# Watt, Again? Boldrin and Levine Still Exaggerate the Adverse Effect of Patents on the Progress of Steam Power

George Selgin
Professor of Economics
Terry College of Business
University of Georgia
Athens, GA 30602
Selgin@uga.edu

John L. Turner*
Associate Professor of Economics
Terry College of Business
University of Georgia
Athens, GA 30602
jlturner@uga.edu

August 18, 2009

*Corresponding author. Prepared for the Center for Law, Innovation & Economic Growth conference on "The Economics and Law of Innovation," Washington University School of Law, April 2-3, 2009.

## I. Introduction

Michele Boldrin and David K. Levine's 2003 Lawrence R. Klein Lecture ended with a decidedly unfavorable account of James Watt's influence on the progress of steam technology. According to that account (Boldrin and Levine 2004, p. 348), although Watt's separate condenser constituted a "significant invention," by choosing to patent that invention in 1769, by having the patent extended by Parliament in 1775, and by aggressively prosecuting anyone who infringed the patent, Watt ultimately "set back the industrial revolution by a decade or two" (ibid., p. 349). Watt's story was therefore said to offer especially compelling support for Boldrin and Levine's claim that patents are "not only superfluous for, but also damaging to, technological progress and social welfare" (ibid., p. 332).

In a comment on Boldrin and Levine's lecture (Selgin and Turner 2006), we observed that their account of Watt's story contained many factual errors, most of which tended to exaggerate the negative consequences of Watt's patent; after reviewing the mistakes in some detail we concluded that it was "far from obvious" that a corrected account would support Boldrin and Levine's bold conjectures.

*Against Intellectual Monopoly* begins with a new version of Watt's story that claims to take our earlier criticisms into account. Here we assess that version and conclude that it shares many of the shortcomings of the original. Although Boldrin and Levine correct some of their previous factual mistakes, they leave others uncorrected; and where they do make corrections, they do so without

correspondingly moderating their original conclusions. Finally, the new version introduces several new inaccuracies calculated, like the original ones, to bolster Boldrin and Levine's thesis. For all of these reasons, we remain unconvinced of the validity of Boldrin and Levine's claim (2008, p. 4) that "The story of James Watt is a damaging case for the benefits of a patent system."

**II. Old Errors Repeated or Revised Half-Heartedly**

Although Boldrin and Levine (ibid., p. 11) thank us for having pointed out "factual mistakes and imprecisions" in their original article, their book repeats many of the same mistakes. Thus they continue to assert (ibid., pp. 1-3) that, after receiving his patent, Watt "remained ahead [of his rivals] not by superior innovation, but by superior exploitation of the legal system" and that "Many new improvements to the steam engine, such as those of William Bull, Richard Trevithick, and Arthur Wolff… were kept idle until the Boulton and Watt patent expired" in 1800. Rather than repeat the evidence contradicting these claims, we encourage interested readers to review our original criticisms, and to judge for themselves whether Boldrin and Levine have taken adequate account of them.

Where Boldrin and Levine do take our earlier criticisms into account, they often appear do so half-heartedly, and without allowing the criticisms to influence their conclusions. For example, in their original essay Boldrin and Levine (2004, p. 349) wrote that "in 1781, when the superior and independently designed Hornblower machine was first produced, Boulton and Watt went after him [Jonathan Hornblower] with the full force of the legal system—bankrupting and

ruining him in the process." Commenting on this passage, we observed (2006, p. 1344-5) first, that Hornblower's engine was not in fact "greatly superior" to Watt's; second, that Boulton & Watt[1] took no legal action at all against Jonathan Hornblower until 1792; third, that rather going after him then "with the full force of the legal system" they merely opposed, successfully, his bid to have his 1781 patent extended; fourth, that the only Hornblower Boulton & Watt ever sued was Jonathan's brother, Jabez Carter, in an action begun in 1796 (ibid., p. 1345) ; and, finally, that Jonathan Hornblower's eventual bankruptcy was due, not to his having been ruined by Boulton & Watt, but by his futile attempt to build an engine that could both pump water and turn machinery. We documented each of these claims.

