THE GREAT MERGER MOVEMENT AND THE DIFFUSION OF ELECTRIC POWER UTILIZATION IN AMERICAN MANUFACTURING, 1899-1909:

A SIMPLE TEST OF THE SCHUMPETERIAN HYPOTHESIS

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INTRODUCTION

The "great" merger movement in the United States occurred between 1895 and 1904. By all accounts, it caused an unprecedented increase in the concentration of American manufacturing assets [Lamoreaux 1985; Golbe and White 1988]. Moreover, it occurred at an extremely important juncture in the evolution of modern industrial technology. It was only after the turn of the century that manufacturing firms began to adopt electricity as a principal source of industrial power [Du Boff, 1979]. The conjunction of these two events—the great merger movement and the diffusion of electric power utilization—therefore suggests a test of Schumpeter's hypothesis that highly concentrated industries are generally more conducive to rapid innovation than less concentrated ones.

This paper uses data from the Twelfth and Thirteenth Censuses of Manufactures to test whether the great merger movement did indeed accelerate the electrification of American industry. It finds that a merger at the turn of the century had a large and statistically significant effect on an industry's use of electric power a decade later, especially when the merger was most likely to have had a large and persistent effect on the industry's concentration. This not only offers some tentative support for the Schumpeterian hypothesis, it also suggests that the great merger movement had much broader consequences for the rate and direction of technological change in the first decade of the twentieth century than has generally been acknowledged.

The next section of this paper elaborates on the Schumpeterian hypothesis. It continues by offering overviews of the great merger movement and the early diffusion of electric power. It then discusses the sample data and presents the empirical analysis. Some conclusions are offered in the final section.

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THE SCHUMPETERIAN HYPOTHESIS

Schumpeter offered two reasons why highly concentrated industries should be conducive to rapid innovation [Fisher and Temin, 1973, 57]. First of all, in highly concentrated industries, firms will generally have greater market power and will therefore be better able to appropriate the returns from an innovation. As Schumpeter explained, "[I]f a patent cannot be secured, or would not, if secured, effectively protect, other means may have to be used in order to justify the investment.... [L]argest-scale plans could in many cases not materialize at all if it were not known from the outset that competition will be discouraged..." [1950, 88-9]. Second, in highly concentrated industries, firms will generally be larger and therefore more effective in developing innovations. As he explained, "[M]onopolization may increase the sphere of influence of the better ... brains.... There cannot be any reasonable doubt that under the conditions of our epoch such superiority is as a matter of fact the outstanding feature of the typical large-scale unit of control..." [*ibid.*, 101].

Schumpeter's use of the word "innovation" was quite distinct. As he explained, "If, instead of quantities of factors we vary the form of the [production] function, we have an innovation" [quoted in Ruttan, 1959, 598]. Thus, when Schumpeter referred to an "innovation" he meant something very similar to what is commonly referred to now as a "technological change" [Ruttan 1959, 598; Schweitzer 1961, 152-3]. Moreover, he was careful to point out that an "[i]nnovation is possible without anything we should identify as invention...." [quoted in Ruttan, 1959, 597]. Thus, in Schumpeter's view the adoption of a new technology constituted an innovation regardless of whether the firm had invented it.

A number of studies have investigated Schumpeter's hypothesis. In a famous theoretical paper, Arrow [1962] proved that, under perfect appropriability conditions, a competitive market would always provide greater incentives to innovate than a monopoly. Since Schumpeter had clearly not assumed perfect appropriability conditions, Arrow's analysis did not disprove the Schumpeterian hypothesis, but it did cast significant doubt on its relevance. Subsequent empirical investigations have cast even further doubt. A number of these have suggested that the underlying technological opportunities may be considerably more important to an industry's innovativeness than its concentration [Scherer, 1967; Scott, 1984; Levin, Cohen, and Mowery, 1985]

This is somewhat ironic, for Schumpeter believed that economics was "only an observational and interpretive science," [1950, 107], and he drew upon empirical evidence—especially evidence about the impact of the turn of the century consolidation movement—in justifying his hypothesis. In rebutting the idea that the consolidations had weakened competition and undermined economic growth, for instance, Schumpeter noted that "the rate of increase in output did not decrease from the nineties from which ... the prevalence of the largest-size concerns ... would have to be dated ...[but rather that]... the standard of life of the masses evolved during the period of relatively unfettered big business" [*ibid.*, 81]. Indeed, he argued that "As soon as we go into details and inquire into the individual items in which progress was most conspicuous ...a shocking suspicion dawns upon us that big business may have had more to do with creating ...[the modern]... standard of life than with keeping it down" [*ibid.*, 82].

