The Machine in Adam Smith's Economic and Wider Thought

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ABSTRACT. This paper exhaustively examines all Adam Smith’s references to ‘machines’, including machine metaphors or analogies, with a view to a comprehensive interpretation of the significance of the machine in his thought as a whole. By bringing together all Smith’s references to machines (and variants of that term), as well as his references to related phenomena, mechanics and engines (and variants), the totality of the various different kinds of uses of these terms assists in clarifying the meaning of each of them. However, this exercise is undertaken particularly with a view to the significance of machines in Smith’s political economy.

Adam Smith’s political economy, at least in its theoretical aspect, is first and foremost a theory of economic development. However, notwithstanding this focus, authoritative interpreters have argued that the Wealth of Nations does not adequately allow for the role of innovation as embodied in new machinery (Campbell and Skinner 1976: 43, 48–49; Rashid 1998: 21–23, 27; Groenewegen 1977: 395–97). It is thereby claimed that Smith over-emphasized ongoing development in the division of labour as the embodiment of technical progress, relative to ‘mechanization’. On the other hand, at a different level, in relation to Smith’s wider thought beyond his political economy, it also has been much noticed that he makes considerable use of machine metaphors, or analogies, in relation to a variety of phenomena (e.g., Skinner 1996: 1–2) – though such parallels are by no means unique to Smith in the eighteenth century. On the face of it there seems something of an incongruity in these contrasting aspects of Smith’s corpus, if both these interpretive points are sound. On the one hand, Adam Smith, political economist, is supposed to have missed the economic significance of actual machines, in particular for technical progress and economic development. On the other, Adam Smith, philosopher, seems readily to see the image of the machine in many phenomena.

The purpose of what follows is to exhaustively examine all Smith’s references to ‘machines’, with a view to a comprehensive interpretation of the significance of the machine in his thought as a whole. By bringing together all Smith’s references to machines (and variants of that term), as well as his references to related phenomena, mechanics and engines (and variants), the totality of the various different kinds of uses of these terms may help to clarify the meaning of each of them. However, this exercise is undertaken particularly with a view to the significance of machines in Smith’s political economy. The first section examines the role of actual machines in his political economy. Section 2 outlines Smith’s notion of nature as machine. Then, human phenomena which are explicitly considered by him as machine-like are detailed in the penultimate section. The final section offers a substantial interpretive resolution of the issue – the significance of the ‘machine’ is Smith’s thought as a whole.1

1. Machines in the Political Economy

In relation to economic phenomena and political economy, a systematic role for the machine emerges immediately in WN, in the context of the analysis of division of labour in the opening
chapters. In the famous example there of pin manufacturing Smith suggests that it is the division of labour itself, in that manufacture, which ‘probably’ led to the ‘invention’ of ‘the machinery employed in it’ (*WN*: 14–15). ‘[T]he invention of a great number of machines’ is one of the three causes he offers for how increasing the division of labour raises labour productivity (*WN*: 17). Smith reiterates his view that the invention of machinery which enhances labour productivity ‘seems to have been *originally* due to division of labour, as labour specialization itself enables and encourages discovery of improved production methods, including invention of new machines: ‘One of the greatest improvements that has been made upon this machine [the steam engine], since it was first invented, was … the discovery of a boy who wanted to save his own labour’ (*WN*: 19–21; emphasis added; the *WN* editors at p. 21n indicate that the story Smith tells here is probably fictitious). However, Smith immediately goes on to add that new or improved ‘machinery’ has ‘by no means’ been entirely the invention of the users of machines. ‘Many improvements’ have been due to specialized producers of machines, distinct from users of them, and also to ‘philosophers or men of speculation, whose trade it is, not to do any thing, but to observe every thing; and who, upon that account, are often capable of combining together the powers of the most distant and dissimilar objects’. The making, improvement and invention of machines, and science itself, thus also become specialized functions within the societal division of labour as a whole, ‘and the quantity of science is considerably increased by it’ (*WN*: 21–22).2

Texts parallel to this division of labour and machines commentary in the opening chapter of *WN* can be found in *LJA*, *LJB* and *edWN*. In these three earlier texts (*LJA*: 345–47; *LJB*: 491–93, 521; *edWN*: 564–65, 567, 569–70) Smith goes rather more fully into how specialized labourers as machine users were induced to improve and invent machines (even slaves), but also affirms that more sophisticated machines were the invention of ‘philosophers’. There is an implication in the *WN* account that machine innovation by machinery users pertains particularly to early or relatively primitive technical progress (‘originally’), which is subsequently, at higher levels of development, at least partly superseded by progress due to innovation arising from machinery producers and science. This is also evident in the earlier texts:

That the *originall* invention of machines is owing to the division of labour is not to be doubted. One whose thoughts all center on one piece of work will be at pains to contrive how to do this in the cleverest and easiest manner.

(*LJA*: 350–51; emphasis added; similarly, *LJB*: 492–93)

In *edWN* (569) Smith is more tentative: division of labour ‘probably’ induced ‘the invention of the greater part of those machines’.