Perhaps in response to the above criticisms, Boldrin and Levine now write (2008, p. 1, our emphasis), "*In the 1790s*, when the superior Hornblower engine was put into production, Boulton and Watt went after him with the full force of the legal system." The revision does away with the troublesome gap separating Jonathan Hornblower's original invention from the only action taken against him as part of Watt's supposedly relentless legal persecution of his rivals. But it does so by fabricating a new myth, to wit: that Hornblower's engine, which he patented in

[1] Following standard practice, except when quoting Boldrin and Levine (who do not do so), we use "Boulton & Watt" to refer to the steam engine company, and "Boulton and Watt" to refer to the two partners themselves.

1781, was not "put into production" until the 1790s. In fact Hornblower erected his first compound engine at the Radstock colliery in 1782.[2]

Apart from substituting "In the 1790s" for "in 1781," Boldrin and Levine make one other change only to their original passage on Hornblower, by dropping the reference to Boulton & Watt "bankrupting and ruining" him. Given our original criticisms the omission would represent a real improvement were it not for a footnote (n. 5) to the new version declaring that "[w]ith the 1799 judicial decision against him [sic], Hornblower had to pay Boulton and Watt a substantial amount for past royalties, while losing all opportunities to further develop the compound engine." This is hardly an improvement. First, it was not Hornblower (whether Jonathan or Jabez) but owners of Boulton & Watt engines who found themselves owing back royalties to Boulton & Watt, after having withheld those royalties in the hope that Watt's patent would be struck down. Second, because Watt's patent was due to expire in 1800, the validation of Watt's patent the year before cannot have prevented Jonathan Hornblower from renewing work on his engine except perhaps for a matter of months.

To the extent that Boldrin and Levine do substantially revise their story, they fail to make corresponding changes to their conclusions. Consider, for

[2] In a footnote, however, Boldrin and Levine (2008, p. 13 n. 5) seem to revert to their original claim, observing that "Boulton and Watt challenged his [Hornblower's] invention, claiming infringement of their patent because Hornblower [sic?] engine used a separate condenser" immediately after having stated that the invention in question "was patented in 1781." Besides ignoring the long interval between Jonathan Hornblower's patent and any legal challenge by Boulton & Watt, this passage wrongly asserts that Hornblower's original engine employed a condenser. It did not; and that is probably why Boulton & Watt didn't sue him. [Cf. Devon & Cornwell Notes & Queries 1921, p. 15; Dickinson and Jenkins 1927, p. 304.]

example, their original claim (2004, p. 349) that Watt's patent "set back the industrial revolution by a decade or two." Although Boldrin and Levine never explain precisely how they arrived at this estimate, it was presumably based on the "explosion" in steam engine numbers and horsepower following the expiration of r Watt's patent, which (according to their thesis) would have taken place long before had it not been for Watt's monopoly. Logically, one would think that, the more dramatic the "explosion" of improvements after Watt's patent expired, the greater the extent of the delay in industrialization attributable to that patent.

Previously we showed (2006, pp. 1346-7) that Boldrin and Levine's original conclusions were based on discredited engine number and horsepower statistics, and that more reliable statistics pointed to a far less dramatic post-1800 "explosion" in steam power. More reliable statistics, reported in Kanefsky (1979) and Kanefsky and Robey (1980), imply an average annual increase in steam engine numbers prior to 1800 that is about 20 percent *higher* than that reported in Boldrin and Levine (2004), and an average annual increase in total engine horsepower after 1800 that is *less than a third* as great as Boldrin and Levine's original figure.[3]

In *Against Intellectual Monopoly*, Boldrin and Levine revise their statistics according to our suggestions (Table 1). So far, so good. But whereas logic would seem to dictate that they also lower their original estimate of the number of years by which Watt's patent delayed British industrialization, they do no such thing.

[3] As we note in the table, although Boldrin and Levine (2004) does not include a horsepower estimate for 1800, a 2005 draft of "Against Intellectual Monopoly," in which reported statistics are otherwise the same as those in Boldrin and Levine (2004), does so.