Schumpeter himself did not expound on the "details" and "individual items," and his argument was stated only in these general terms. But he clearly believed that the turn-of-the-century consolidations had accelerated the rate of technological innovation and that more focused investigations would bear this out. This paper offers such an investigation.

THE GREAT MERGER MOVEMENT

There is little doubt that the great merger movement caused the most significant discrete change in industrial structure in American history. At its peak in 1899, there were more than four mergers for every billion dollars of real GNP. By contrast, at the peak of the merger movement of the 1980s, in 1986, there was barely more than one merger per billion dollars of real GNP.[1] And whereas the total value of the assets acquired through merger in 1899 constituted more than 12.5 percent of GNP, the total value of the assets acquired through merger in 1986 constituted only about 5 percent of GNP.[2] Indeed, the size and impact of the great merger movement were reflected in the voluminous discussions given to it in contemporary newspapers, periodicals, and academic writings.

The public's concern seems to have been well-founded. It appears that in many cases the mergers caused significant increases in their industry's concentration. According to Lamoreaux [1985], for instance, seventy-two of the ninety-three mergers that she was able to trace produced consolidations with at least forty percent of the market share. And forty-two of the mergers produced consolidations with at least seventy percent of the market share. Others have undertaken similar investigations and arrived at similar conclusions.[3] Given the importance that economists have long attached to industry structure, and the magnitude of the change in industry structure wrought by the great merger movement, it is surprising that so little is understood about its consequences.

Although a number of writers have attempted to evaluate the consequences of the great merger movement,[4] they have tended to focus on the inefficiencies induced by noncompetitive pricing. While the impact of the consolidations on prices was undoubtedly important, the movement may have had much broader consequences. The great merger movement occurred dead in the center of the "second industrial revolution."[5] The competitive environments faced by many firms during this period were dominated by technological change. If the great merger movement succeeded in lessening competitive pressures, therefore, it may also have affected the rate and direction of technological change.

EARLY ELECTRIFICATION IN AMERICAN MANUFACTURING

The first significant use of electric power in American manufacturing was as a source of illumination.[6] In some cases electric lighting offered distinct advantages [Nye, 1991, 192-3]. For example, because electric lighting improved visual acuity, it diffused early and rapidly in the printing industry where visual acuity was particularly important. It was also cleaner than gas or kerosene, and therefore diffused rapidly in industries such as meat packing and sugar refining in which cleanliness was

important. Moreover, because it was safer, it reduced insurance costs in other industries such as flour milling and textiles, which were known to present special fire hazards.

The productivity improvements associated with electric lighting paled, however, in comparison with those that were realized when factories began using electricity as a source of motive power. According to Du Boff [1979], the use of electricity as a source of motive power evolved through three overlapping stages. In the first stage, which occurred mostly prior to 1895, plants used their existing steam engines to generate electricity for electric motors, which ran groups of machines. The principal savings at this point derived from the energy efficiencies associated with using electric motors.

In the second stage, which occurred mostly after 1893, firms continued to generate their own electricity, but used it to power individual motors on each machine. At this point, savings derived not only from energy efficiencies but also from the capacity to run machines separately rather than having to keep the whole plant running for a single machine. The final stage occurred when firms began turning to central stations for their electricity rather than generating it themselves. This occurred mostly after 1900 and yielded the most substantial cost savings.