The invention of new machinery or its introduction into production are discussed further in *WN*. There is in particular frequent reference to new machines as labour-saving and/or cost-reducing devices (*WN*: 104, 209, 260–61, 263, 277, 282, 287–88, 343, 676, 684). The actual introduction of new machines that reduce direct labour input required per unit of output, certainly under competitive conditions, entails also that the innovations are cost-reducing, otherwise they would not be introduced.3 In his commentaries on such labour-saving innovations Smith sometimes asserts that they are both labour-saving and cost-reducing, and presumably takes this for granted in those instances where he does not say so explicitly, since it follows so straightforwardly from his own theory that they would not otherwise be introduced. In the context of one discussion of labour-productivity-enhancing machines, he is very explicit: ‘The expence which is properly laid out upon a fixed capital of any kind, is always repaid with great profit, and increases the annual produce by a much greater value than that of the support which such improvements require’ (*WN*: 287). While this is primarily about social benefit in terms of augmenting society’s net product, that it also applies at the level of the individual producer is evident from this further comment: ‘When any expensive machine is erected, the
extraordinary work to be performed by it before it is worn out, it must be expected, will replace the capital laid out upon it, with at least the ordinary profits (WN: 118).4

The further, remaining ideas in relation to machines in Smith’s political economy may be noted briefly. In kinship with his idea of skilled labour as accumulated human capital (our term), Smith likens an educated worker to an ‘expensive machine’; the resulting ‘improved dexterity’ is akin to ‘a machine … which … abridges labour, and which, though it costs a certain expence, repays that expence with a profit (WN: 118–19, 282; cf. 684 on slaves as machines, and similarly, LJB: 526). An ‘improved farm’ is also likened to a ‘useful machine’ (WN: 282). Naturally enough, he recognizes also that the increase of sophisticated and extensive division of labour in the production of commodities in general, and accompanied in general by innovation in machinery, applies as well to the production of machines themselves (WN: 23; edWN: 562). Introduction of machines cheapens the commodities produced by those machines, and likewise, the cost of machines or of their upkeep can be reduced (WN: 287–88, 291, 296). Perhaps most significant among these further ideas is an insight in the Introduction to Book II, that the simplification of labour activity, associated with increasing division of labour – one may say, the rendering of labour activity more repetitive, mechanical, or literally machine-like – itself opens up increasing opportunities for replacing labour activity with machines: ‘as the operations of each workman are gradually reduced to a greater degree of simplicity, a variety of new machines come to be invented for facilitating and abridging those operations’ (WN: 277; cf. Aspromourgos 2009: 139). There is really an intimating of this idea also in the likening of educated workers to ‘expensive’ machines, and of improved labour dexterity to a new labour-saving machine, and the comparison of slave production and machine production (WN: 118–19, 282, 684). It is clearly enough implied as well in other commentaries concerning division of labour and machines, quoted and cited above (this section, first two paragraphs).

Finally, what concrete examples of ‘machines’ used in production does Smith offer in his economic analyses? He provides quite a few, and these make evident that he includes under the term even very primitive non-labour instruments of production, which would now rather be called mere ‘tools’. Here is a quite comprehensive list of non-labour production inputs explicitly characterized as machines:

‘fire-engines’ (WN: 20; i.e., steam engines); ‘ship’, ‘mill of the fuller’ (fulling: gathering or pleating cloth), ‘loom’, ‘shears’ (WN: 23); ‘spinning-wheel’, ‘fulling mill’, ‘wind’ and ‘water mills’ (WN: 263); tailors’ ‘needles’, an ‘iron-work’, including the ‘furnace’, ‘forge’ and ‘slit-mill’ (machine for cutting iron into rods, nails and so on), and ‘the machinery … for drawing out the water and for other purposes’ in mines (WN: 279–80); ‘wind or a water milne’ (mill, probably for corn in particular; LJA: 85); ‘plow’, ‘hand-mills’, ‘wind or water mill’, ‘drill plow’, ‘fire engine’ (LJA: 346–47, 351); weighing scales (LJA: 370); ‘plow’, ‘water miln’, ‘hand miln’, ‘fire machines’ (evidently steam engines), ‘wind and water-milns’ (LJB: 492); carpenter’s ‘plane’ (LJB: 526); ‘loom’, ‘mill of the fuller’, ‘sheers of the clipper’, ‘plough’, ‘wind or water mill’, ‘hand mills’, ‘drill plow’ (edWN: 562, 569); ‘condensing engine’ (steam engine or air pump, probably the latter in this context; EPS: 139); James Watt’s ‘copying machine’ (Corr: 248).

Also characterized as machines are a variety of military weapons, from ‘cannon’, ‘mortar’, and ‘catapulta’ down to ‘javelin’ and ‘bow and arrows’ (WN: 708); ‘clocks and watches’ (WN: 139–40); watches, carriages (implicitly) and ‘a machine for cutting … [human] nails’ (TMS: 180–82); ‘wind-gun’ (device for shooting missiles by the force of compressed air; EPS: 139). Smith’s demarcation of the elements of fixed capital (WN: 282) implies that buildings used in production are not regarded as machines, though he says they are akin to ‘machines and instruments of trade’, as also are land improvements and acquired labour skills. The corollary of that fourfold demarcation – if treated strictly, as constituting the mutually exclusive and collectively exhaustive elements of fixed capital – is that any production inputs nominated by Smith as
elements of fixed capital which are not buildings, land improvements or acquired labour skills are implicitly 'machines and instruments'.