Instead, they reach the less imprecise but hardly less temperate conclusion that Watt's patent retarded British economic development by "about 16 years" (Boldrin and Levine 2008, n. 5).[4] We are led to conclude, in consequence, that Boldrin and Levine's claim regarding the effects of Watt's patent on the pace of British industrialization is only loosely based on the statistics used to sustain it.[5]

Boldrin and Levine's revised claims concerning the more rapid growth of steam power after 1800 also ignore our (2006, p. 1347) observation that *exponential* horsepower growth, derived using Kanefsky's (1979) data and plotted below (along with linear growth) in Figure 1, shows no post-1800 "explosion" at all. Instead, the horsepower growth rate increases only slightly between 1760-1800 and 1800-1830, with a more substantial increase for the period 1830-70. This delayed and very slight acceleration contradicts Boldrin and Levine's "blocking power" thesis. It is, on the other hand, consistent with an alternative view that attributes the late acceleration of horsepower growth mainly to a gradual decline in the actual and perceived riskiness of high-pressure steam engines.[6]

Because Boldrin and Levine supply no reasons for not heeding our suggestion that they consider exponential growth rates, we can only assume that they see no grounds for treating technological growth as being "naturally" exponential. Grounds do, nevertheless, exist. They have been most famously

[4] Boldrin and Levine (2008, p. 3) also repeat their original claim, only put as a question: "Was Watt's patent a crucial incentive needed to trigger his inventive genius? Or did his use of the legal system to inhibit competition set back the industrial revolution by a decade or two?" That the question is intended to be rhetorical is evident from the surrounding text.

[6] See Selgin and Turner (2009).

articulated by Ray Kurzweil (2001), whose treatment of technological change as "an evolutionary process where the outputs of the process are used as inputs in the next phase of development" (Tuomi 2003, p. 3) appears to fit steam power quite well. An exponential view of technology growth is, moreover, also implicit in the "cumulative" view of research and invention that informs modern discussions of the economics of patents (e.g. Scotchmer 1991), including that of Boldrin and Levine themselves. Finally, models of "endogenous" technological change (e.g. Aghion and Howitt 1992 and Grossman and Helpman 1991) typically link such change to population growth, and British population growth during the Industrial Revolution was itself notoriously exponential.[7]

**III. The "Break Even" Question**

In some instances Boldrin and Levine take advantage of our original criticisms, not to correct, but rather to *compound*, their previous errors. For example, instead of taking seriously our criticisms of their original arguments to the effect that Boulton & Watt would have broken even without any extension of Watt's patent, they claim that we inadvertently "make [their] case quite convincingly":

> Quoting F. M. Scherer they [Selgin and Turner] assert that seventeen years before the second patent expired they, Boulton and Watt, were already breaking even....Whatever profits Boulton and Watt made after that, were all extra rents due to their opportunity costs. So, we all agree that, at least for the final 17 years, the patent was not serving a useful economic purpose,

[7] "[I]n the second half of the [18th] century, British population moved into an exponential mode of growth which exceeded 10 percent per decade for the period 1781-1911—its peek rise of 17 per cent being reached in the decade ending 1821" (Deane 1996, p.25).

> hence it was damaging because it created monopoly distortions (Boldrin and Levine 2008, pp. 11-12).

With all due respect to Boldrin and Levine, we do not agree with them at all. As a minor point, neither we nor Scherer ever state that Boulton & Watt broke even in 1783. The phrase we actually use is "in the mid-1780s" (Selgin and Turner 2006, p. 1343; compare Scherer 1965, p. 183, n. 46). More importantly, and as we insisted in the very passage from which our "break even" remark was taken, whatever Boulton & Watt's actual break even date was, that date must not be confused with the date on which the firm would have broken even *without* Watt's patent.

The really crucial question, though (as we also insisted in our original comments) is not whether Boulton & Watt would have broken even without a patent but whether or not the partners *expected* to be able break even without one. Of course it's true, as Boldrin and Levine (2008, p. 11) observe, that Watt's patent "was not serving any economic purpose" after Boulton & Watt broke even. But at most this fact supplies grounds, not for regretting Watt's original patent, or even its 1769 extension, but for wishing that the patent might have been voided *ex post facto*—a procedure the merits of which hardly seem to require comment.