At this stage of the electrification process, electric power was both labor-saving and capital-using [Woolf, 1984]. Electrification occurred therefore only in conjunction with substantial retoolings of existing manufacturing plants and the construction of entirely new ones. Indeed, the importance of the electrification process in the first decade of the twentieth century is attested by the prevalence of electric power utilization in new facilities. As the *Special Report of the Census of Manufactures* noted in 1905, "Practically all the newer factories and shops in the U.S. of any size, constructed within the past five years, have an electrical drive either exclusively or for most purposes"[Du Boff, 1979, 95].

Since the adoption of electric power constituted an innovation, at least in the sense that Schumpeter intended, and since the great merger movement significantly increased the concentration of a large number of American industries immediately prior to the final and most important stage in the electrification process, the Schumpeterian hypothesis implies that the merger movement should have accelerated the diffusion of electric power utilization during the first decade of the twentieth century. Some writers have, in fact, alluded to such a connection. According to Rosenberg and Birdzell, the great merger movement helped to facilitate the electrification process by reducing the risks associated with large investments and thereby making it easier for manufacturers to finance them. As they put it,

> [B]etween 1880 and 1900, the United States was increasing its industrial capacity and altering manufacturing technology in ways that required extensive replacement of obsolete plants.... There were serious obstacles to finding the required capital. There was a serious need for new forms of enterprise better able to attract capital.... [T]he plausible expedients were tried many times: incorporation, the formation of trusts, and, after 1894, mergers.... Although these promotions produced many enterprises that failed, they also produced a number of large enterprises that proved able to raise the capital required for reconstruction and expansion ... and a burgeoning American economy emerged from the merger movement ready to take off on a second industrial revolution, powered by the internal combustion engine and electricity. [215, 1986]

Nye, on the other hand, views the great merger movement as the first step in a profound structural transformation of American business and the electrification process as an integral part of that transformation. As he explained,

> The corporations developed contemporaneously with the new electrical industry, and they were capital intensive, requiring heavy investment in new machinery. Rationalization of production and economies of scale required tools driven by electric motors, large electric ovens regulated to precise temperatures, giant electric cranes, and other expensive electrical equipment. [174, 1991]

Nonetheless, the connection between the great merger movement and the electrification of American industry remains largely unexplored. And the relevance of the Schumpeterian hypothesis has never been seriously investigated. The remainder of this paper will attempt to evaluate the implications of Schumpeter's hypothesis for this connection using a sample of manufacturing industries from the turn of the century.

THE SAMPLE DATA

A sample was constructed from the industries surveyed in the Twelfth and Thirteenth Censuses of Manufactures. It included those industries surveyed in the Thirteenth Census which were classified identically in the Twelfth Census, or which corresponded exactly with a group of industries surveyed in the Twelfth Census. Two of the industries[7] were dropped because their classifications were too broad to have any real meaning, and one was dropped because of missing observations.[8] This left a sample of 197 firms (see the Appendix for a list). These were classified into one of two groups according to whether a horizontal merger had been recorded for the industry by Ralph Nelson in his study of American merger movements [Nelson, 1959]. Based on this criterion, there were horizontal mergers in 81 of the industries in the sample.

The Twelfth and Thirteenth Censuses of Manufactures include survey data, collected in 1899 and 1909, respectively, on the industries' capital stocks, outputs, and power usage. As the data in Table 1 indicate, industries that experienced merger activity at the turn of the century generally had larger establishments than those that did not. Moreover, the absolute increase in the size of their establishments between 1899 and 1909 was, on average, about three times greater than in those industries that did not experience a merger. This corroborates the view that the great merger movement occurred principally in the mass-production industries [Lamoreaux,

TABLE 1
Descriptive Statistics

	No Merger	Merger	Overall
Capital per Establishment in 1899 ($)	47,079	192,980	107,069
Capital per Establishment in 1909 ($)	90,781	347,694	196,415
Total Horsepower per Establishment in 1899	45.03	226.58	119.68
Total Horsepower per Establishment in 1909	65.56	344.39	180.21
Electric Horsepower per Establishment in 1899	3.18	12.29	6.92
Electric Horsepower per Establishment in 1909	24.16	103.51	56.79
Electric Horsepower/ Total Horsepower in 1899	0.126	0.061	0.099
Electric Horsepower/ Total Horsepower in 1909	0.397	0.319	0.365

1985]. It also indicates that there were, in general, very large investments undertaken subsequent to the turn of the century.

