

Testing the Schumpeterian Hypothesis

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INTRODUCTION

The late Joseph Schumpeter, a towering figure of the twentieth century, had opposing views about economic development (Winter, 1984; Awan, 1986). His early work (1934) argued that innovation is promoted by the presence of entrepreneurs outside the firm. Later he argued that innovation activity is promoted by large firms, for whom the innovation process is endogenous (1942). It has been suggested that endogeneity of the entrepreneurial function in the large firm eliminates the entrepreneur and subverts the entrepreneurial spirit, thus bringing into question the future of capitalist society (Heilbroner, 1984).

The lack of innovative activity has recently emerged as a possible source for both the recent decline in the U.S. manufacturing sector and the deterioration of the competitive position of many U.S. industries (Griliches, 1986). Despite this concern, very little has been established in the literature to identify those conditions and market environments which are either conducive to or hinder innovative activity.¹

Unfortunately, the concern of empirical research has chiefly focused on the innovative activities of relatively large firms (Scherer, 1965, and Cohen et al., 1987) and thus have relevance only to the later Schumpeterian hypothesis.² The inferences that have been made may be misleading since, as this paper will show, almost half of innovations made are achieved by firms which employ fewer than 500 workers. Moreover, past studies have related only to indirect measures of technical change (Pakes, 1985). Yet, product innovation has, historically, been the most significant form of technical progress (Shapiro, 1986). The purpose of this paper is to test the Schumpeterian hypothesis offering a direct measure of product innovation and applying it to data newly released by the U.S. Small Business Administration. Not only is this the first broad measure of innovation for manufacturing industries generally, but it can also accommodate all firm sizes.

The first section of this paper summarizes Schumpeter's two views about innovation. Earlier empirical findings on the later Schumpeterian hypothesis are presented in the second section. Variations in innovation rates across manufacturing industries are examined in this third section. The major hypotheses emanating from previous findings are presented in the fourth section along with a cross-section regression model estimating innovation rates. A summary and conclusions are presented in the last section, which argues that there is support for both the early and later Schumpeter hypotheses about innovation.

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The Two Schumpeters

In the *Theory of Economic Development*, Schumpeter (1934) calls attention to the role of the entrepreneur, who plays a central role in his analysis of capitalist evolution. It is the entrepreneur's social function that is central to the book. The entrepreneur, as a member of a social class, is central to the economy's continual self-generated growth. While it is the "essentially unadventurous bourgeois class that must provide the leadership role, it does so by absorbing within its ranks the free spirits of innovating entrepreneurs who provide the vital energy that propels the system. The underlying 'preanalytic' cognitive vision is thus one of a routinized social hierarchy, creatively disrupted by the gifted few," (Heilbroner, 1984, p. 690) who are not associated with an established firm.

In *Capitalism, Socialism and Democracy*, Schumpeter draws attention to the role of the large (monopoly) firm as an effective engine of economic progress: "The monopolist firm will generate a larger supply of innovations because there are advantages which, though not strictly unattainable on the competitive level of enterprise, are as a matter of fact secured only on the monopoly level" (1942, p. 101). In this case innovation is typically not the result of outsiders but is endogenous to the model. Galbraith concurred with this later Schumpeterian view that "There is no more pleasant fiction than that technical change is the product of the matchless ingenuity of the small man forced by competition to employ his wits to better his neighbor. Unhappily, it is fiction" (1956, p. 86).

However, it is also the large corporation that draws attention to Schumpeter's gloomy expectations for economic progress. The ideologically plausible capitalism, as Schumpeter himself wrote, contains no purely economic reason why capitalism should not have another successful run. The socialist future of Schumpeter's drama, therefore, rests wholly on extraordinary factors. The large corporation, by taking over the entrepreneurial function, not only makes the entrepreneur obsolete, but undermines the sociological and ideological functions of capitalist society:

"And so the capitalist process loses its élan. The bourgeois family, the great transmission belt of entrepreneurial values, becomes infected with the prevailing disease of rationalism. The bourgeois class loses faith in itself. With very little resistance, it yields to the new order—for capitalism, in its dissolution, is in fact creating a new order: socialism. The drama proceeds at an indeterminate pace, with the death sentence given a century-long "short-run". . .

(Heilbroner, 1982, p. 59, emphasis added.)