Boldrin and Levine (2008, p. 4) appeal to Scherer's work again in claiming that their view concerning the dispensability of Watt's patent is "neither new nor particularly original." Referring to Scherer as a "prestigious academic supporter of the patent system," they quote him as follows:

> Had there been no patent protection at all,..Boulton & Watt certainly would have been forced to follow a business policy quite different from that which they actually followed. ... The alternative would have been to emphasize manufacturing and service activities as the principal source of profits, which in fact was the policy adopted when the expiration date of the patent of the separate condenser drew near in the late 1790s... . It is possible to conclude more definitely that the patent litigation activities of Boulton & Watt during the 1790s did not directly incite progress... .Boulton & Watt's refusal to issue licenses allowing other engine makers to employ the separate-condenser principle clearly retarded the development and introduction of improvements (ibid., pp. 4-5).

A careful reading of Scherer, however, reveals a very crucial difference between him and Boldrin and Levine that the quotation above masks. For Scherer recognizes that Watt's patent played an important part in helping him to secure funds for his invention, and, in particular, that Matthew Boulton probably would not have gone into partnership with Watt had Boulton not been able to secure the patent's extension. Regarding the latter point, Scherer (1965, p. 184) observes that Boulton's partnership with Watt

> did not begin formally until after the extension had been enacted, and its termination date was set as the extended patent's expiration date. Thus there are reasonable grounds for inferring that Boulton's decision to invest in the project was influenced by the certainty of at least some patent protection, if not by the possibility of extended protection. In this case the grant of a patent monopoly was a probable incentive for investment in technological innovation, although not an incentive for invention.

This view is certainly distinct from Boldrin and Levine's (2008, p. 4) claim that patents, once secured, serve only "to prevent economic progress and hurt competitors."[8]

Boldrin and Levine obscure the difference between their views and Scherer's both by failing to quote the passage above and by omitting, in the passage they do quote, a crucial qualifying clause. In its entirety the opening sentence of the passage they quote reads: "Had there been no patent protection at all, *and had Boulton nonetheless invested in the steam-engine venture,* Boulton & Watt certainly would have been forced to follow a business policy quite different from that which they actually followed" (Scherer, 1965, pp. 184-85; emphasis added). Given Scherer's own doubts as to whether Boulton would have invested in Watt's engine without extended patent protection, it seems wrong for Boldrin and Levine to place as much confidence as they do in their counterfactual claims concerning how Boulton & Watt would have fared without a patent. Instead, the partnership plans might have fallen through altogether, with Boulton returning his attention to his other manufacturing activities, and Watt abandoning steam engines once and for all to work as a land surveyor. This no-less plausible counterfactual hypothesis points to a rather different verdict concerning the extent to which Watt's patent was counterproductive.

[8] It bears repeating as well that Watt obtained his original financing, from John Roebuck, in return for granting Roebuck a two-thirds stake in his patent.

## IV. New Errors

### IV.1. The Compound Engine

Boldrin and Levine's new version of Watt's story includes some errors not found in the original. For example, Boldrin and Levine claim (2008, p. 4) that Jonathan Hornblower's compound engine, rather than the Boulton & Watt single cylinder type, "was the basis for further steam engine development after their [Boulton & Watt's] patents expired," and the related claim that Arthur Woolf's 1804 "revival" of Hornblower's design "became one of the main ingredients in the (post-1800) efficiency explosion" (ibid, p. 4, n6). Neither claim is true. Although Woolf's engine gained some adherents in Cornwall, by the mid 1820s even they had rejected it in favor of Trevithick's single cylinder design, which was found to be substantially less expensive, just as efficient, and more reliable (Hill 1989, pp. 108-9; Forrest 1864, pp. 77-8; Galloway 1881, p. 192n; Pole p. 53).[9] Neither could Woolf's engine have played much of a role in the post-1800 efficiency "explosion," both because it was never all that popular, and because the "explosion" (assuming that's the right term) was most pronounced after the mid 1830s, when a concerted switch to truly high-pressure (>100 psi) engines finally began.