Elsewhere, though without explicitly recourse to the terms 'machine(s)' or 'machinery', Smith's references to engines amount also to instances of machines: 'engines for drawing out ... water' from mines, and also by implication here, the 'iron forge' and 'smelting-house' (WN: 307); 'frames or engines for knitting gloves or stockings', as well as (implicitly) 'utensils made use of in the cotton, linen, woollen and silk manufactures' (WN: 659); 'fire-engines' (LJA: 349; edWN: 570, 574; Meek, Raphael and Stein 1978: 582); and there is a reference to 'mechanical engines' in the abstract (LRB: 223, discussed in sec. 3 below). There is also a reference to 'warlike engines', with the concrete examples of 'battering rams, balistae (kinds of giant crossbow for propelling missiles), catapultas', and associated 'skifful [sic] engineers' (LJA: 232–33). Under 'Army' in the index of WN (1022; the index is from the 3rd edition of the book) there is a sub-entry, 'Is the speediest engine for civilizing a barbarous country', referring to page 706. The term is not used there, a 'well-regulated standing army' being characterized as 'the instrument' for civilizing a barbarous country. 'Mechanicks', 'mechanick trades', 'mechanical arts', and variants, are frequently used to refer to species of labour. 'Clergy' in the index has a sub-entry, 'Curates worse paid than many mechanics'; at the relevant pages the discussion is in terms of 'master mason', 'journeyman mason' and 'journeyman shoemakers' (WN: 146–47, 1030). Introduction of new machinery is also articulated as 'improvements in mechanicks' (WN: 287, 296). Under 'Watch movements' in the index there is a single entry concerning price reductions due to 'mechanical improvements', the text using this example to illustrate cost reductions associated with introduction of labour-saving new 'machinery' (WN: 260, 1078). Under 'Woollen cloth', again, there is a sub-entry concerning 'mechanical improvements', and the text there also discusses new 'machinery' and 'machines' (WN: 263, 1079).

2. Nature as Machine

One rather original psychological principle which Smith enunciates in TMS is the idea that things are approved of, not only in proportion to their fitness in meeting the purposes for which they are intended, but also for the sake of their fitness as such, a distinct and further aesthetic value. The 'fitness of any system or machine to produce the end for which it was intended' gives it 'propriety and beauty'. But 'this fitness, this happy contrivance' is 'often ... more valued, than the very end for which it was intended'; the exact adjustment of the means for attaining any conveniency is 'frequently ... more regarded, than that very conveniency' (TMS: 179). As Raphael and Macfie (1976b: 14) put it, '[u]seful means are valued first for the ends at which they aim, but then we are charmed by the beauty of their own sheer efficiency'. Smith goes on to argue that this principle informs also economic motivation, characterized here as involving an element of human self-deception, which leads into the one 'invisible hand' reference in the book (TMS: 180–85). The significance of efficiency as an aesthetic value is captured in the phrase, 'the system, the machine or oeconomy by means of which' an end is produced (TMS: 183; emphasis added), which connects also with the concept of 'the economy of nature' (TMS: 77; Aspromourgos 2009: 11–12, 59–61). Machines figure in Smith's commentary here; but for our purpose it more importantly serves to cast light on references to natural and other phenomena as machine-like, both elsewhere in TMS and in other texts.

At a number of points in TMS the universe itself is characterized as a machine. Smith discusses the notion of the 'divine Being', the 'administrator and director', 'the great Conductor', who contrives and conducts 'the immense machine of the universe' to produce 'the greatest possible quantity of happiness', 'the prosperity of the universe' (TMS: 235–36). In relation to the logic of Stoic morality, he speaks of how 'all, even the smallest of the co-existent parts of the universe', 'all, even apparently the most insignificant of ... events', are conceived of as 'exactly fitted to one another', in 'one immense and connected system', are 'all
essentially necessary’ to the ‘prosperity’, ‘continuance and preservation’ of ‘the whole machine of the world’, resulting from the ‘arrangement and contrivance of the whole’ by its ‘all-wise Architect and Conductor’ (TMS: 289). Similarly, earlier in TMS (19) Smith mentions in passing ‘the various appearances which the great machine of the universe is perpetually exhibiting, with the secret wheels and springs which produce them’. Hence the theme of the fitness of machines for their purposes, elsewhere used to illustrate the aesthetic value of fitness or efficiency as such (TMS: 179–81, as discussed immediately above), is in these passages paralleled by the fitness of the universe, likened to a machine, for its purposes – which at core is the economy-of-nature concept. In this same spirit, ‘the mechanism of a plant, or animal body’ is supposed as exemplifying how ‘in every part of the universe we observe means adjusted with the nicest artifice to the ends which they are intended to produce’ (TMS: 87). In the ‘History of Astronomy’, ‘mechanical principles’ are approvingly cited in relation to natural science (EPS: 79, 101, 103; also EPS: 245; LJA: 354).

