

**Firm Size and R&D;
Testing the Schumpeterian Hypothesis**

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I. INTRODUCTION

Ronald Coase succeeded in linking up organization with cost in "The Nature of the Firm." He has said that his theory, "explained why there were firms but not how the functions which are performed by firms are divided up among them" (Williamson and Winter 73). Economists, thanks to Coase, understand that firms exist because some transactions internal to firms are less costly than similar transactions carried out in markets and that the limit of the firm depends on cost comparisons at these margins. Coase suggests that we build on his theory and try to understand the internal operations of a firm and the decisions firms make so that we can become more knowledgeable in the field of industrial organization.

The firm is forced to choose among a multitude of decisions; however, this paper aims solely to look at the question of R&D, research and development, expenditure. More specifically, this paper asks the question, What is the relationship between the size of the firm and R&D? And do larger firms spend more on R&D relative to their size than smaller firms? The answers to these questions have important implications concerning a firm's incentives for growth and innovation. These answers will also put us a step closer to understanding the functions performed by firms as Coase suggests.

Exploring the relationship between R&D and the size of the firm is not a novel idea. Joseph Schumpeter in 1942 developed his theory that large firms would spend more on R&D relative to their size than small firms. John Kenneth Galbraith followed with his ideas a decade later arguing that large firms would find R&D expenditure less risky than small firms. More recently, Kenneth Arrow in 1962 has articulated that larger firms are better able to capture the property rights to their inventions and thus have a greater incentive for R&D activity. Harold Demsetz in 1969 has criticized Arrow's theory stating that it is unclear whether a large or small firm is better suited for R&D expenditure. Although Schumpeter and Galbraith have offered no real world data to support their claims, their theories have been surprisingly supported by various economists. I plan to see if the evidence supports this popular belief that larger firms spend more on R&D relative to their size than smaller firms after first examining these prevalent views more closely.

II. THE SCHUMPETERIAN HYPOTHESIS

Schumpeter argues in *Capitalism, Socialism, and Democracy* that the degree of innovation is positively correlated with short-run protection and market power (Schumpeter 1942). Schumpeter believes that a large firm needs short-run legal protection which would provide enough short-run market power to create an incentive to invest in R&D. Without any protection, Schumpeter feels that large firms would not be as likely to invest in innovative activities and there would be no technological change. Schumpeter states that only large firms could induce technological change because small firms were incapable of "optimal" expenditures for R&D. In other words, small firms would not have the ability to spend efficient resources on R&D because doing so would be too hazardous in such a competitive environment. Schumpeter argues that large firms have a greater incentive to spend more on R&D than small firms because they have more

resources available to stimulate technological change and can expect larger gains to innovation than smaller firms because their market share (or market power) would serve as a buffer to immediate imitation.

An economist wishing to study innovation and R&D will have trouble overlooking the Schumpeterian hypothesis because although his argument is not backed by strong proof, his argument is logical and strong in dictating that innovation requires a sizable commitment of resources and that imitation by others (as in the case of perfect competition) reduces the rewards enough so that there are diminishing incentives to innovate. Because research is very costly for a small firm (which does not have the capital and extensive technology like the larger firms) and it is less expensive for a small firm to imitate another firm's innovative activities rather than to innovate itself, Schumpeter suggests that the small firm will not choose to participate in many innovative activities.

III. OTHER THEORIES RELATING FIRM SIZE AND INNOVATION

1. Galbraith on the Economics of Technical Development

John Kenneth Galbraith follows Schumpeter's hypothesis and argues that large firms are "perfect" for innovation (Galbraith, 1952). Galbraith states in *American Capitalism*, "Because development is costly, it follows that it can be carried on only by a firm that has the resources associated with considerable size" (Galbraith 92). Here Galbraith defines cost as the time and risk involved in the execution of an R&D project. Galbraith asserts that small firms do not have the time to spend on R&D because it is too costly and risky and in contrast large firms can spread the risk over a large number of R&D projects. He believes that the larger firms are more capable than the smaller firms at minimizing the costs associated with R&D. Finally, Galbraith states that only large firms can fully exploit the results of R&D expenditures.

2. Arrow on Inventive Activity

More recently, the relationship between firm size and expenditure on research and development has been articulated by Kenneth Arrow in "The Rate and Direction of Inventive Activity." (Arrow 1962) Arrow explains that small competitive firms will underinvest in R&D because they are risk averse, financially weaker, and unable to fully exploit the returns to innovative activities. Arrow's argument is a culmination of the views of Schumpeter and Galbraith with a greater focus on risk and property rights. Arrow asserts that smaller competitive firms are less able to establish property rights over their inventions and therefore technological innovation becomes a public good because imitation is impossible to prevent. Arrow suggests that obviously no firm will desire to produce a public good and knowingly drive itself out of business, thus only larger firms with greater market power will have better incentives for innovation.