### VI.2. Pickard's Patent

[9] Unlike Trevithick Woolf refused to give up on cast iron boilers, which were prone to cracking at pressures above 60 psi.

Although Woolf's design was altogether abandoned for pumping engines, a few rotary engines employing it remained in use after the 1820s (Pole p. 53 n.27). [9] Staring in 1839 James Sims attempted a British revival of the compound engine, using a version of his own design. But it, too, was eventually found to be less economical than rival single-cylinder designs; by 1863 most of Sims's engines had been dismantled (Forrest 1864, p. 48).

Boldrin and Levine argue (2008, p. 2) that, because James Pickard had patented the most obvious means for converting reciprocating to rotary motion, "involving the combined use of a crank and a flywheel," Watt was obliged "to contrive an alternative less efficient mechanical device, the 'sun and planet' gear," and that "[i]t was only in 1794, after the expiration of Pickard's patent that Boulton and Watt adopted the economically and technically superior crank." Elsewhere (ibid., p. 1) they state that the idea of using a crank had been "unfairly anticipated" by Pickard's partner, Matthew Wasborough, and (ibid., n. 3) that their view "[t]hat Pickard's patent was unjust is also the view of Selgin and Turner…who, like Watt, do not seem to provide any evidence of why this was so."

First of all, concerning whether Pickard's patent was "unjust," we never employed that term. However, we did relate the well-known story of how Pickard got the idea of using a crank from an unfaithful (and probably drunk) Soho employee. We also cited a reputable source for the story (Dickinson and Jenkins 1927, pp. 148-56), and added a footnote to the effect that the story is affirmed by internal documents preserved at the Boulton & Watt Archives. We are consequently unable to understand why it should appear to Boldrin and Levine that we "do not provide any evidence" for our claims.

Second, the "sun and planet" gears (not "gear"), which were invented not by Watt himself but by his employee William Murdoch, were not technically inferior to a crank and flywheel; indeed, the fact that they generated two shaft rotations for each engine stroke was a decided advantage. Nor were they substantially more

costly. Had they been so, or had they been as inferior as Boldrin and Levine claim, Boulton & Watt would presumably have ceased using them altogether when Pickard's patent expired in 1794. Instead, and contrary to what Boldrin and Levine state, Soho kept on equipping engines with sun and planet gears until 1802 (Dickinson and Jenkins 1927, pp. 129 and 169).[10]

IV. 3. The Soho Foundry

Boldrin and Levine (2008, p. 2) claim that "it was only after their patents expired that Boulton and Watt really started to manufacture steam engines," because until then the firm was able to extract "hefty monopolistic royalties through licensing." Mere attention to dates reveals the inaccuracy of this view, for Boulton & Watt determined to build the Soho Foundry—a new facility for producing steam engine parts—in 1795, and completed it a year later, that is, four years ahead of the expiration of Watt's principal patent. The reasons for their having done so are, moreover, well known, and had nothing to do with their having anticipated the abandonment of their engine licensing scheme. First, Boulton and Watt discovered that John Wilkinson, who had been the most important and reliable supplier of iron components for Boulton & Watt engines, had also been manufacturing components for pirate engines. This discovery led to the collapse of friendly relations between the two firms. Second, Wilkinson's Bersham ironworks had been closed by injunction following a violent dispute between John Wilkinson and his brother William (Roll 1930, pp. 149-60).

[10] Cranks ultimately came to be favored for their greater durability.

It is true, on the other hand, that so long as Boulton & Watt continued to rely on engine royalties as their main source of profits, they were willing to supply engine parts at a loss, and that they had to abandon this practice after 1800 (ibid., p. 275).

IV. 4. Murdoch's Steam Carriage

According to Boldrin and Levine, instead of showing gratitude to William Murdoch for helping them to get around Pickard's patent, Boulton and Watt treated him very shabbily. Murdoch, they write (2008, p. 13), "was legally barred from developing" the "steam carriage" he'd designed in 1781 "by Boulton and Watt's successful addition of the high-pressure engine to their patent, although Boulton and Watt never spent a cent to develop it." But this account, which is based, according to Boldrin and Levine, on information from (1) an amateur website called "Cotton Times"; (2) the *Wikipedia* entry on Murdoch; and (3) industrialist Andrew Carnegie's (1905) biography of Watt, is contradicted by the one found in Samuel Smiles' essay on Murdoch in his *Men of Invention and Industry*, which draws on the direct testimony of Murdoch's son.