3. Human Phenomena as Machine-Like

In his ‘History of the Ancient Physics’ Smith offers a conjecture on the natural origins of monotheism. In early human history the incomprehensibility of nature rendered alien the idea of ‘an universal mind, of a God of all, who originally formed the whole, and who governs the whole by general laws’. But once ‘philosophers’ discovered, ‘or imagined they had discovered’, ‘the chain which bound all her [Nature’s] different parts to one another’, once ‘the Universe was regarded as a complete machine, as a coherent system, governed by general laws, and directed to general ends, viz. its own preservation and prosperity, and that of all the species that are in it’,

the resemblance which it evidently bore to those machines which are produced by human art, necessarily impressed those sages with a belief, that in the original formation of the world there must have been employed an art resembling the human art, but as much superior to it, as the world is superior to the machines which that art produces. The unity of the system, which, according to this ancient philosophy, is most perfect, suggested the idea of the unity of that principle, by whose art it was formed … .

(EPS: 113–14)

There is a short step only between this conception of the universe as unified machine and the conception of human theories as machine-like, unified systems, reflecting that unity of the world, or its parts, as machine-like systems. Or at least theories are then easily conceived of as reflecting the human search for systematic and unified explanations for the appearances of the world. ‘System’ is a term Smith much uses as shorthand for an organized body of theoretical principles or explanatory ideas, aimed at an overall coherence of understanding. His likening of intellectual systems to machines in the ‘History of Astronomy’ leads him to provide an explicit definition of what an actual machine is: ‘a little system, created to perform, as well as to connect together, in reality, those different movements and effects which the artist has occasion for’. Hence also, intellectual systems ‘in many respects resemble machines’: ‘A system is an imaginary machine invented to connect together in the fancy those different movements and effects which are already in reality performed’.

There is also a parallel between the development over time of machines and of theory. The first machines for ‘any particular movement’ are ‘the most complex’, with subsequent development enabling ‘the same effects’ to be ‘more easily produced’, ‘with fewer wheels’ and ‘fewer principles of motion’. Similarly, the first theoretical systems are ‘always’ the most complex, with multiple explanatory principles; but ‘often’, subsequently, ‘one great connecting principle is … found to be sufficient to bind together all the discordant phaenomena that occur
in a whole species of things’ (EPS: 66–67). Hence the Copernican system, ‘like a more simple machine’ than the Ptolemaic system, ‘connected together, by fewer movements, the complex appearances of the heavens’; it rendered ‘the appearances of the heavens more completely coherent’, ‘by a more simple and intelligible, as well as more beautiful machinery’ (EPS: 73–74).

Theoretical progress is like technical progress, to the extent that the latter is embodied in simplification of machines. Scientific understanding also is akin to grasping, one may say, the invisible hands of causation behind the appearances of nature: ‘Who wonders at the machinery of the opera-house who has once been admitted behind the scenes?’ (EPS: 42; cf. Ross 1995: 167). Smith’s political economy is itself a more complete intellectual system, synthesizing and unifying earlier theory and doctrine (Stewart 1811: 322–23; Skinner 1996: 176–77).

Though less complete than that between the development of machinery and theory, Smith discerns also a parallel between the development of machinery and language. In his ‘Considerations Concerning the First Formation of Languages’ Smith conjectures that language over time becomes ‘more simple in its rudiments and principles’, as with ‘mechanical engines’, but proportionally also ‘more complex in its composition’. Elucidating the parallel, he here provides an expansive statement concerning the progressive improvement of machinery by simplification:

All machines are generally, when first invented, extremely complex in their principles, and there is often a particular principle of motion for every particular movement which it is intended they should perform. Succeeding improvers observe, that one principle may be so applied as to produce several of those movements; and thus the machine becomes gradually more and more simple, and produces its effects with fewer wheels, and fewer principles of motion.

(LRB: 223)

It is likewise with languages, except that the ‘simplification of machines renders them more and more perfect’, while the ‘simplification of the rudiments of languages renders them more and more imperfect … for many of the purposes of language’ (LRB: 224; emphasis added) – more prolix, less aurally attractive, and less capable of elegant expression (LRB: 224–26). The same argument appears more briefly in the ‘Lectures on Rhetoric’: languages ‘have made advances a good deal similar to those in the constructions of machines’; but ‘the simpler the machine the better, … the simpler the language the less it will have variety and harmony of sound and the less it will be capable of various arrangement: and lastly it will be more prolix’ (LRB: 13).

Finally, there are some instances of machine parallels in relation to ethics and political society. The tendency to approve the propriety and beauty of things fitted to their purposes, discussed in Part IV, chapter 1 of TMS (and by us, in the opening paragraph of section 2 above), is extended in the following chapter to the estimation and approval of human character and actions. When character is ‘fitted … to promote … the happiness both of the individual and of the society’, it has ‘at least all the beauty which can belong to the most perfect machine that was ever invented for promoting the most agreeable purpose’ (TMS: 187). Approval of this ‘beauty’ is akin to the ‘satisfaction with which we consider a well-contrived machine’ (TMS: 192; cf. 326–27, for the same parallel, in very similar language). Similarly, ‘human society’ itself, considered ‘in a certain abstract and philosophical light’, appears ‘like a great, an immense machine, whose regular and harmonious movements produce a thousand agreeable effects’:

As in any other beautiful and noble machine that was the production of human art, whatever tended to render its movements more smooth and easy, would derive a beauty from this effect, and, on the contrary, whatever tended to obstruct them would displease upon that account: so virtue, which is, as it were, the fine polish to the wheels of society, necessary pleases; while vice, like the vile rust, which makes them jar and grate upon one another, is as necessarily offensive.