3. Demsetz's Critique of Arrow

Harold Demsetz in "Information and Efficiency: Another Viewpoint," argues that Arrow's theory is not plausible (Demsetz 1969). Demsetz is not necessarily attacking Arrow's conclusion that large firms are better suited for R&D activity, rather he is attacking the premises behind Arrow's conclusions. Demsetz states that competition among small firms may actually produce greater research and innovation. Demsetz believes that Arrow's reasons for why competitive firms underinvest could be used just as easily to explain why large firms underinvest if, for example, one was to argue that larger firms have more difficulty in capturing the property rights to their inventions. Demsetz claims that risk is not avoidable at a zero cost because avoiding risk may be more costly than undertaking the risk. His attack of Arrow's argument concerning risk explains that risk can be used in defense of small or large firms, thus it negates risk as an important attribute of R&D and as a characteristic of the firm's size. Secondly, Demsetz attacks Arrow's claim that innovation in a competitive firm is defeated because property rights are not clearly defined:

...it may be no more difficult to police property rights in many kinds of knowledge than it is to prevent the theft of automobiles and cash. And even if some kinds of information are more difficult to protect, I am not sure which institution yields the better solution to the problem... (Demsetz p.11)

Demsetz is not arguing that innovation is best carried out by a large or small firm, rather he believes that it is not clear based on Arrow's assumptions what the relative size of the firm with regard to innovation should be. Demsetz declares that Arrow's argument is idealistic because no known firm whether large or small can completely protect itself from the risk associated with innovation nor can it fully own the rights to all of its innovations indefinitely. To suggest that a larger firm can spend more efficiently on R&D than a smaller firm simply because of the problems of risk and of property rights is a fantasy and Demsetz effectively comments:

But modern analysis has yet to describe efficiency in a world where indivisibilities are present and knowledge is costly to produce. To say that private enterprise is inefficient because indivisibilities and imperfect knowledge are part of life, or because... persons are risk-averse, is to say little more than that the competitive equilibrium would be different if these were not the facts of life. But if they are the facts of life...they cannot be erased from life at zero cost... (Demsetz p.19)

Demsetz does not leave the reader with a direct answer as to why firms innovate, nor does he give a theory of innovation, instead he concludes with the notion that individual firms decide on R&D expenditures by looking at a balance between the possible returns than can be earned by additional experimentation (on the margin) and the costs associated with them. He prescribes that the innovator should strive to find a balance between three

main objectives: to take part in a wide variety of experimentation, put investment into promising ventures, and the have the ability to fully gain from any knowledge that results from the innovative process (Demsetz 20).

IV. TESTING THE SCHUMPETERIAN HYPOTHESIS

Economic theory in the subject of research and development especially during the early 1940s to the 1960s apparently has given weight to the notion that larger firms will spend more on R&D. Although Schumpeter, Galbraith, and Arrow have slightly different reasons as to why larger firms spent more on R&D; their conclusions are identical. While Demsetz does not state that larger firms spend more on R&D, he does not say that smaller firms spend more on R&D. Demsetz suggests that it is inconclusive whether a large or small firm spends more on R&D. Thus the task remains to see if the Schumpeterian hypothesis is supported by modern econometric analysis. Through a brief examination of the studies done by Horowitz, Hamberg, Worley, Comanor, Scherer, Mansfield, Grabowski, and Mueller; I will look to see if larger firms do indeed spend more on R&D relative to their size when compared to smaller firms.

A few studies suggested an extremely weak positive association between R&D employment and firm size. Horowitz in "Firm Size and Research Activity" finds a weak correlation between research expenditure per sales dollar in his study that used data from 1947, 1951, and 1952 (Horowitz 1962). Hamberg discovers that the ratio of R&D employment to total employment to be only slightly correlated with total employment and total assets as well (Hamberg 1966). Log-linear regression revealed that the elasticity of R&D effort with respect to firm size exceeded unity in only three of the industries. Worley notices that the elasticity of R&D effort with respect to firm size exceeded unity in only two of the eight industries that he studied (Worley 1961). Worley looked at 198 firms and notes that the firms in the middle-sized range tended to spend more on R&D employment than both firms that were smaller, and those that were larger. Log-linear regressions were fit by Comanor in his 1967 study titled "Market Structure, Product Differentiation, and Industrial Research." Comanor looks at 387 firms in 21 groups and discovers that the estimated elasticity of research employment with respect to firm size was never significantly greater than unity and was significantly less than one for 7 of the 21 industries (Comanor 1967). The econometric analyses relating R&D employment to the size of the firm have demonstrated that there is no obvious pattern showing that larger firms have a greater number of R&D employees. According to the above studies using R&D as measured by the number of R&D employees, the validity of the Schumpeterian hypothesis appears to be in question.