The data in Table 1 also provide some insights into the industries' power usage. Between 1899 and 1909 total horsepower usage per establishment and electric horsepower usage per establishment rose across most industries. The increases were especially pronounced, however, in industries that had experienced a merger at the turn of the century. It is interesting to note that, in both 1899 and 1909, the proportion of total horsepower provided by electricity was greater in those industries that did not experience a merger than in those which did. The increase in the proportion of total horsepower provided by electricity between 1899 and 1909 appears to have been greater, however, in industries that did experience a merger.

In summary, between 1899 and 1909 there were significant increases in the size of manufacturing establishments, the total horsepower used per establishment, and the electric horsepower used per establishment across most industries in the sample. In general, these increases were more pronounced in industries that had experienced mergers at the turn of the century. Any inferences as to whether the merger movement itself contributed to these increases, however, and, in particular, whether it contributed to any increases in the relative use of electric power, will require a more systematic analysis of the data. Such an analysis is presented below.

EMPIRICAL ANALYSIS

Regression analysis is used to test whether the great merger movement had a statistically significant effect on electric power usage in 1909. Three different dependent variables are used to reflect the industries' electric power usage in 1909. The first is the amount of electric power used per establishment in 1909, the second is the ratio of electric power to total horsepower used in 1909, and the third is the ratio of the electric power used to the value of industry output in 1909. To provide a comparison with these results, the regressions are also done with the total horsepower used per establishment in 1909 as the dependent variable.

Two merger variables are used. The first is a binary variable that equals one when a merger had been recorded for the industry during the 1895-1904 period by Ralph Nelson. The second is a refinement of this variable that attempts to focus on those mergers that should in general have had a more significant and persistent effect on their industry's concentration. This is a binary variable that equals one when a merger had been recorded for the industry by Nelson and when the amount of capital per establishment in the industry in 1899 was larger than the sample average.[9]

Other variables are also used as regressors to account for the effects of other factors that might have been conducive to rapid electrification. In general, when the dependant variable is some measure of the extent of electrification in 1909, the lagged value of that variable is included in the regressions as an independent variable. The rationale is that the extent of early experimentation with electrification may have reflected the extent of the underlying technological opportunities for electrification in that industry, and also that early experimentation may have facilitated and therefore accelerated further electrification.

Since this alone may not fully account for the effects of the underlying technological opportunities, dummy variables are created to reflect the industries' memberships in the fifteen different categories identified in the Twelfth Census of Manufactures (see the Appendix for a list of the groups as well as the industries' memberships in them). These dummy variables are also used as regressors. The rationale is that, in general, the underlying technological opportunities are probably much more similar within the groups than between them.

As the data in Table 1 indicate, the merger movement was associated with a number of other changes in American manufacturing industries, including an increase in the average size of establishments. In some cases, it is obvious that the effects of the average size of establishments must be separated from the effects of the merger movement (for instance, when the dependent variable is electric power used per establishment). But since electrification may have proceeded more rapidly in industries dominated by large establishments, some account has to be taken of the effects of establishment size even in the other cases. Thus, the amount of capital per establishment in an industry in 1909 is also used as a regressor.

The regression analysis raises two econometric problems. First, because lagged dependent variables are correlated with the errors, ordinary least squares (OLS) estimates are biased. Nonetheless, because they are not contemporaneously correlated with the errors, OLS estimates are still consistent. Second, because the decision to utilize electric power may have been related to a decision about the appropriate size of the establishment, the amount of capital per establishment in 1909 may be contemporaneously correlated with the errors. If so, OLS estimates will not only be biased but inconsistent as well. Instrumental variable (IV) estimates are therefore computed instead, using capital per establishment in 1899 as the instrument for capital per establishment in 1909. These provide consistent estimates.