The extent to which the large corporation replaces the small- and medium-sized enterprise should have a positive influence on economic growth in the "short run." However, as the resulting economic concentration starts to have a feedback effect on entrepreneurial values, innovation and technological change may decline in the large corporation, bringing about slower economic growth. Technology as "the means by which new markets are created, the source of that 'perennial gale of creative destruction', that fills the sails of the capitalist armada," (Heilbroner, 1984, p. 686) may die out.³

To what extent can slower economic growth during the 1970s and early 1980s be attributed to the slowdown of "market creating" innovation by large firms? This is a complicated question. However, in the U.K. between 1956 and 1983 the ratio of manufacturing firms' innovations share to their shares of employment declined from 0.91 to 0.37 for firms with between 5,000 and 9,999 employees. The decline was similar for all larger firm-size categories (Pavit et al., 1986). In the U.S., R&D expenditures relative to sales dropped from 4.2 percent to 2.6 percent between 1968 and 1979. The overall slowdown in the growth of productivity during

the 1970s can be attributed, at least in part, to the relative and absolute decline in private sector R&D expenditures by large firms (Griliches, 1986).⁴ While the large firm carries out a disproportionate share of R&D, the entrepreneur, and in some cases the individual inventor, is not an endangered species. On the contrary, it would appear that in the present world the innovative entrepreneur, operating in a profit-maximizing environment exerts at least a minimum influence, and often plays a central role in innovation (Shapiro, 1986, Winter, 1984).

Testing the Later Schumpeterian Hypothesis

A substantial industrial organization literature relating market structure to innovation exists which provides some insight into the so-called Schumpeterian hypotheses that innovation activity is promoted (1) by the presence of imperfect competition, and (2) by large rather than small firms (Kamien and Schwartz, 1982). Most empirical studies have also attempted to identify the environment most conducive to technical progress but unfortunately, no completely satisfactory measure of technological progress has been available. A few studies have been able to use direct measures of innovations (Mansfield, 1968; Freeman, 1971; Pavit et al., 1987; Acs and Audretsch, 1986, 1987), but most have relied on proxy variables. These proxy variables have either been some measure of innovative output, such as patented inventions (Scherer, 1965, Pakes, 1986), or else innovative inputs, such as R&D expenditures (Connolly and Hirschey, 1984, Scherer, 1984, Cohen et al., 1987).

The literature has generally focused on the relationship between technical change and firm size, level of industry concentration, and the extent of entry barriers. Not surprisingly, the focus of many of these studies has been on the relationship between market concentration and proxy measures of innovation. For example, Scherer (1965) found that concentration has only a modest effect on the number of patented inventions, which gave mild support to the latter Schumpeterian hypothesis. Connolly and Hirschey (1984) found a negative relationship between R&D and concentration, while Mansfield (1981) found a negative relationship only for the most ambitious and risky projects. A positive relationship between R&D expenditures and concentration has generally exists in industries with low technological opportunities (Scherer, 1967, Shrieves, 1978). The relationship between R&D expenditures is apparently more complicated in higher technological opportunity class industries. Examining those industries in which a technologically fertile environment exists, Angelmar (1985) found that the level of concentration was positively related to technical change only when R&D was both expensive and uncertain, but without barriers to imitation. Levin et al. (1985) found that industrial concentration has no independent significance as a determinant of innovation once technological opportunity is controlled for.

Several studies have also used proxy measures of innovation to test the second tenet of the Schumpeterian hypothesis, specifically, that large firms are more conducive to innovative activity than are small firms. Scherer (1965) found that inventive output was positively related to firm size but the relationship was less than proportional.⁵ These findings underlie the prevalent assumption that the empirical relationship between the volume of innovative activity and firm size was an S-shaped one, with a relatively low share for small firms, increasing for the medium and large firms, and then slowing down for the very largest. A recent study which used Federal Trade Commission Business Data, found that firm sized had no independent effect on innovative output. However, their data "are drawn from firms that are among the largest in the U.S. manufacturing sector" (Cohen et al., 1987, p. 564).

When the entire spectrum of firm size is studied, small firms have been found to contribute a significant number of innovations. This has been substantiated in several studies for different time periods and different countries (Freinman and Fuentevilla, 1976, Edwards and Gordon, 1984, Pavit et al., 1986 and 1987, Acs and Audretsch, 1986, 1987). Pavit et al. (1987), using a direct measure of innovative output for the period 1945-83, found little support for the S-shaped relationship between firm size and innovative output. They hypothesized that the relationship was U-shaped and becoming increasingly so over time. That is, small firms and large firms are more innovative than medium-sized ones.