(TMS: 316)
Already in Part IV, chapter I, Smith had also extended to the organization of political society, the idea of approving the fitness of things as such, independent of the desirability of their purposes:

The perfection of police, the extension of trade and manufactures … make part of the great system of government, and the wheels of the political machine seem to move with more harmony and ease by mean of them. We take pleasure in beholding the perfection of so beautiful and grand a system … . All constitutions of government, however, are valued only in proportion as they tend to promote the happiness of those who live under them. This is their sole use and end. From a certain spirit of system, however, from a certain love of art and contrivance, we sometimes seem to value the means more than the end, and to be eager to promote the happiness of our fellow-creatures, rather from a view to perfect and improve a certain beautiful and orderly system, than from any immediate sense or feeling of what they either suffer or enjoy.

(TMS: 185)

Stewart (1811: 322) reports a comment from a 1755 Smith manuscript (no longer extant): ‘Man is generally considered by statesmen and projectors as the materials of a sort of political mechanics’ (see also note 7 above).

4. Interpretation

Notwithstanding the views of some earlier commentators (cited in our opening paragraph above) there is very considerable, one may say abundant, textual evidence for the major and systematic role of machines, alongside division of labour, in Smith’s thinking about technical change and economic development. To be sure, increased labour specialization and introduction of new machinery are separable dynamics in principle, and the former is more prominent textually in *WN*; but they are very commonly coupled together by Smith as, in effect, two sides of the same coin in the process of labour-saving innovation. This conclusion, however, is subject to one important qualification. In suggesting limitations of Smith’s political economy with regard to the role of machinery, Campbell and Skinner (1976: 43, 48–49) speak of ‘mechanization’ (but without definition). The various production inputs which Smith explicitly refers to as machines, detailed in section 1 above, make evident enough that he includes under this term and concept elementary instruments of production which would now rather be characterized as mere tools (e.g., shears, needles, carpenters’ planes). The introduction of such ‘machinery’ is not what one has in mind when imagining a process of ‘mechanization’. So, innovation in machinery is certainly not much less important for technical change than labour specialization in Smith’s thinking; but the picture that emerges from his examples makes this innovation something less than mechanization as this would later and now be understood.

Of course, if, following the *Oxford English Dictionary* (‘mechanize’), one rather tautologically defines ‘mechanization’ merely as introducing machines into industrial processes, then the introduction into production of anything Smith characterizes as machines can, on his own terms, be regarded as mechanization. But if one conceives of mechanization in a somewhat stronger sense, as labour-saving technical change which also increases the machine-output or machine-labour ratio in production, then it is somewhat more questionable whether Smith has mechanization in this stricter sense in mind in his machine commentaries. But it is not all that questionable. He certainly has (direct) labour-saving constantly in mind. Furthermore, at least one of the commentaries concerning introduction of new machines implies clearly enough that the cost of the new machinery over its life, per unit of output, is higher than the machine costs previously were (*WN*: 118, discussed in sec. 1). This suggests mechanization in the somewhat stronger sense, and probably it is implicit in other Smith commentaries on machine innovation as well. In such situations the decision-maker must weigh increased machinery costs against lower wage costs, and possibly higher revenue, with a view to ascertaining whether the
(expected or actual) profitability of an innovation is sufficient to justify it. But in any case, it is not clear that any precise technological meaning attaches to ‘mechanization’ – either in terms of rising machine-output or machine-labour ratios – in an economic system subject to ongoing technical change, in which (direct) labour saving is occurring via introduction of new machinery, as well as cheapening of machines themselves.

There is, however, a further and even stronger conception of mechanization worth considering – ‘automation’, in the sense of production processes that operate more or less autonomously with respect to labour. The significance of the machine in Smith’s political economy does not really rise to this benchmark as to what constitutes mechanization. One may even go so far as to suggest that there is a qualitative difference between the role of machinery in Smith’s conception of technical progress and later conceptions connected with automation. The contrast can be illustrated by way of the distinction made by Marx (1967: 371–86, 418–27), between a notion of machine production in which machines control the labour activity of workers, as against production systems in which machines are mere tools of human labour, controlled by workers. Nevertheless, even with respect to this standard, Smith’s insight (noted in sec. 1 above) that simplification of labour activity in the process of division of labour opens up increasing possibilities of substituting machines for labour activities points towards automation. Babbage (1835: 169–75) draws attention to this aspect of Smith’s treatment of division of labour. Having outlined ‘the principles usually assigned as the causes of the advantage resulting from the division of labour’, including its ‘suggest[ing] … the contrivance of tools and machinery to execute its processes’ (original emphasis), Babbage (1835: 173–75) concludes that all these principles together can be summarized ‘in the words of Adam Smith’:

This great increase of the quantity of work, which, in consequence of the division of labour, the same number of people are capable of performing, is owing to three different circumstances; first, to the increase of dexterity in every particular workman; secondly, to the saving of the time which is commonly lost in passing from one species of work to another; and lastly, to the invention of a great number of machines which facilitate and abridge labour, and enable one man to do the work so many.