Table 2 presents IV estimates for regressions in which electric power per establishment in 1909, *ELEST09*, and total horsepower per establishment in 1909,

TABLE 2
IV Estimates with ELEST09 and HPEST09 as Dependent Variables

	(1) ELEST09	(2) HPEST09	(3) ELEST09	(4) HPEST09
CONSTANT	−50.03	−101.46	−55.74	−99.30
	(−0.90)	(−0.60)	(−0.99)	(−0.58)
ELEST99	2.34	—	2.32	—
	(6.42)		(6.28)	
HPEST99	—	1.09	—	1.11
		(7.59)		(7.23)
Food and kindred products	32.50	−15.65	39.01	−7.88
	(0.56)	(−0.09)	(0.65)	(−0.58)
Textiles	34.73	83.63	38.74	81.40
	(0.62)	(0.50)	(0.69)	(0.47)
Iron, steel, and their products	84.34	205.08	93.79	215.98
	(1.44)	(1.16)	(1.57)	(1.18)
Lumber and its remanufactures	53.20	113.54	62.91	126.14
	(0.91)	(0.64)	(1.05)	(0.68)
Leather and its finished products	33.85	95.28	34.70	91.87
	(0.48)	(0.45)	(0.49)	(0.42)
Paper and printing	55.50	141.38	59.36	140.07
	(0.93)	(0.78)	(0.98)	(0.76)
Liquors and beverages	21.95	81.55	26.82	95.04
	(0.34)	(0.41)	(0.41)	(0.47)
Chemicals and allied products	42.44	95.24	47.67	104.07
	(0.72)	(0.53)	(0.80)	(0.57)
Clay, glass, and stone products	58.81	152.76	70.97	172.52
	(0.99)	(0.84)	(1.17)	(0.93)
Metals and metal products	17.69	69.35	27.66	81.64
	(0.32)	(0.41)	(0.49)	(0.47)
Tobacco	33.05	20.08	49.08	55.96
	(0.36)	(0.07)	(0.52)	(0.19)
Vehicles for land and transport	146.36	214.33	155.79	231.26
	(2.32)	(1.12)	(2.42)	(1.18)
Shipbuilding	22.49	−30.53	40.88	7.09
	(0.24)	(−0.11)	(0.43)	(0.02)
Miscellaneous industries	47.54	87.33	54.58	90.77
	(0.87)	(0.53)	(0.98)	(0.53)
Handtrades	92.85	−36.63	99.77	−31.91
	(0.96)	(−0.12)	(1.02)	(−0.10)
MERGER	9.72	39.14	—	—
	(0.73)	(0.97)		
BIGMERGER	—	—	39.34	64.30
			(2.01)	(1.06)
CAPEST09	1.8E-04	1.6E-04	1.5E-04	1.1E-04
	(6.84)	(1.12)	(4.80)	(0.65)
Adusted R-squared	0.65	0.71	0.64	0.70
Mean of dependent variable	56.79	180.21	56.79	180.21

t-statistics are in brackets.

HPEST09, are used as dependent variables. Separate regressions are run to test for the effects of each of the two merger variables, *MERGER* and *BIGMERGER*. The results indicate that electric power per establishment in 1899, *ELEST99*, and capital per establishment in 1909, *CAPEST09*, are the best predictors of *ELEST09*, and total horsepower per establishment in 1899, *HPEST99*, and *CAPEST09* are the best predictors of *HPEST09*.[10] *MERGER* is statistically insignificant in both cases. *BIGMERGER*, on the other hand, is a statistically significant predictor of *ELEST09* but not of *HPEST09*. The results therefore suggest that the mergers did have a significant effect on the rate of electrification in American manufacturing after the turn of the century, but only when they were likely to have had a large and persistent effect on an industry's concentration.

The first and second columns of Table 3 present the results of IV estimations in which the ratio of electric horsepower to total horsepower in 1909, *ELHP09*, and the ratio of electric horsepower to the value of output in 1909, *ELOUT09*, are used as dependent variables and *BIGMERGER* is used as the merger variable. The results indicate that the ratio of electric horsepower to total horsepower in 1899, *ELHP99*, is the best predictor of *ELHP09*, and the ratio of electric horsepower to the value of output in 1899, *ELOUT99*, is the best predictor of *ELOUT09*.