Several studies have focused on the relationship between entry barriers and proxy measures of innovation. Freeman (1971), and Acs and Audretsch (1986, 1987) found support for the hypothesis that innovative activity is higher in the presence of low capital intensity than when confronted by a high capital-labor ratio. By contrast, other studies have failed to find a significant relationship between either capital intensity or advertising expenditures and R&D (Comanor, 1967).

The Data

Perhaps the greatest obstacle facing researchers who undertake to measure technological change has been the lack of data on innovation activity. In an effort to remedy this deficiency, the Office of Advocacy of the U.S. Small Business Administration mounted six studies between 1980 and 1986 to provide a direct measure of innovative activity. These essentially consisted of extensive surveys, of which the latest compiled a list of innovations from numerous technology, engineering, and trade journals published in 1982. The data base was constructed to facilitate assignment of innovations to the relevant four-digit standard industrial classification (SIC) industry. There is, of course, a considerable time lag between the time an invention is made and the resulting innovation, or when the invention is introduced to the market, and a perhaps even greater time lag between the application of research and development (R&D) and other innovative inputs and the invention. Thus, it is not at all unrealistic to expect that most of the innovations included in the 1982 data base resulted from economic conditions and, more specifically, the market structure of the late 1970s. More detailed explanations of the data base can be found in Acs and Audretsch (1986, 1987) and Edwards and Gordon (1984).

Several other qualifications must be made about the application of this data base. First, while we can conceptualize in the manner of Shapiro (1986) how markets are developed and expanded through product and process innovation, the trade journals report relatively few process, service and management innovations and tend, mainly, to capture product innovations. Second, while the innovations were classified according to importance by the Small Business Administration, all recorded innovations are considered as homogeneous in this study. Despite these qualifications, these data certainly are the best measure of innovative activity across manufacturing industries that have been developed. The simple correlation of 0.48 between the innovation measure and the 1977 Federal Trade Commission (FTC) R&D expenditure reveals that R&D and innovation activity are not at all the same economic phenomenon.

Several economists have argued that the absolute number of innovations made is not the best measure of innovative activity, since it is not standardized by some equivalent measure of industry size. That is, direct comparisons between industries are better made after standardizing the innovative measures for industry size. Since some of the innovations could not be identified by industry, this study uses only 4,531 innovations in manufacturing. The average manufacturing innovation rate per employee (thousands) was 0.2735.⁶ The innovation rate has the advantage of standardizing the measure for the relative weight of the industry.

TABLE 1
Innovation Rates From 1977 Inventions^a

Sector	No. of Industries	R&D/Sales 1977 (%)	Innovation Rates
Food	47	0.4	0.2119 (0.1742)
Textiles	30	0.4	0.0740 (0.0612)
Apparel	33	0.4	0.1253 (0.1553)
Lumber	17	0.8	0.1400 (0.2179)
Furniture	13	0.8	0.3053 (0.2917)
Paper	17	0.9	0.1616 (0.1651)
Printing	17	0.9	0.0426 (0.0350)
Chemicals	28	3.6	0.7592 (0.5945)
Petroleum	5	0.7	0.3386 (0.3797)
Rubber	6	2.1	0.1204 (0.0787)
Leather	11	0.6	0.1356 (0.1487)
Stone, Clay & Glass	27	1.3	0.2130 (0.1640)
Primary Metals	26	0.7	0.1586 (0.2905)
Fabricated Metal Products	36	1.2	0.3224 (0.3109)
Machinery (non-electrical)	45	4.9	0.6039 (0.6728)
Electronics	39	6.9	0.3713 (0.3510)
Transportation Equipment	17	3.1	0.1250 (0.1289)
Instruments	13	6.3	1.3586 (0.9939)

^aInnovation rates are defined as the number of innovations divided by employment (thousands of employees). Standard deviations are listed in parentheses. R&D/sales figures are from the National Science Foundation (1986). The two-digit SIC sector mean values are the weighted average (using 1977 value-of-shippments) of the four-digit SIC industry values.

Table 1 shows the average innovation rates for industries aggregated to the two-digit SIC level. For example, in the 47 industries in the food sector there was an average of 211.9 innovations per million employees. Thus, the average innovation rate in the food sector was about three times as high as that in textiles, but only slightly higher than the rate in apparel or lumber. The lowest innovation rates were in the printing (0.0426), textiles (0.0740), rubber (0.1204), and transportation equipment (0.1250) industries. The highest innovation rates were in the instruments industries (1.3586).