\[WN: 17\]15

The significance of ‘simplification’ – in the instance reiterated in the last paragraph, the significance of labour simplification for innovation in machinery – is one important unifying idea in the parallels Smith draws between actual machines and other phenomena. For Smith, simplification in a variety of phenomena enhances power, so to speak, in some sense or other. Simplifying labour activity increases labour productivity via enhancement of labour dexterity, as well as increasing the scope for machines to replace labour. It is a fairly natural accompaniment to this idea that machines also can become progressively simpler in the course of technical progress: ‘improvements in mechanicks, as enable the same number of workmen to perform an equal quantity of work, with cheaper and simpler machinery’ (WN: 287). Similarly, scientific advance – the development of superior theories or theoretical systems – is associated with progressively ‘more simple’ theories, ‘like a more simple machine’ (EPS: 71, 73).16 Note also in this context that the labour productivity benefits of division of labour are applied by Smith also to intellectual division of labour among the sciences (WN: 21–22; LJA: 347; LJB: 492; edWN: 570, 574). Perhaps by implication from this, the progress of science is associated not only with scientific theory becoming simpler, but also scientific work. This is nowhere explicitly said but there is explicit appeal to improved dexterity of scientists (WN: 22; LJB: 492; edWN: 570). The development of languages is associated with grammatical simplification, though in this case the parallel is less than complete, with some linguistic disadvantages arising as well (LRB: 13, 220–24). The simplification principle is not, however, applied to nature as machine, presumably because, in accordance with the economy-of-nature notion, the universe is already perfected, in some sense, and incapable of improvement. Nor is it applied to human society. But the constitution of competitive commercial society, the ‘system of natural liberty’, is characterized...
as 'simple' (*WN*: 687), and the 'simple regulations' of police in London are favourably contrasted with the 'numerous' regulations of Paris (*LJB*: 486). There is also an aesthetic of simplicity in relation to language and literature (e.g., *TMS*: 217, 252, 291; *LRB*: 33).

The dynamic of progressive simplification is not, however, the most important unifying idea in Smith’s parallels between machines and other phenomena. The primary, generic idea informing the understanding of all these paralleled phenomena – the core notion unifying their meaning – is *system*. Hence Smith’s definition of actual machines makes them ‘little system[...]* (*EPS*: 66; quoted more fully, sec. 3 above).11 One may ask of Smith’s machine parallels, are they mere metaphors in the sense of rhetorical decoration, or are they analogies which provide a degree of explanation by supposing that phenomena operate in a manner akin to an already understood phenomenon, the machine (see Cremaschi 2002: 90–91, 107, 109–10)?2 They deserve to be characterized as analogies, but the more important truth is the common bond of ‘system’ – an abstract notion of an ordered, coherent structure more or less efficiently fitted for some definite end or purpose. This is what all these phenomena actually are for Smith, with machine the preferred concrete analogy for illuminating his notion of system. The proposition that Newtonian or mechanical philosophy was Smith’s model for good science has been well challenged (Redman 1997: 207–58; Montes 2003, reproduced in Montes 2004: 130–64). Lindgren (1969: 899; also 906–07, 909–10) has even argued for ‘language, not mechanics, as the model of inquiry’. As against this dichotomy, our diagnosis here may suggest that for Smith, theories, both in natural science and in political economy, are particular instances of systems – of which language is the most fundamental from among those systems that are human artefacts (which include also actual machines, ethical codes, constitutions of societies, policy regimes, and so on).18

Purposive systems are what all the phenomena that Smith likens to machines actually are; but why then this particular choice of metaphor or analogy? Perhaps, as Cremaschi (2002: 90) suggests, it is silently based on the dictum that the things humans (really) know are the things they make, so that for the benefit of his audiences, Smith treated machine as the most intuitively intelligible form of system. (Cremaschi actually speaks of ‘technology’.) One may conjecture that it is also attributable to Smith’s great enthusiasm for the machine, an enthusiasm due particularly to his having grasped its importance in technical progress, labour productivity growth and economic development, and for the associated ‘general opulence’ that he predicted, in competitive commercial society, would filter high and rising consumption down to all (Aspromourgos 2009: 205–14): ‘useful machines’ (*WN*: 279, 282–83), ‘ingenious machines’ (*WN*: 263; *edWN*: 569; *EPS*: 139), ‘beautiful machines’ (*WN*: 139; *TMS*: 186–87, 316; *EPS*: 74). They were tangible expressions of human progress. A comparison of all this in Smith with the limited role of technical change in the economics of contemporaries such as François Quesnay, Anne Robert Jacques Turgot and James Steuart would serve only to throw into sharper relief the significance of the machine in Smith’s economics, even allowing the qualification that machines for him include mere tools. Smith seems to have had also some direct exposure to important eighteenth-century engineering developments, notably, those of James Watt, who was employed at the University of Glasgow during Smith’s time there (Thorpe 2007: 127–29).19 He is alleged to have even characterized himself as a machine, in 1790, albeit one by then ‘breaking down’ (Ross 1995: 403; cf. 374; Bryce 1983b: 32–34).

