America since the 18th century, tracing modern understandings of the concept back to the study of early industrial machinery, through industrial revolution and post-enlightenment rationality, and into the 20th century when it became ubiquitous, and its meanings and use more diverse and influential. Nevertheless this is no seamless trajectory. Rather, six case studies from Europe and America are presented in chronological order organised loosely around three levels of analysis – context, metaphor and quantification. The use of these three 'foci' seemed ambiguous by the book's end, and there was seemingly some discord in the choice of case studies (although this is more than compensated for by research in three languages!). Alexander's principal claims about the causal significance of early industrial machine-study on the one hand, and the great synthetic theories of Darwin and Marshall on the other, to the subsequent development of an intellectual forest of efficiencies by mid-20th century (each shaped in different ways by their political, cultural and economic contexts) is an intriguing argument however. Indeed there is much to admire in the combination of fascinating detail and arresting commentary throughout what is a thoroughly researched and fluidly expressed addition to the intellectual historiography of modern industrial culture.

The first third of the book deals with the origins of conceptual efficiency. Beginning with an account of famed British engineer John Smeaton's studies on waterwheels, the reader is taken on a journey through some of the most thorough investigations of industrial machinery staged at engineering institutions in France and America up to the mid-19th century. The search for 'perfected machines' necessitated an enhanced understanding of particular mechanical principals, both static and dynamic, and as these found parallels in the grand social, economic and scientific theories of the period (personified here in the form of Charles Darwin and economist Alfred Marshall), ideas about what efficiency meant matured and diffused. The middle third comprises two differing 20th-century manifestations of efficiency, from scientific management consultants influencing popular 'personal' efficiency in America, to the social control accrued from workplace seating strategies in Weimar Germany. The final chapters consider first the relationship between efficiency and morality in an essay on the academic furore surrounding Fogel and Engerman's *Time on the Cross* and their analysis of efficiency in the slave trade, before concluding with a summary of efficiency in the globalised economy and contemporary networks of culture.

The central message of Alexander's thesis then is that although efficiency comes in many forms – closely linked to the characteristics of their particular historical contexts – the most powerful and enduring concepts of efficiency found in modern western commerce and culture have their origins in the study of machines in 18th-century England. Modern efficiency therefore begins with the birth of modern engineering, and in this regard the outstanding name is constructor of lighthouses, bridges and canals, and founder of the Royal Society of Civil Engineers, John Smeaton (1724–1792). Smeaton designed and built waterwheel models with a dual purpose in mind. He wanted waterwheels to work more effectively in harnessing the power of flowing water, but as a philosopher engineer he also craved knowledge of the fundamental principals governing the optimal calibration of such machines. Newton's laws of mechanics were not readily applicable to the flux and unpredictability of real-world dynamic systems and Smeaton's models were therefore aimed at defining and quantifying the effects of constituent input-output forces (water-flow and wheel-speed) in relation to a set of variables (wheel-size, paddle dimensions, and positioning in relation to water-flow). From these experiments a more dedicated and nuanced appreciation of how motive force could be manipulated to produce ever higher output yields gripped the nascent field of mechanical engineering, though confusion about the core tenets of mechanical efficiency abounded for long after this. Alexander moves swiftly from the 1750s to the 1830s in an elegant comparison of Smeaton's early efforts with those of later mechanical institutes, demonstrating how far formal conceptualisation of different types of technical efficiency had developed. The Franklin Institute, founded in the machine-tool district of Philadelphia, acted as a melting pot for new ideas on mechanical engineering with the purely pragmatic objective of civic betterment. There, the first large-scale research projects in waterwheel design sought to overcome the ongoing confusion about

elemental principals of millwright construction and encountered the considerable complexities of waterwheel dynamics. This demanded great efforts of analysis. During 1830 some 1,381 experiments were carried out with every aspect of their workings diligently tabulated in what is described as one of the earliest engineering handbooks.

When news of the Franklin experiments reached scientific elites in Europe, the results were deemed a triumph of empirical investigation. But as is made clear in a fine chapter on Gérard-Joseph Christian of the Conservatoire des Arts et Métiers in Paris, a wide variety of industrial machinery beyond the waterwheel had also received detailed examination by this time, refining a technical understanding of efficiency that had become entwined with egalitarian philosophies about industrial and societal organisation. The Conservatoire was a hub for industrial knowledge in Restoration France and Christian and his colleagues immersed themselves in the study of manufacturing, mining and agricultural machines. Acquiring knowledge about moving parts, the transmission of motion and the effects produced was accomplished in the drawing of detailed technical illustrations displayed in industrial exhibitions. Various models of technical efficiency equating mechanical work with mass-times-distance-moved were developed upon the precept that the perfect machine produced the maximum output with the minimum waste. The Conservatoire published heavily, describing ‘real machines in actual use’ (p. 40) and disseminating works of theory on industrial processes in its journal, *L’Industriel.* Throughout her discussion of such journals and of Christian’s seminal *Plan de Technonomie* (with its vision of perfect machines liberating workers from unpleasant labour) there is a rich sense of how the intimate examination of machinery was opening up new ways of imagining efficiency, not just in a technical sense, but in the macro-system sense, shaping into compassionate theories of industrial organisation. Alexander is to be commended for persuasively integrating this point into her understanding of the journey of efficiency, and more so for bringing fresh research on the Conservatoire to Anglophone readerships.