Table 1 also shows the 1977 R&D sales ratio for two-digit levels. While the instruments

and electronics industries both had R&D sales ratios in excess of 5 percent, which is high relative to others, these industries also had the highest innovation rates. On the other hand, the textile and lumber industries had low R&D sales ratios and also low innovation rates. Thus, there is generally a positive association between R&D and innovative activity.

The Model

Based on the theories and findings in the empirical literature discussed above, we test the hypothesis that innovative activity is significantly influenced by industry market structure, particularly the level of concentration, the extent of entry barriers, the size distribution of firms, the degree of unionization, and the potential for technological progress in the industry, by estimating the following regression model:

$$(1) \quad \begin{aligned} \text{Innovation/Employee} = & \beta_0 + \beta_1 \text{ Capital Intensity} \\ & + \beta_2 \text{ Concentration} \\ & + \beta_3 \text{ Collective Bargaining} + \beta_4 \text{ Growth} \\ & + \beta_5 \text{ Advertising} + \beta_6 \text{ Large-firm Share} \\ & + \beta_7 \text{ Human Capital} + \beta_8 \text{ Scientists} + \mu \end{aligned}$$

where the dependent variable is the number of innovations introduced in the four-digit SIC industry, divided by industry employment.⁷ Included as an explanatory variable is the 1977 capital-output ratio, defined as gross assets divided by value-of-shipsments. According to the later Schumpeterian hypothesis, as interpreted by Comanor (1967), high levels of capital intensity represent significant entry barriers and should exert a positive influence on innovative activity.

Also included is the four-firm concentration ratio in 1977. If β_2 exceeds zero, the later Schumpeterian hypothesis that concentrated industries are conducive to innovative activity will be supported. Conversely, if β_2 is less than zero, the hypothesis that more competitive markets are a catalyst for innovative activity will be supported.

The percentage of employees in the industry engaged in collective bargaining in 1975 is also included. More recently, several models have been developed arguing that unions capture rents from intangible capital investments, and, in particular, those accruing from innovation-producing R&D (Connolly et al., 1984). To the extent that unions are successful in such rent-seeking activities, the ease of appropriability by the innovative firm is clearly reduced. Therefore, a negative relationship between union and TI is expected.

The percentage growth in the number of employees between 1972 and 1977 is also an explanatory variable.⁸ Since industries experiencing higher growth rates are more likely to be in the earlier stages of the product life cycle, and therefore face a richer potential for exploiting technological advances,⁹ β_4 is expected to be positive.

Advertising intensity is measured by advertising expenditures divided by value-of-shipsments, 1977. Since advertising reflects both the extent of product differentiation in the industry as well as a barrier to entry (see Comanor, 1967), the later Schumpeterian hypothesis implies that it should have a positive influence on innovation activity. The large-firm share is the percentage of an industry which is accounted for by firms with more than 500 employees in 1977.¹⁰ To the extent that large firms contribute to innovations, the large-firm share should be positively related to innovative activity.

For purposes of this study human capital is defined as professional and kindred workers,

plus managers and administrators, plus craftsmen and kindred workers, as a percentage of total employment in 1970.¹¹ Human capital is expected to be positively related to innovative activity, since it reflects the potential for commercial technological advances in the industry. Also included is a measure of R&D intensity, defined as the number of scientists and engineers engaged in R&D, as a percentage of total employment in 1970. Since this measure should reflect the "technological opportunity class" (Kamien and Schwartz, 1975, 1982) of an industry, it should be positively related to innovation activity. Finally, μ is defined as stochastic disturbance. A correlation matrix of the independent variables is in Appendix A¹².

Regression Results

Using total innovations per employee as the dependent variable, the cross-section regressions for 247 four-digit SIC manufacturing industries are shown in Table 2. In Equation 1 the negative, but statistically insignificant coefficient of capital intensity implies that higher levels of capital intensity do not lead to a significantly higher level of innovative activity.

The negative and statistically significant coefficient of concentration suggests that higher levels of concentration tend to be a deterrent towards innovative activity. While the emergence of a negative and significant relationship is consistent with the findings of Connolly and Hirschey (1984), it is a much stronger result than found by Scherer (1965) and Levin et al. (1985).

The negative and statistically significant coefficient of collective bargaining implies that the extent to which an industry is unionized is negatively associated with the number of innovations. Growth has a negligible impact on innovation activity, but advertising is positively and significantly related to innovative activity. Thus, while Comanor (1967) could find no evidence supporting his hypothesis that the extent of product differentiation in an industry is positively related to innovative activity, we find support for that hypothesis here.