The coefficient of *CAPEST09* is negative and statistically insignificant in both cases. This casts doubt on whether the size of establishments had any influence on the electrification process at all, and suggests that, if anything, it was more likely that electrification proceeded rapidly in industries characterized by small establishments. The coefficient of *BIGMERGER* is positive and statistically significant at the 90 percent level of confidence in both cases (in column one it is statistically significant at the 95 percent level of confidence). This corroborates the view that, when the mergers were most likely to have had a large and persistent effect on their industry's concentration, they tended to accelerate the rate of electrification.

Since the coefficient of *BIGMERGER* in column one is 0.09 and the mean of *ELHP09* is 0.37, *BIGMERGER*'s contribution to the proportion of total horsepower provided by electricity in 1909 was more than 20 percent of the sample average. And since the coefficient of *BIGMERGER* in column two is 0.00019 and the mean of *ELOUT09* is 0.00030, *BIGMERGER*'s contribution to the ratio of electric power use to total output in 1909 was more than 60 percent of the sample average. This suggests that the mergers were quantitatively as well as statistically significant when they occurred in industries characterized by large establishments.

Since *CAPEST09* is statistically insignificant in both cases it is dropped and *ELHP09* and *ELOUT09* are regressed on the remaining variables by OLS. Columns three and four of Table 3 show the results. *ELHP99* and *ELOUT99* remain the best predictors. The coefficient of *BIGMERGER* is positive and statistically significant at the 95 percent level of confidence in each case.

TABLE 3
IV and OLS Estimates with ELHP09 and ELOUT09 as Dependent Variables

	IV		OLS	
	(1) ELHP09	(2) ELOUT09	(3) ELHP09	(4) ELOUT09
CONSTANT	0.10	8.66E-05	0.10	8.79E-05
	(0.81)	(0.29)	(0.83)	(0.30)
ELHP99	1.22	—	1.23	—
	(10.77)		(10.95)	
ELOUT99	—	1.17	—	1.17
		(4.52)		(4.56)
Food and kindred products	0.18	−5.58E-05	0.18	−5.84E-05
	(1.39)	(−0.18)	(1.35)	(−0.19)
Textiles	0.07	1.21E-05	0.06	9.11E-06
	(0.55)	(0.04)	(0.50)	(0.03)
Iron, steel, and their products	0.17	9.67E-05	0.16	9.06E-05
	(1.29)	(0.31)	(1.20)	(0.29)
Lumber and its remanufactures	0.13	1.42E-04	0.12	1.39E-04
	(0.94)	(0.45)	(0.90)	(0.45)
Leather and its finished products	0.16	−8.56E-06	0.16	9.06E-05
	(1.04)	(−0.02)	(1.01)	(−0.03)
Paper and printing	0.18	6.96E-05	0.17	6.77E-05
	(1.34)	(0.22)	(1.30)	(0.21)
Liquors and beverages	0.06	−4.01E-05	0.05	−4.26E-05
	(0.34)	(−0.12)	(0.36)	(−0.12)
Chemicals and allied products	0.06	1.85E-05	0.05	1.49E-05
	(0.43)	(0.06)	(0.37)	(0.05)
Clay, glass and stone products	0.08	3.35E-04	0.07	3.31E-04
	(0.57)	(1.05)	(0.52)	(1.05)
Metals and metal products	0.10	−8.39E-05	0.09	−8.80E-05
	(0.82)	(−0.28)	(0.75)	(−0.30)
Tobacco	0.14	−4.33E-05	0.14	−4.66E-05
	(0.69)	(-0.09)	(0.67)	(-0.09)
Vehicles for land and transport	0.20	4.61E-04	0.20	4.58E-04
	(1.43)	(1.36)	(1.40)	(1.36)
Shipbuilding	0.17	3.34E-04	0.17	3.31E-04
	(0.83)	(0.67)	(0.80)	(0.67)
Miscellaneous industries	0.15	1.06E-04	0.14	1.03E-04
	(1.21)	(0.36)	(1.15)	(0.36)
Handtrades	0.32	2.03E-04	0.30	1.97E-04
	(1.46)	(0.39)	(1.40)	(0.39)
BIGMERGER	0.09	1.88E-04	0.07	1.79E-04
	(2.00)	(1.79)	(2.18)	(2.46)
CAPEST09	−4.25E-08	−1.84E-11	—	—
	(−1.01)	(−0.75)		
Adjusted R-squared	0.45	0.11	0.45	0.11
Mean of dependent variable	0.37	2.99E-04	0.37	2.99E-04

t-statistics are in brackets.

