The Engineers and Standardization

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Thorstein Veblen predicted that engineers and other "industrial experts" would become so disenchanted with the misdirection of their innovative efforts by business "saboteurs" that they would organize a "soviet of technicians," for the purpose of seizing the reins of control in order to manage the industrial system along industrial lines [35]. Veblen's prediction (which he may or may not have meant to be taken seriously) did not come true and the reasoning upon which he based his ill-fated prophecy has generally been ignored. Those who have dealt with the Veblenian prophecy have concentrated on explaining how and why Veblen was so wrong [13; 20; 27; 30; 31]. In this paper we follow a different course. We use Veblen's analysis of the engineers, though not his prediction, to reexamine their roles and goals. Veblen's stress on the importance of interstitial arrangements among firms can be used to describe revolutionary changes that the engineers did help promote. It can also be used to explain the conflict between their revolutionary functions and their conservative proclivities. Our goal is to describe Veblen's view of the engineers in the context of his explanations of the industrial and business transformation of late 19th century firms.

Veblen explained that transformation in his most important work, *The Theory of Business Enterprise.* Achievement of the pecuniary goals of early firms then depended on achieving "an unsophisticated productive efficiency" in combination with luck in the vagaries of trade in a world of relatively slow and uncertain transport and communication. New machine processes adopted late in the 19th century resulted in standardized inputs and outputs, created interdependent processes [36, p. 23], and gave new opportunities. It was now possible to benefit from interdependence of the processes. It was also possible, Veblen observed, to benefit from "interstitial disturbance." Because industrial processes required that goods move across "the boundary between different spheres of ownership" [36, p. 46] there were opportunities for pecuniarily advantageous disruptions. However, because these pecuniary advantages came in large measure at the expense of other businesses, business reorganization (mergers and combinations) to eliminate such boundaries also became advantageous. Veblen saw in this explanation for much of the business

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reorganization underway as he wrote. Firms were acting to protect themselves from predation by other firms[36, pp. 48-49].[1]

Veblen also described the ways in which increases in the value of assets--often resulting from capitalization of intangible assets such as increases in market power--gave access to credit, and access to credit gave rise to further opportunities to increase asset values. From the standpoint of the firm (and its managers) the value of assets could be increased by effective management of integrated processes, *or* from strategic disruption of the industrial interstices caused by ownership. In all aspects of his theory of business enterprise Veblen emphasized the importance of standardization and the interdependence of industrial processes as the driving force behind reorganization, behind the disruption of past practice and business organization, and as the source of pecuniary advantage and disadvantage. Veblen is, of course, not the only student of the era to have made this observation. Chandler's explanation of the rise of managerial capitalism rests heavily on the opportunities that interdependence and standardization offered well-organized firms [6]; Yates and Hounshell also describe the importance of standardization for American business practice as a source of efficiency and profitability [37; 16]. But Veblen's darker perspective describes the sense of conflict in this period: the firms of Chandler, Yates, and Hounshell innovate and achieve; Veblen's captains of industry disturb, pertubate, disrupt and drive other would-be captains out. A different perspective and one that may be useful in understanding the engineers.

Some Facts and a Conventional Portrait

The increases in the numbers of engineers, and industrial research scientists, at the turn of the century has been well documented [25, p. 253; 19, p. 53]. The standard picture is one in which these engineers undertook in-house industrial research, an activity that enhanced market position and profitability for the employing firms and increased aggregate rates of growth as well. On this there is little or no disagreement.

Just how the work of these engineers should be described is more disputatious. Were they scientists? Or were they "merely" technicians, designers [20]? Frequently just such a distinction is made. John Mills, in his discussion of the engineer in society, observed that the scientist takes "a broader and more basic approach than his engineering colleagues" [21, p. 47]. Edwin Layton observed that, "by its very nature, engineering science is less abstracted and idealized . . . [and] most engineers have been willing to accept an identification as applied scientist" [20, p. 695]. The implication is that engineers working in business firms simply apply knowledge created by their learned colleagues in the scientific community who perform the loftier task of scientific research: fairly typical is the picture of the engineer presented by J.E. Hobson, Director of Stanford's Research Institute in the 1950s: "the engineer is not playing with scientific matters for the pleasure he derives from his studies; he has a very

[1]That the Coase Theorem apparently had antecedents in the work of Veblen is interesting.

specific purpose and objective in mind: that of applying his technical knowledge to an economic problem" [14].