The coefficient of the large-firm share is positive and statistically significant, implying that the greater the proportion of an industry with large firms, the greater is the level of innovative activity. While this result does not support the findings of Cohen et al. (1987), it does not necessarily contradict the findings of Scherer—that the relationship between innovation and firm size is S-shaped—since Scherer only looked at large firms. It does, however, lend support to the findings of Pavit et al. (1987) that the relationship between innovation and firm size is U-shaped. While firm size is an important determinant of innovation, we also know that the small firms supply almost half of the innovations.¹³

The coefficient of human capital is similarly positive and statistically significant. This suggests that industries which utilize a relatively high content of skilled labor tend to be more innovative than those that rely on unskilled labor.

While the coefficient of scientists is negative and statistically significant, this result could be attributable to multicollinearity. The simple correlation between scientists and human capital is 0.93, which may introduce considerable bias in their estimated coefficients. Thus, in Equation 2, a slightly different measure of R&D intensity is substituted for scientists. This alternative measure, scientists 2, is defined as the percentage of scientists and engineers who are engaged in R&D. While the coefficient of the alternative R&D variable, scientists 2, becomes statistically insignificant in Equation 2, the coefficients of the other variables remain virtually unchanged.¹⁴

Because the correlation between the large-firm share and concentration is relatively high, .67, the large-firm share is excluded from Equation 3. The omission of the large-firm share

TABLE 2
Regressions of Total Innovation Rates^a

Equation	Capital Intensity	Concentration	Collective Bargaining	Growth	Advertising	Large-firm Share	Human Capital	Scientists ¹	Scientists ²	Constant	R ²	F
1	-0.206 (0.181)	-0.006 (0.002)**	-0.004 (0.002)**	-0.065 (0.442)	31.714 (17.672)*	0.292 (0.157)*	6.642 (1.277)**	-0.107 (0.053)**	—	0.126 (0.102)	.302	12.909**
2	-0.169 (0.180)	-0.006 (0.002)**	-0.004 (0.002)**	-0.106 (0.444)	34.629 (17.915)*	0.265 (0.157)*	4.779 (0.687)**	—	-0.435 (0.349)	0.302 (0.127)**	.295	12.449**
3	-0.171 (0.181)	-0.004 (0.001)**	-0.003 (0.002)**	-0.036 (0.441)	33.085 (17.747)*	—	6.777 (1.281)**	-0.098 (0.053)*	—	0.170 (0.100)**	.292	14.117**
4	-0.140 (0.179)	-0.006 (0.002)**	-0.004 (0.002)**	0.113 (0.444)	31.775 (17.789)*	0.260 (0.157)*	4.313 (0.577)**	—	—	0.199 (0.095)**	.290	13.97**
5	-0.068 (0.188)	-0.006 (0.002)**	-0.005 (0.002)**	-0.027 (0.465)	27.334 (18.590)	0.3380 (0.165)**	—	0.137 (0.025)**	—	0.366 (0.096)**	.223	9.816**

^aThe dependent variable is the industry innovation rate. Standard errors are listed in parentheses.

*Significant for the 90% level of confidence, two-tailed test.

**Significant for the 95% level of confidence, two-tailed test.

leaves the regression results virtually unchanged from Equation 1. The coefficient of capital intensity increases from -0.206 to -0.171 , but remains statistically insignificant. The coefficient of concentration also changes slightly, from -0.006 to -0.004 , but remains statistically significant. While the coefficient of collective bargaining remains statistically significant, that of growth remains statistically insignificant. The coefficient of advertising increases only slightly, from 31.714 to 33.085, as does the coefficient of human capital, from 6.642 to 6.777. Thus, the regression estimates are apparently robust with respect to inclusion or exclusion of the large-firm share.

Because of the likely multicollinearity between scientists and human capital, scientists is excluded from Equation 4. Once again, the estimated coefficients reveal considerable robustness; the coefficients of concentration, collective bargaining, advertising and the large-firm share are virtually identically between Equations 1 and 4, while the coefficient of human capital changes only modestly, from 6.642 to 4.313. In Equation 5, human capital is excluded from the regression. The most significant result in Equation 5 is the positive and statistically significant coefficient of scientists. This suggests that the negative coefficient of scientists in Equation 1 is probably a biased result of multicollinearity and that the positive and statistically significant coefficient in Equation 5 is the unbiased estimate.