It is important to understand that the studies relating R&D employment to the size of the firm have come under some scrutiny since many economists believe that R&D expenditure is not best measured by the total number of R&D employees. Thus, several economists have found it more useful to measure R&D spending as noted on the individual firm's accounting statements and firm size according to sales and assets. Scherer criticized small studies done using R&D employment, and he conducted a very large study using 448 firms intended to reach more accurate conclusions than those smaller studies that used less than 100 firms (Scherer 1965). His conclusions reveal that there was no relationship between R&D employment and firm size except for the fact that

R&D employment increased faster than firm size among the smaller firms but increased more slowly in the larger firms. Scherer also notes that R&D employment fell among the very largest firms. (This observation is somewhat similar to Worley's above who finds that mid-sized firms spent the greatest percentage of their sales on R&D.) Scherer points out that the only industries that seemed to show a consistent increase in R&D intensity with an increase in sales were the chemical industries and the auto and steel industries. Mansfield criticizes studies that measure R&D using R&D employment. Rather Mansfield measures R&D according to total amount spent on R&D as reported by the individual firms. In his study in "The Economics of Technological Change" he estimates a log-linear relation between R&D spending and firm size for ten firms in the chemical industry, nine in petroleum, eight in pharmaceuticals, seven in steel, and four in glass (Mansfield 1968). He finds that the coefficient of firm size did not shift systematically over time except for in the chemicals industries where larger firms consistently spent more on R&D. In regard to the other firms in the petroleum, drug, steel and glass industries, the largest firms in these industries spent no more on R&D relative to sales than did these smaller firms.

Grabowski, in a similar study to Mansfield's, regresses research expenditure against sales and its square for sixteen chemical firms and ten drug companies in "The Determinants of Industrial Research and Development: A Study of the Chemicals, Drug, and Petroleum Industries." (Grabowski 1968) Among the drug firms, R&D initially increased but then decreased among the largest of the firms. In contrast, research and development intensity steadily increased with firm size in the chemical industry. Grabowski states in his conclusion that factors other than size were contributing to the differences in the drug and chemicals industries.

Mueller's four equation econometric model of the firm, fit using a sample of sixty-seven firms indicated that research intensity was negatively associated with firm size measured by sales. Mueller states in "The Firm Decision Process: An Econometric Investigation," that, "Somewhat surprisingly the sales coefficient (intercept) is negative for all four years (when indeed) one expects that larger firms will undertake more R&D..."(Mueller 72) Mueller continues in his study with the suggestion that the relationship between the size of the firm and R&D expenditure is not easy to measure and that given its inherent difficulties economists are left to wonder about the exact relationship between firm size and R&D.

V. CONCLUSION

Given the evidence of the econometric analyses above, there is no obvious conclusion that larger firms spend more on R&D than smaller firms. While there is variability in the studies in the way that R&D is defined, still no single experiment consistently showed larger firms spending more on R&D than smaller firms regardless of how R&D was defined except for in the chemicals industries (as noted by Mansfield and Grabowski). The results of this paper have serious implications: the credibility of the Schumpeterian hypothesis is weakened because of the lack of supporting evidence. Furthermore, economists are forced to realize that much work needs to be done in the field of industrial organization in order to fully understand the decisions a firm must face, for example those concerning R&D, even if it means putting widely accepted theories to the test of

real world data.

Thus, it seems that with the possible exception of the chemicals industries, there is hardly any support for the hypothesis that the intensity of innovational effort increases with firm size. In reviewing previous literature, either there is a very slight relationship between R&D and firm size, there is a positive relationship between R&D and firm size up to a point and then there is a negative relationship (perhaps an inflection point), or there is a negative relationship between R&D and the size of the firm for the entire range of firm size.

While Demsetz may be correct in stating that the relationship between R&D and the firm is not obvious, it is important that studies come up with similar observations before any general conclusions can be made. Since there is a discrepancy in the results of the above experiments, there is obviously no easily explainable relationship between R&D and the size of the firm. Perhaps a detailed study within industries, looking at very similar firms, or perhaps the same firm over a long period of time could serve as a better test. If nothing else this paper suggests that hypotheses should be put to the test of real world data before they are generally accepted if we are to fully comprehend the actual workings of the economy.

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