CONCLUSION

The regression analysis offers some tentative support for the view that the great merger movement accelerated the diffusion of electric power utilization in American manufacturing after the turn of the century. In those industries in which a merger was most likely to have increased concentration for an appreciable time—those in which large-scale production was prevalent—it appears that a merger at the turn of the century had a large and statistically significant effect on the subsequent use of electric power. Since the utilization of electric power at the turn of the century constituted an important innovation, at least in the sense that Schumpeter intended, the results therefore offer some tentative support for Schumpeter's hypothesis that a high degree of industry concentration is conducive to rapid innovation. Moreover, they appear to corroborate Schumpeter's own views about the impact of the consolidation movement.

In addition to supporting the Schumpeterian hypothesis, the results also suggest that the great merger movement had important consequences for the rate and direction of technological change in American manufacturing industries after the turn of the century. As Nelson and Wright [1992] note, the turn of the century was a pivotal point in American economic development. It was only after then that the American economy acquired the technological leadership that it subsequently held for much of the twentieth century. If the great merger movement did indeed accelerate the electrification of American industry, it may also have had a significant role in the rise of American technological leadership. While the results of this study can only be regarded as tentative, they do suggest that the connection between the great merger movement and the subsequent rate of technological advancement warrants further investigation.

APPENDIX

The following is a list of the industries from the Twelfth and Thirteenth Censuses of Manufactures used in the regression analysis. They have been grouped according to the categories defined in the Twelfth Census. Where two or more industry classifications were merged, the merged industry name is used. In some cases an industry appears in more than one category because of a merger of classifications. Those industries for which a horizontal merger was recorded are denoted by an *.

Food and Kindred Products: bread and other bakery products*; chocolate and cocoa products*; coffee and spice, roasting and grinding; confectionery*; cordials and syrups; flavoring extracts; flouring and grist mill products*; food preparations*; glucose*; lard, refined; oleomargarine; rice, cleaning and polishing*; slaughtering and meat packing*; sugar and molasses*; vinegar and cider;

Textiles: awnings and tent sails; bags other than paper; belting and hose, linen and rubber; carpets and rugs, other than rag*; carpets, rag; cloth, sponging and refinishing; clothing, horse; clothing, womens' factory product; cordage and twine*; cotton

goods*; dyeing and finishing, textiles*; flax, dressed; furnishing goods, mens'; hammocks; hats and caps; hosiery and knit goods; mats and matting; millinery and lace goods; oakum; oilcloth; shoddy; silk and silk goods; upholstering materials;

Iron, Steel, and their Products: cutlery and edge tools*; files*; firearms; foundry and machine shop products*; iron and steel*; iron and steel, bolts and nuts*; iron and steel, doors and shutters; iron and steel, forgings*; iron and steel, nails and spikes; iron and steel, pipe*; pens, steel; safes and vaults; saws; scales and balances; screws*; sewing machines, cases and repairing; springs, steel, car and carriage*; typewriters and supplies*; vault lights and ventilators; wire*; wirework;

Lumber and its Remanufactures: baskets, rattan and willow ware; billiard tables and materials; boxes, cigar; coffins and burial cases and trimming*; cooperage*; cork cutting; lasts; lumber and timber products*; matches*; pulp goods*; pumps, not including steam; rules, ivory and wood; sewing machine cases, repairing and attachments; showcases; wood preserving; wood turned and carved*;

Leather and its Finished Products: belting and hose leather; leather goods; leather, tanning and finishing*;