According to Smiles (1890, pp. 133-6), Murdoch's experimental steam carriage was itself inspired by a model Watt had toyed with several years before. But Watt had given up the idea, having seen no commercial potential in it. That is why, upon learning of Murdoch's experiments, Watt "feared that they might interfere with his [Murdoch's] regular duties, and advised their discontinuance." But when Murdoch persisted Watt, far from "barring" his way, advised Boulton

> that, rather than lose Murdock's services, they should advance him 100£; and if he succeeded within a year in making an engine capable of drawing a post-chaise carrying two passengers and the driver, at the rate of four miles an hour, that a locomotive engine business should be established, with Murdock as a partner.

Nor is it true that, by including the steam-carriage idea in his 1784 patent, Watt merely sought to preempt Murdoch's patenting the idea himself. On the contrary, despite his doubts Watt seriously pursued the steam-carriage idea until 1786, writing that year (according to Carnegie, whom Boldrin and Levine claim as a source for their own story) that he was still "resolved to try if God will work a miracle for these carriages" (Carnegie 1905, p. 190).[11] Watt's continuing doubts, which led him to finally abandon the steam carriage project once and for all, were based on his estimate that such a carriage would have to carry "twenty pounds of coal and two cubic feet of water per horsepower on the common roads" (ibid.). Although Murdoch, to Watt's dismay, persisted a little longer in his own experiments, at last he reluctantly accepted Watt's verdict.

IV. 5. High-Pressure Steam

Boldrin and Levine's revised telling of Watt's story places more emphasis than the original did on the role of high-pressure engines in the supposed post-1800 "explosion" in steam engine numbers and efficiency. "The key innovation" behind this explosion, and particularly behind such developments as the steam

[11] In fact we find nothing in Carnegie's generally flattering biography of Watt, either in the pages cited by Boldrin and Levine (Carnegie 1905, pp. 140-1) or elsewhere, that supports Boldrin and Levine's claims concerning Watt's shabby treatment of his most loyal worker. All Carnegie has to say directly concerning this matter is that, although Murdoch's model steam carriage "performed well…nothing important came of" it (ibid., p. 147).

train and steamboat, Boldrin and Levine (2008, p. 2) observe, "was the high-pressure steam engine—development of which had been blocked by Watt's patent." Although Watt himself never used high-pressure steam, his separate condenser patent supposedly prevented others from doing so:

> new steam engines, no matter how much better than Watt's, had to use the idea of a separate condenser. Because the 1775 patent provided Boulton and Watt with a monopoly over that idea, plentiful other improvements of great social and economic value could not be implemented (ibid., p. 3)

The fatal flaw in this argument is its assumption that high-pressure steam engines require condensers, separate or otherwise. In fact, they don't.[12] Indeed, the vast majority of such engines, including all those employed on locomotives and steamboats, did not employ them.[13] It follows that Watt's monopoly of the separate condenser alone cannot have posed a barrier to the emergence of high-pressure steam technology.

Although this last observation may seem to cut the ground from beneath Boldrin and Levine's entire thesis concerning the ill effects of Watt's patent, it does not actually do so, because the specifications for both Watt's original (1769) patent and the one granted him in 1782 [check date] included headings referring to the "expansive" working of steam, that is, for using steam to push a piston, rather than as a means for creating a vacuum to pull it. A more sophisticated version of the claim that Watt's patent(s) stood in the way of the development of high-pressure steam engines assumes that these headings gave Watt an effective monopoly of

[12] For details see Selgin and Turner (2009).
[13] The principle exceptions were high-pressure engines employed on ocean-going vessels, the condensed exhaust steam from which supplied a needed source of fresh water.

engines that employed steam expansively, at any pressure, and whether condensing or not. But while this version of the "blocking power" thesis is certainly more credible than that put forward by Boldrin and Levine, it, too, is incorrect, as we have endeavored to show elsewhere (Selgin and Turner 2009).