NOTES
* Faculty of Economic and Business, University of Sydney, Sydney NSW 2006, Australia. Email: tony.aspromourgos@sydney.edu.au. The author is indebted to … for comment, without thereby implicating any of them in the final product.
1. The six volumes of the Glasgow Edition of Smith’s works are referred to throughout by the usual abbreviations: *TMS* (Raphael and Macfie 1976a), *WN* (Campbell, Skinner and Todd 1976),
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*EPS* (Wightman, Bryce and Ross 1980), *LRB* (Bryce 1983a), *LI* (Meek, Raphael and Stein 1978), *Corr* (Mossner and Ross 1977), respectively. *LJA* and *LJB* are used to distinguish the two sets of lecture notes on jurisprudence in the fifth volume; *edWN* refers to the ‘Early Draft of Part of The Wealth of Nations’, also in that volume.


3. Direct labour input is to be distinguished from the labour input directly and indirectly required, the latter including the labour embodied in other produced inputs, including the machines themselves. When Smith speaks of reducing labour input, he seems, clearly enough, to intend only direct input.

4. Recall in this context that wages (of productive labour) are part of capital in Smith’s political economy (Aspromourgos 2009: 163). Note also that fixed capital for him does not consist only of physical labor (as Smith (1940: 720), LJB (412) and *Corr* (299, 306).

5. But Smith says only that fixed capital consists ‘chiefly’ of these four elements (*WN*: 282). Strict application of the fourfold demarcation would make seed corn a machine or instrument, though this is really, rather, symptomatic of the inappropriateness of his categorizing seed as fixed capital (*WN*: 281). Other slight references to machines, of an economic nature, occur at *WN*: 253, 283, 288–89, 681, 685, 754 (concerning patents for new machines; also *LJA*: 11, 83; *LJB*: 472); *EPS*: 247.

6. *WN*: 119, 122, 140, 143–44, 348, 395, 397, 697; *LJA*: 101, 226, 256, 266, 308, 342, 376; *LJB*: 411, 413, 450, 527; *edWN*: 574; Meek, Raphael and Stein 1978: 582 (‘First Fragment on the Division of Labour’); *EPS*: 247; *Corr*: 276. The term ‘mechanicks’ (coupled with ‘geometry’) is also used to refer to a branch of elementary education (*WN*: 785–86; also *Corr*: 61, 70) and ‘mechanical’ science (‘philosophy’) is referred to as one of the branches which emerges from the division of labour within science (*LJA*: 347; *LJB*: 492; *edWN*: 570). The latter is probably intended to convey something like mechanical engineering, or more fundamental science or mathematics of the motion of matter, or both; the references are too cryptic to be sure. There is also the reference to ‘mechanical engines’ in *LRB* (223). Slight references to engineers occur in *WN* (726), *LJB* (412) and *Corr* (299, 306).

7. Intellectual systems (however efficient and beautiful) and the human pursuit of ‘system’ can have a dark side as well, most notably, the ‘man of system’ (*TMS*: 231–34), and further below this section. False intellectual systems are much discussed throughout Smith’s corpus (not least, ‘the mercantile system’).

8. Invisible chains of causation is a metaphor often employed by Smith, and connects with his notion of the invisible hand (Aspromourgos 2009: 337). See in particular ‘the invisible hand of Jupiter’ (*EPS*: 49).

9. Elsewhere in *TMS*, Smith speaks in passing of ‘the mechanism by which nature produces’ certain human sentiments of approbation and disapprobation (93); of how, in certain instances, self-command is produced ‘as it were, mechanically’ (143); and of the ‘contrivance or mechanism within’ to which various principles of approbation are imputed (315). In *LRB* (65) there is a mere fragmentary phrase in the text (‘[remember mechanickall part whi]’) – consequently, entirely obscure as to its significance.

10. The parallel continues to the next page:

   all the several wheels of the machine of government ["might"] be made to move with more harmony and smoothness, without grating upon one another, or mutually retarding one another’s motions … to put into motion so beautiful and so orderly a machine.  

   (*TMS*: 186)

Earlier in the same chapter Smith speaks also of ‘[p]ower and riches’ as ‘enormous and operose machines’ (*TMS*: 182). In *WN* the Bank of England is described as ‘a great engine of state’ (320); import restrictions and export encouragement are characterized as the ‘two great engines’ of the mercantile system, for enriching a country (450, 642); and monopoly ‘of one kind or another’ is called ‘the sole engine of the mercantile system’ (630).

Mayr (1986: 106) downplays these references as ‘neither analogies nor metaphors … rather they were shopworn figures of speech’, citing *TMS*: 185–86; *WN*: 450, 630, 642. But he has not
at all placed them in the larger context of all Smith’s machine parallels – a strange omission in view of the central theme of Mayr’s book. (His detailed discussion of Smith at pp. 171–80 does not address the role of the machine in his thought.) Mayr also suggests that at least these particular wheel and engine references were ‘chosen precisely for their ambiguousness to refer to subjects for which the writer had no affection’: the machine-like State as the (undesirably) authoritarian State (p. 106; also 135). In fact society-as-machine is by no means such an unqualified negative notion in Smith.