CONCLUSION

We have argued that Schumpeter had more than one theory of economic development. Using a more direct measure of innovation, over the full spectrum of firm sizes, it was established that innovative activity is promoted by large firms, although monopoly power deters innovation. These conclusions emanate from testing the following hypothesis: innovation rates are significantly influenced by industry market structure, particularly the level of concentration, the extent of entry barriers, the size distribution of firms, and the potential for technological progress in the industry. While the literature implies a somewhat ambiguous relationship between concentration and technological progress, our results are unequivocal—industry innovation rates fall as the level of concentration rises. This strong negative relationship between innovation rates and concentration may be interpreted as “evidence” of the Schumpeterian prognosis that monopoly power undermines the sociological and ideological functions of capitalist society (Heilbroner, 1984).

While the literature has generally found support for an S-shaped relationship between innovation and firm size, our results lend support to the U-shaped one, where both small and large firms are conducive to an innovative environment. New firms using innovation as a strategy are deconcentrating markets¹⁵ as well as creating competition between small and large firms, entrepreneurs and large corporate managers. Perhaps Schumpeter did not foresee, because of his aristocratic European background, that the entrepreneurial “spirit” that characterized the nation’s earlier history would again emerge and exert a strong feedback on entrepreneurial values. The contemporary supply of new small firms suggests that Schumpeter’s earlier hypothesis is as relevant as the later one.

FOOTNOTES

1. For an excellent review of these empirical tests, see Kamien and Schwartz (1982 and 1975).
2. Kamien and Schwartz (1975, p. 15) characterize the Schumpeterian debate as, “A statistical

- relationship between firm size and innovative activity is most frequently sought with exploration of the impact of firm size on both the amount of innovational effort and innovational success."
3. While the Schumpeterian hypothesis suggests that high entry barriers, through promoting market power, are conducive to higher levels of innovative activity, Dasgupta and Stiglitz (1980) develop a model in which a pure monopolist who is protected by entry barriers has little incentive to invest in R&D. Also see Elliott (1980) especially pages 55-57.
 4. In 1977 the top 400 firms on the Fortune 500 list accounted for 90 percent of private sector R&D spending in the United States (Connolly and Hirschey, 1984).
 5. Note that Scherer's (1965) study was limited to the largest 500 corporations and generally excluded firms with fewer than 5,000 employees.
 6. Employment data are based on 1977.
 7. Because the 1982 innovations were, on average, the result of 1977 inventions, the dependent variable can actually be viewed as the number of 1977 inventions, divided by employment, that ultimately proved to be commercially successful by 1982.
 8. The percentage growth rates are divided by five.
 9. The literature on the product life-cycle defines the introduction and growth stages—when growth rates are at their maximum—as the phases with the most potential for technological progress. For a discussion see Vernon (1966).
 10. The large-firm share is measured in terms of employment. It is the percentage of total employment accounted for by firms with more than 500 employees.
 11. This is the only year available for this measure. Because most industry-specific characteristics, such as human capital, are fairly stable over a lengthy period, the lag between the independent and dependent variables should not result in any serious bias.
 12. A summary of all variable sources and further data descriptions are available from the authors upon request.
 13. Recent studies have shown that the greater the extent to which an industry is composed of large firms, the higher will be the innovative activity, but that increased innovative activity will tend to emanate from the small firms, and not the large firms, in the industry (Acs and Audretsch, 1986). Further, small firms have the relative innovative advantage in markets more closely approximating the competitive model while large firms have the innovative advantage in markets characterized by imperfect competition (Acs and Audretsch, 1987).
 14. The estimated coefficients of human capital and scientists 2 are still not likely to be free from the bias caused by multicollinearity. The simple correlation between scientists 2 and human capital is 0.60.
 15. For example, see Acs, Audretsch and Carlsson (1988), and Carlsson (May 1988).

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APPENDIX A
Correlation Matrix of Independent Variables

	Capital Intensity	Concentration	Collective Bargaining	Growth	Advertising	Large-firm Share	Human Capital	Scientists ¹
Concentration	.31	—						
Collective Bargaining	.21	.27	—					
Growth	-.09	-.09	-.06	—				
Advertising	-.06	.16	-.08	-.03	—			
Large-firm Share	.27	.67	.29	.06	.08	—		
Human Capital	.05	.24	-.08	.17	-.03	.39	—	
Scientists ¹	.06	.24	-.01	.19	-.05	.42	.93	—
Scientists ²	-.05	.22	-.10	.11	.11	.28	.60	.60