## V. Conclusion

Boldrin and Levine's new telling of Watt's story remains is hardly more persuasive than their original (2004) version. Although they have corrected some of their earlier errors, their account remains inaccurate and one-sided. Although, told in this fashion, Watt's story makes for an exciting introduction to the rest of Boldrin and Levine's book, the story's value as a source of reliable inferences concerning the general merits and shortcomings of the patent system is open to doubt.

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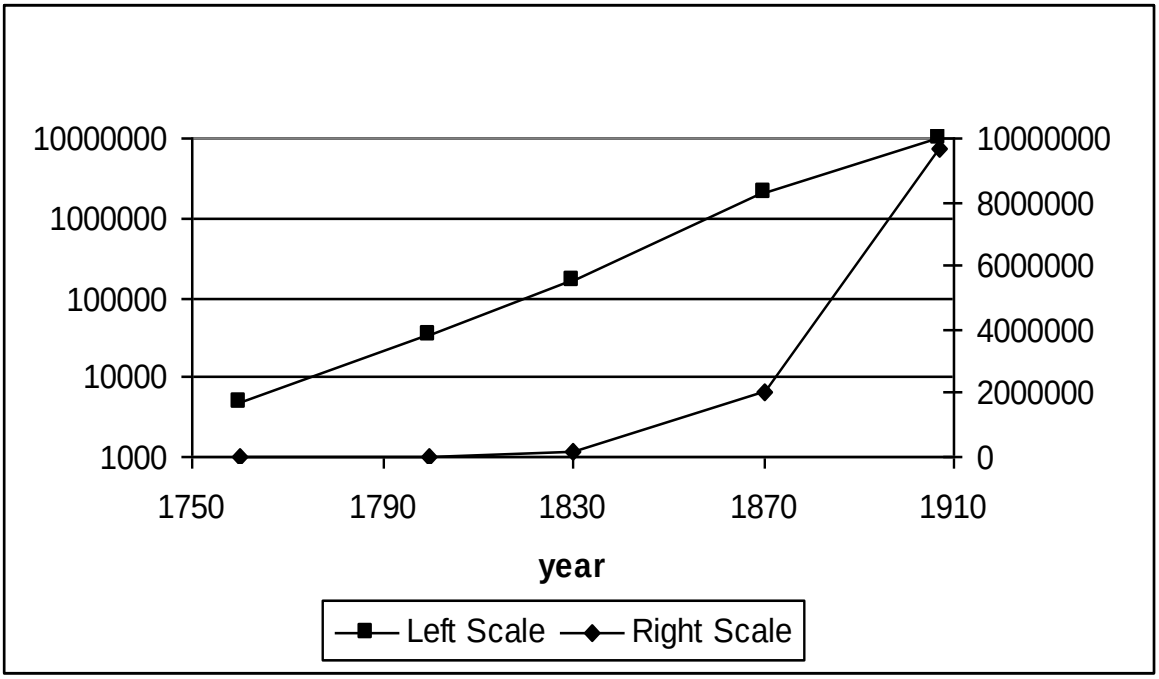
**Table 1. Boldrin and Levine Engine and Horsepower Statistics**

| *Engines* | (2004, 2005) | (2008) |
|---|---|---|
| **1760** | n/a | 510 |
| **1776** | 132 | n/a |
| **1800** | 1,000 | 2,25 |
| **Average growth** | 36.2 / year | 43.5 / year |
| | | |
| *Horsepower* | | |
| **1800** | 10,000* | 35,000 |
| **1815** | 210,000 | 100,000 |
| **Average growth** | 13,333 / year | 4,333 / year |

* Although Boldrin and Levine (2004) does not supply a horsepower estimate for 1800, a 2005 draft of "Against Intellectual Monopoly" (Boldrin and Levine 2005) does. The statistics reported in the 2005 draft are otherwise the same as those in Boldrin and Levine (2004).

**Figure 1. Estimated UK Horsepower From Steam Technology, 1760-1907**




**Note:** The numbers in the figure are original to Kanefsky (1979). The left scale is logarithmic.