Paper and Printing: bags, paper*; boxes, fancy and paper*; cardcutting and designing; engraving and diesinking; engraving, wood; labels and tags; paper and wood pulp*; paper patterns; photolithographing and photoengraving; printing and publishing; stereotyping and electrotyping;

Liquors and Beverages: liquors, distilled*; liquors, malt*; liquors, vinous*; malt*; mineral and soda waters;

Chemicals and Allied Products: baking and yeast powders*; bone, ivory and lamp black; chemicals*; dyestuffs and extracts*; explosives*; fertilizers*; oil, castor; oil, cottonseed and cake*; oil, essential; oil, linseed*; oil, not elsewhere classified*; paints; patent medicines and compounds; petroleum refining*; salt*;

Clay, Glass and Stone Products: brick and tile*; crucibles; emery wheels*; glass*; glass, cutting, staining, and ornamenting; grindstones*; hones and whetstones; kaolin and other earth grinding*; lime and cement*; marble and stone work; mirrors; pottery and fire-clay products*;

Metals and Metal Products, not Iron and Steel: babbit metal and solder; brass and brass goods*; clocks*; electroplating; galvanizing; gold and silver, leaf and foil; gold and silver reducing and refining*; handstamps; lead, bar, pipe, and sheet*; needles and pins; pens, fountain, and gold; smelting and refining, not from ore*; tinfoil; type founding; zinc, smelting and refining*;

Tobacco: tobacco products*;

Vehicles for Land Transportation: bicycles and tricycles*; carriages and sleds, childrens'; carriages and wagons*; cars, general shop construction*; cars, railroad and street*;

Shipbuilding: shipbuilding*;

Miscellaneous Industries: agricultural implements*; artificial feathers and flowers; artists materials; axle grease; belting and hose, linen and rubber; blacking; bluing; boots and shoes, rubber*; brooms and brushes; buttons; calcium; coke*; corsets; dentists' materials; drug grinding; electrical apparatus and supplies*; enameling and enameled goods*; engravers' materials; fire extinguishing chemicals; fireworks*; foundry supplies; fur goods; furs, dressed; gas, illuminating and heating*; gloves and mittens; glue*; graphite and graphite refining; grease and tallow; hat and cap materials; house furnishing goods; ice, manufactured*; ink; instruments, professional and scientific; jewelry and instrument cases; lapidary work; mattresses and spring beds; models and patterns; mucilage and paste; musical instruments, materials; musical instruments, pianos and organs*; optical goods; pencils, lead; pens, fountain and gold; photographic apparatus and materials*; pipes, tobacco*; rubber and elastic goods*; soap and candles; soda water apparatus; sporting goods; steam packing; surgical appliances; umbrellas and canes; whips; windmills; window shades;

Hand Trades: sewing machines, cases and repairing.

NOTES

1. See Golbe and White [1988, 273] as amended by Carlton and Perloff [1994, 35].
2. See Golbe and White [1988, 275] as amended by Carlton and Perloff [1994, 36].
3. See Stigler [1968, 101-2] for a summary.
4. These include Livermore [1935], Stigler [1968], Nutter and Einhorn [1969], and Lamoreaux [1985].
5. See Hughes [1983] for an overview of the "second industrial revolution."
6. This occurred in the 1880s. Electricity was used in some American factories as early as the 1870's as a source of power for fire alarms and clocks. These uses were more notable, however, for their novelty than for their impact on manufacturing productivity. See Nye [1991, 188-91].
7. These were "fancy goods not elsewhere classified" and "stationery goods not elsewhere classified."
8. This was "china decorating."
9. As Chandler [1990, 35] has pointed out, the difficulty of financing a viable capital investment constituted a significant barrier to entry at the turn of the century. Thus, the large size of the establishments probably made subsequent entry by new competitors more difficult. The initial increase in industry concentration was probably also greater when larger establishments were combined.
10. The constants and industry category dummies are statistically insignificant in most of the regressions. Since there is a very high degree of multicolinearity between them this is not at all surprising. These variables are not of particular interest themselves. They have been included only to help isolate the effects of the mergers.

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