Considering efficiency in its broadest terms is a theme pursued in an engaging comparison of Charles Darwin’s *Origin of Species* (1859)with Alfred Marshall’s *Principals of Economics* (1890), conducted with reference to how their conceptions of efficiency can be categorised between static and dynamic types. Marshall, the great economic theorist, apparently paid little attention to Darwin’s writing making a link between them appear tenuous at first glance, and there is perhaps greater scope for debate about how Darwin understood efficiency than Alexander’s balance-and-progress characterisation allows for. Yet the significance of Darwinian thinking to economic and commercial domains – and the role of efficiency therein – becomes clearer once juxtaposed with a debate about Alfred Marshall and the nature of late 19th-century economic theories. Here there is much food for thought, particularly on Marshall’s experiences in visiting engineering workshops in America where he at once witnessed a new range of industrial technology and encountered different attitudes in the managers and workers there. This fed back into his developing economic theory in which the industrial marketplace, though in a constant state of flux, could be usefully understood in a static, quantitative fashion. Isolated and quantified, relationships between technology and competitiveness, management and labour, and even between characteristics of a population and personal qualities such as perseverance or adaptive thinking often seemed to fall into predictable patterns. Both Darwin and Marshall represented pinnacles of synthetic thinking in the 19th century - their commonality being the insight that within large-scale dynamic systems (ecological and economical respectively), measurable differences in individual efficiency could make the difference between success and failure over the long-term. In business, as in nature, success in the competition for limited resources was determined by the extent to which methods that minimised waste and maximised output could be perfected. Alexander shows that these lines of thinking increasingly permeated a wide range of intellectual matters by mid-19th century, linking efficiency with ideas of social progress and commercial growth. What is interesting is that in the midst of this renewed and expanded focus on the potential power of efficiency, the broadest thinkers on economics continued to find inspiration in studying the workings of reaping machines, glassworks and watch factories.

The remainder of *The Mantra of Efficiency* is a focus on 20th-century expressions of the meme. During a major American hearing on railroad taxation in 1910, the efficiency consultant Harrington Emerson was

called as an expert witness and declared that efficiency measures could save American railroads ‘one million dollars a day’. After this, American interest in efficiency ‘truly exploded’ and was soon used to describe ‘diets, appliances, child rearing and education, clothing design, exercise, saving money, and the path to global dominance ... By 1915 the word *efficiency* was plastered everywhere – in headlines, advertisements, editorials, business manuals, and church bulletins’ (p. 79). Here, Alexander draws on her paper recently published in *Social Studies of Science*, unearthing rich detail on the nature of engine efficiency, showing how brake horse power measurement was ranged alongside a plethora of elaborate quantification techniques used to judge how well combustion engines balanced their fuel input with energy output. The idea of efficiency as a balancing act was transferred out of this preoccupation with machine perfection first into the political realm of governmental and industrial policy and second into the personal realm of self-help, promising perfected lifestyles to public audiences, especially those new to the disorientating life of the growing city. The reform journal *Independent* published guides on personal efficiency written by these consultants in scientific management. Alexander delved into the books and articles written by these men (followers of Frederick Taylor (1856–1915), the so-called Father of scientific management), aimed at popular audiences, again hinting at great fluidity between technical and popular appreciations of stability, planning and control. An important point is that although these were universal ideals to a certain extent, the idea of efficiency could be used to implement them in authoritarian and constrictive ways. A chapter on the ergonomics of workplace seating in Weimar Germany addresses these issues, followed by a historiographical account of the slave trade in which the question of whether or not efficiency can or should have moral qualities in modern academic debate forms the focus. Alexander concludes by considering the sheer variety of ways in which efficiency endures in importance and continues to be reinterpreted in economically and culturally modern times.

The Mantra of Efficiency is a salutary reminder that universal ideals of rationality manifest themselves in different and sometimes surprising ways; that rationality and all its sub-categories are among the most powerful ideas – in their generic and specific forms – readily utilised for emancipation or oppression (both social and technical). Anyone fascinated by the relationship between technology and culture will enjoy reading this, and will be prompted to pause for thought at several junctures thanks to Alexander’s skill for historical juxtaposition. Specialists in the different areas covered will find new details and stimulating perspectives and students interested in efficiency will be thankful for a thoroughgoing and authoritative bibliographic essay in the appendix. Whilst the focus of the thesis drifts somewhat in the final chapters, particularly in an erratic conclusion, the case studies themselves and many of the ideas linking them are valuable and provocative respectively. This is by no means a definitive intellectual history of efficiency – such a thing is surely impossible – but as the first intellectual history to reach beyond efficiency’s use in an isolated context, it constitutes an informed appraisal and condensation of a number of prominent, longstanding themes that have arisen in the vast literature on technology in modern times. *The Mantra of Efficiency* widens our understanding of how ideas of efficiency began, how efficiency has been experienced in different historical circumstances, and indeed how it can be understood in a more complex way than simply *doing-better-what-is-already-being-done*.

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