11. References by Smith to ‘wheels’, actual or metaphorical, aside from nine innocuous references to actual wheels, occur at *TMS*: 19, 87, 185–86, 816; *WN*: 263, 289* (money, ‘[the] great wheel of circulation’), 291–92, 296, 625* (‘the wheel of the great state lottery of British politicks’); *EPS*: 60* (planetary motion as like ‘a little wheel inclosed within the outer circle of a great wheel’), 66–67, 71–72, 80* (a body ‘wheeling about both its own axis and the Sun’); *LRB*: 223; *LJA*: 319* (‘the wheels of … government’), 346; *LJR*: 492; *edWN*: 569–70. Thirteen of these eighteen instances actually occur in contexts where machines, mechanics or engines are discussed, so they have already been cited (the further five are starred above); and quotations given above, from seven of those thirteen, have included explicit reference to wheels.

12. Rising machine-output (or machine-labour) ratios, of course, are not synonymous with rising capital-output (capital-labour) ratios in the modern sense, even if one excludes wages from capital: apart from circulating capital there is also non-machine fixed capital. Note also that labour-saving technical change which is associated with a higher machine-output ratio is necessarily associated also with a higher machine-labour ratio, but the machine-labour ratio can be rising even if the machine-output ratio is falling. Eltis (1975, esp. 445–49; reproduced in 1984: 68–105, esp. 96–100) is equivocal concerning the behaviour over time of fixed-capital-to-output ratios in Smith’s theory, but there is no discussion of machines versus other elements of fixed capital (*cf.* n. 16 below).

13. The *Oxford English Dictionary* traces the term ‘automation’ back only so far as the late nineteen-forties. But Marx (1967: 381, 383, 418–20, 423) writes of production systems as ‘automaton[es]’, ‘automatic system[es]’ of machinery, and of ‘the automatic factory’, following Andrew Ure. Ure (1835: 15, 19, 22, 32, 368–69) speaks of the factory as a ‘complex automaton’, ‘automatic machinery’ (‘hardly known’ to Adam Smith), ‘self-acting machines’, and ‘the automatic organs’ of the factory. He defines the factory, strictly, as ‘a vast automaton, composed of various mechanical and intellectual organs, acting in uninterrupted concert for the production of a common object, all of them being subordinated to a self-regulated moving force’ (pp. 13–14).

14. Strangely, Young (1928: 530), on the other hand, denies that it is to be found in Smith:

It is generally agreed that Adam Smith, when he suggested that the division of labour leads to inventions because workmen engaged in specialised routine operations come to see better ways of accomplishing the same results, missed the main point. The important thing, of course, is that with the division of labour a group of complex processes is transformed into a succession of simpler processes, some of which, at least, lend themselves to the use of machinery.

Note also against Young’s statement, that the idea of labour simplification enabling perception of new machine possibilities does not require that these possibilities are perceived *only* by the labourers themselves, as Smith makes explicit (see sec. 1, first two paragraphs).

15. We here quote the Glasgow Edition; Babbage’s quotation, without citation, has two slight word differences and two differences of punctuation. It may be added that the degradation of the labourer which Smith discusses in *WN*, book V flows precisely from division of labour making labour activity machine-like (*WN*: 781–88; Aspromourgos 2009: 139–40, 146).

16. For explicit reference to division of labour and labour simplification, see *WN*: 15, 18, 20, 144, 277, 676, 781–82, 784–85; *LJA*: 345–46, 350–52; *LJR*: 491, 539; *edWN*: 568. For simplification of theory, see also *EPS*: 56, 67, 69, 74–76, 86–87, 140, 244–45. The idea of simpler (actual) machines being better machines is also implied and explicit in the parallels at *EPS*: 67, 73–74; *LRB*: 13 (‘[t]he simpler the machine the better’), 223–24 (‘simplification of machines renders them more and more perfect’). Smith’s observation about cheaper and simpler machines (*WN*: 287) incidentally indicates that while machine-output ratios may rise in the course of technical
progress (as discussed above this section), this is by no means inevitably so for him, and perhaps the contrary is more to be expected, given the notion of machine simplification. As mentioned in note 12, falling machine-output ratios are consistent with rising machine-labour ratios, when innovation saves direct labour.

17. Machines are identified with systems also at TMS: 179, 183, 185–86, 236–37, 289, 326–27; EPS: 73–74, 113–14. Compare with Ross (1995: 117), concerning the characterization of ‘the mechanized production unit’ as ‘the system’, from the late eighteenth century. A search of the CD-ROM of the Glasgow Edition, for ‘system’ and variants thereof, yields about 340 hits (not including editorial apparatus and indexes). This is the number of paragraphs in which the term or variants appear, so there are actually many more individual instances than that number.

18. Lindgren (1969: 909) asserts that ‘Smith did not … anywhere, suggest that systems imitate machines or vice versa’. But in relation to the latter, see again the definition of machines at EPS: 66. Lindgren (1973: 1–19) is a revised version of this paper. See also Christie (1987: 218–21) and Dascal (2006: 107–08).

19. On Smith and Watt, see also Corr: 248; Ross (1995: 146–47). The strong claim that Thorpe’s (2007) article seeks to sustain, that engineering principles play a substantial role in Smith’s social thought, is a considerable overstatement.

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