As employees expected to apply their knowledge to business problems, the engineers are generally assumed to have been (and to be) attuned to the pecuniary goals of the firm by training, skill and inclination. The statements that describe the ideal engineer as a highly skilled technician with a keen sense of cost and profit are many [4; 34]. Not only were engineers thought to be commercially attuned by virtue of engineering training, they were also, from early on, exhorted to supplement their technical engineering skills with business education rather than trying to educate their business employers on technical matters.

The well-documented efforts of engineers to gain status within firms have reinforced the view that engineers were natural (and naturally conservative) allies of the businessman. Layton and others have described the way in which engineers redefined themselves as professionals through professional organizations, academic certification, and upward mobility into the managerial ranks of business [19]. Monte Calvert described this as a slowly evolving process. In the late nineteenth century it became common for factories to hire young mechanical engineers to serve as "general trouble-shooter[s]," having as their main responsibility the task of watching over the steam engines and other machines [5, p. 141]. Although their span of authority increased apace with growing complexity of machines, output and processes, they had nonetheless entered these large, bureaucratic firms without "built-in status." Having little in common either with skilled craftsmen on the production line or with those in the managerial ranks, they began to organize technical associations where they met for camaraderie and the exchange of professional and technical information with their professional colleagues at other firms.

It is also true that the engineers--both as individuals and through their professional associations--sought to find ways to improve the efficiency of society. At the same time they sought to improve their status and contribution to the firms that employed them. They did so in many ways: activities ranged from the careful and cautious efforts of Herbert Hoover to the misguided utopianism of the technocrats.

However, the evidence in support of the former, more conventional view of the engineers is very strong. And, the engineers in that conventional view were in strong support of the pecuniary goals of the firms for which they worked and were as well strongly interested in their own professional and pecuniary status. They were, in other words, hardly revolutionary. If so the question must be: How could Veblen have thought otherwise? To answer this question we must turn now to Veblen's description of the engineers.

Veblen's View of the Engineers

Veblen made his wildly wrong prediction about the engineers in a series of articles that were collected and published (in 1921) under the title *The Engineers and the Price System.* This book was widely noted upon its publication and again in the 1930s with the "Technocracy" movement [9, p.

510-14]. It remains the major source for those who want to understand Veblen's prediction about the engineers and the source of his error.

However, there is little in *The Engineers and the Price System* that is not in *The Theory of Business Enterprise*, published in 1904. This is important for our argument because we do not join most other interpreters in thinking that it was the aftermath of WWI that formed Veblen's view that there might be a progressive role for the engineers in industrial society. There can be little doubt that the flurry of association with a group of engineers and visionaries all connected loosely with the ASME and the founding of the New School in 1919, as well as the general interest in the possibility of revolution in the U.S. (1919 was the height of the Red Scare) all contributed to the specifics of *The Engineers and the Price System* [3; 9; 27]. That it might be engineers such as those associated with the ASME who would lead the way out of a fundamental dilemma of industrial capitalism was a product of the events of 1918 and 1919. However, the fundamental dilemma and the probable character of its solution were laid out with greater care and precision by Veblen in *The Theory of Business Enterprise.*

In this view, engineers--those who devised that standardization and thus implemented that interdependence--would not necessarily serve the pecuniary interests of the firms for which they worked. For some firms--those that emerged as victors in the Veblenian wars--the engineers were able to set the goals of greater standardization and interdependence made possible by boundary removal. For other firms--those under attack, or the losers--the engineers were the source of the very standardization and integration that had placed the firms in jeopardy. Standardization was welcomed by those firms able to control the benefits, feared by those who couldn't.

In other words, the industrial and pecuniary aims of firms, and thus engineers, were not always--or even often--identical. Industrial processes dictated a flow of standardized products across the boundaries created by business organization. Pecuniary aims led to strategies that might, or might not, serve that flow. A view of engineers that sees them as natural allies of business interests and defines those interests within unquestioned business boundaries will miss the importance of the strategies for boundary disputes that Veblen stressed. We will return to this point at the end of our paper. Our task for now is to establish that the engineers were indeed instrumental in the standardization/integration that is crucial to Veblen's argument.

The Engineers and Standardization

In thoroughly industrialized modern economies, the importance of product and process standardization is relatively little noted. Engineers (and industrial research scientists) are seen as contributing to the development of new products and processes. However, and not, we think, surprisingly, Sinclair [28], Thompson [33], Knoedler [17] and others who have surveyed the activities of professional engineering groups such as the American Society for Testing Materials (ASTM), the Society of Automotive Engineers (SAE), the AREA (American Railway Engineers Association), and the ASME have found abundant evidence to support the proposition that turn-of-the-century engineers devoted considerable effort to standardization. Industrial standardization was one of the major activities of industrial research laboratories, according to comprehensive surveys taken in 1917 and 1940 [10; 24].

The steel industry offers good examples. Around the turn of the century steel producers made efforts to standardize certain products because they were increasingly required to produce a proliferation of similar products according to specifications drawn up by their customers [17, Chap. 3]. Steel producers hoped to benefit from standardization because they would be better able to reduce production costs and export steel. *Iron Age* advocated standard specifications to be jointly developed by both producers and consumers, noting that "it will be a powerful incentive to a general adoption of the specifications if they escape the suspicion that the maker rather than the consumer was favored in framing them" [15, 1900, p. 26]. Steel consumers hoped to obtain better quality steel from standardization of products [26, p. 22; 15, 1908, p. 28 and 1907, p. 1696; 2, 1925, pp. 425-26].

Reduction of costs and movement towards technologically more sophisticated standards was also a common theme in engineering discussions of standardization. In the early days of the ASME, much effort was directed at standardization [32, p. 154]; and the ASME in the early 1880s even lobbied Congress for federal support for their efforts to promote increased standardization [28, p. 40). ASME viewed standardization as the most effective means of using and transferring technical information. Engineers found standards appealing for both industrial and pecuniary reasons--their "sense of order" and the economic gains that standardization allowed [28, p. 47].

Standardization was not simply an 1880s fad for engineers. In 1919 C.A. Adams, of the Federal Bureau of Standards, praised the continued efforts to promote standardization by such groups as the Society of Automotive Engineers as "not only reduc[ing] the annoyance of repair work to the purchaser but . . . [also]greatly reduc[ing] the cost of automobiles. . . . [Standardization] is also largely responsible for the primacy of this country in that field" [1, p. 291]. The Federated American Engineering Societies' famous study on waste in American industry identified lack of standardization as a major cause of lower-than-potential levels of production [7]. Another major report on standardization, issued by the National Industrial Conference Board (NICB) in 1919, noted that "mass production made increasingly necessary the discovery [and consistent use] of 'best' materials, processes and devices, and increased standardization upon the basis of deliberate research" [15, 1913, p. 387]. Cited by the NICB were the savings achieved by the War Industries Board during World War I via standardization: had the conservation and standardization programs instituted during the war been continued, the NICB estimated savings to be fifteen percent of the materials used in the 269 industries studied [22, p. 9].

Although the War Industries Board estimates are striking, much standardization had been accomplished prior to WWI, and standardized specifications were a major means whereby this standardization was achieved. Specifications were typically detailed lists of various physical and chemical criteria for products or materials to be purchased; in some cases criteria for testing and sampling the material were included as well [17; 18]. The best specifications were devised by careful research and testing on the part of producers or consumers of the product, and thus were used as the basis of purchasing contracts. One technical engineering association, the ASTM, was heavily involved in standardization efforts from its inception [38, p. 1], and constantly worked to obtain conformity to the best specifications in use. Standardization of standards became important as well: in an announcement in 1917 about an upcoming joint effort with four other technical associations, named the American Engineering Standards Committee, the ASTM declared its objective to improve *and* standardize specifications, to make "standards more rational . . ., to unify and simplify the methods of arriving at engineering standards, to insure cooperation between the different societies [2, 1917, p. 47].

A similar process of standardization occurred in the early automotive industry--the discovery of the benefits of using alloy steel in various automobile components, and the early use of specifications by the SAE to ensure high standards of quality for these materials, pushed the industry toward "proper standardization [which] will mean a tremendous saving to the industry and the public, for it spells efficiency, bettering quality, reducing cost, and facilitating production" [15, 1910, p. 573]. The Studebaker Company was one of many automakers "engaged in analyzing, explaining, and testing the various kinds of materials and apparatus that enter into the construction of the complete motor car . . . savings are effected in many ways in the cost of production and these pay many times over for the cost of operating the laboratory in the course of a year" [15, 1913, p. 387]. As George Thompson observed, in the auto industry it was not simply a matter of ensuring quality and reducing costs that was crucial to the standardization movement [33]. With vigorous competition early on pushing out many small suppliers, Hudson, one such small firm, recognized that product differentiation had led to excessive dependence on a few small suppliers. Hudson was instrumental in setting up the SAE's Standards Committee, where producers and consumers together developed the standard specifications with the aim of achieving greater interchangeability of parts and greater mass production economies. In the first decade of the committee's work, they issued 224 sets of standards, managing along the way to reduce greatly varieties of common automotive components. After the first decade alone, the savings from standardization were estimated to be $750 million, approximately fifteen percent of the retail value of automobiles.

The Engineers' Dilemma

As Alfred Chandler has described it, those firms that succeeded during 1880-1920 did so through control and speed of turnover. Firms, or more precisely, managers of the large hierarchically-organized, vertically-integrated corporations that effected the industrial transformation at the turn of the century, organized their large production and distribution empires in order to increase the speed with which money was transformed into more money. Through these "economies of speed" they were able to increase their pecuniary efficiencies. Engineers at the turn of the century aided this process by standardization--in fact, the engineers were essential to the process.

But Veblen also observed that the ability to interfere with speed, by virtue of managerial control over large bureaucratic corporations linked with other such corporations across interfirm and interindustry interstices could be pecuniarily advantageous. What Veblen described as sabotage--his quite deliberately chosen word in *The Engineers*--encompassed more than the commonly recognized monopolistic restrictions on quantity and increase of price.

Veblen did not offer a static theory of the firm and moreover he was keenly aware that the overall price level trended downward during the years before he wrote *The Theory of Business Enterprise*. Thus, he spent little time in *Business Enterprise* (and little too in *The Engineers*) on monopolistic pricing practices. Nevertheless, sabotage--which he took pains to define as largely legal "restriction, delay and hindrance" in use of industrial capacity--was important in his treatment of the U.S. economy because good business practice called not simply for higher prices than might otherwise have prevailed for business output [35, pp. 38-40]. More important for Veblen were the advantages that accrued to managers (though not necessarily owners) of firms when they could increase their access to credit by perceived appreciation of their industrial collateral. This could mean that the move toward economies of speed--aided by the move toward the best practice and toward the best standards as designed by the engineers--was hindered by the managers' move toward ever greater earnings. Recall from the earlier description of Veblen's theory that asset enhancement was a way to increasing credit and increasing credit a way to increase the value of assets held. And, assets could be increased in value by strategic manipulation of the boundaries that created interstices in the smoothly functioning system that the engineers were creating.

Veblen described the process this way:

> [The]...negotiations and much of the strategy that leads up to a business consolidation are of the nature of derangements of industry. . . . [B]usiness interests and maneuvers commonly delay consolidations, combinations, correlations of the several plants and processes. . . Serviceability, industrial availability, is not the decisive point [36, p. 39].

The instances that Veblen cites in support of these contentions are duplication of track and terminal equipment among railways, the working of the Northern iron-ore beds, and the events leading up to the formation of U.S. Steel [36, Chap. 3].

Engineers, as a result of the ongoing battles for pecuniary advantage in the dynamic world that Veblen described, had to contend with an inherent conflict of interest between their training to engineer products and processes in the most efficient and functional manner, and their responsibilities to serve the goals of their employers--a conflict that helps explain some of the contradictions in descriptions of engineers' professional activities. That there was conflict has been agreed upon by all who have written about the engineers. However, we now suggest that Veblen's analysis allows a different view of that conflict. With engineers, as members of many professional technical organizations and as employees of firms, moving toward *both* greater standardization *and* greater managerial involvement, it was inevitable that they would find these goals irreconcilable. Critical to engineers' notion of standardization was the design of ideal standards and use of those standards to achieve complete interchangeability, interchangeability that would assist firms to achieve mass production efficiencies. Critical to the firm was product differentiation via either real or reputational quality differences, and even withholding of best products if the firm had sufficient market power to sell its products of lesser quality. This produced conflict for engineers during the 1910s and 20s in that engineers, both as professional employees for firms and within professional engineering associations, began to find themselves in conflict over whether to honor their engineering instincts to try to achieve high quality, low-cost products and processes, or whether to assist their employers in making larger profits, often by withholding the best engineering practices available.

Engineers could not easily resolve their conflicting professional responsibilities to employers on the one hand and engineering principles on the other hand. The difficulties involved in the actual adoption of standards were substantial. Knoedler has described the divergent goals of railroad engineers and steel company engineers in their studies of rail steel and how 'best practice' depended on whether one used or produced the steel. Thompson observed, in his discussion of standardization efforts by the SAE, "the ultimate test of standards . . . was not simply publication but use" [33, p. 9]. Although standards obtained endorsements from smaller auto producers in the 1910s, it was only in the mid 1920s, as these smaller automakers began to exit the industry, that GM became more active in the SAE standardization process and GM's representatives helped to divert SAE's attention to inter-industry purchasing and engineering practices to help automakers vis-a-vis steel makers. In these three industries--steel, railroads, and automobile--the large corporations began to support standardization only when the economic benefits of standardization accrued to them.

Layton (and others) describe conflict over the status of engineers within firms, a conflict that led to an evolutionary process whereby engineers sought to attain professional status and middle-class wages throughout the period of industrial transformation. This, we suggest, was only part of a larger conflict for engineers between loyalty to the firms that increasingly gave them professional status and good wages, and the professional goals that often stood in conflict with those of these same firms.

Resolution of the conflict between industrial and pecuniary interests was not--even if evolutionary--without conflict for individuals. Illustration of this comes from a passage, described by Bruce Sinclair, from a pageant put on by the Engineers' Club of St. Louis in 1930. The play depicts engineers as trying valiantly to establish best practice at the firms. But midway through the play the protagonist, Every Engineer, figures out the game and informs his corporate employer that he has an idea, "a peacherino true, for multiplying all gas bills by two." Near the end of the play a character portraying Success declares that "[F]ew men attain my friendship without sin" [28, pp. 256-57].

Further evidence of the conflict faced by engineers comes from the activities of such activist engineers as Morris L. Cooke, Henry Gantt, Frederick Newell, and Charles Steinmetz who tried to advance industrial interests at the expense of pecuniary [19; 20; 29; 30; 31]. Many of these engineers were influenced by, if not part of, the Progressive movement; they hoped to use their engineering skills to improve the efficiency and productivity of American industry [29]. Henry Gantt, a disciple of Taylor and scientific management, an admirer of Veblen, and a persistent critic of business, in 1916 described the worst business abuse as "the right to exercise power without the ability to exercise it properly" [11, p. 812]. Gantt saw the engineers as the solution:

> . . . the day will come when the principles underlying the managing mechanism for an industry will be as clearly defined and as well understood as those underlying the design of a steam engine. . . . It is the function of the engineer to discover or develop those principles [12, p. 18].

As is reasonably well known, interest in using engineering principles to increase overall efficiency and enhance justice was not limited to a small group of left-leaning engineers. Herbert Hoover was among the best known of those who advocated attack of problems in "the scientific spirit" [39, p. 169]. Although efforts to solve social problems sometimes led to discussion of explicit conflicts of interest [8]--discussion of the possibilities for use of engineering knowledge often proceeded in happy disregard of such conflict. And, indeed, the revolutionary possibilities did seem to fade even as Veblen returned in 1921 to the theme that he had first set out almost two decades earlier.

Conclusion

The attention given to Thorstein Veblen's observation that the engineers were more likely to be a revolutionary force than were the workers has obscured the more important contributions that he makes to business history. Veblen's treatment of the engineers in *The Engineers and the Price System* was a semi-popular elaboration of his more thorough explanation of the nature of business enterprise at the turn of the century. Veblen described business enterprise in the industrial transformation of the U.S. economy in terms of strategies employed to exploit the interstices created by business organization; interstices at which gain could be gotten precisely because industrial efficiency required that they either be eliminated or paved over. The possibility that the engineers might be the true revolutionaries in the capitalist order of the 1920s was consequence of the fact that the engineers were the industrial experts to whom the interstices were a problem. As the engineers worked to create specifications and standards that did pave over the breaks in the flow of goods created by the legal and commercial system of business ownership and management they tended to work counter to the pecuniary interests of businesses that were served by taking advantage of those interstices.

What should be important to business historians today is not whether or not Veblen was right in thinking that the engineers might become more thoroughly revolutionary. What Veblen--treated as a serious observer if not a wise prophet--offers is an addition to the standard treatment of the engineers. They were indeed employees who served industrial efficiency and did so by combining understanding of technical processes and of costs. They were also--as the usual story says--employees interested in their status within the firm and increasingly incorporated into the managerial hierarchy. They were also, however, inherently subversive to the existing business order. We should not only modify the usual description of the engineers to give greater importance to standardization as a key goal of the early engineers. What must also be added is recognition that this very standardization was subversive of an old order. Recognition that standardization offered both advantages and disadvantages also provides clearer understanding of the process of business formation and success.

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