Asymmetric Information and the New Theory of the Firm: Financial Constraints and Risk Behavior

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Recent developments in the theory of the firm have been closely related to developments in examining the economic implications of imperfect information. This treatment of the firm goes beyond both its Arrow-Debreu incarnation as a disembodied production set, and its formulation as an efficient nexus for minimizing the cost of economic transactions due to Coase, and more recently to Oliver Williamson (1985). Asymmetrically distributed information between a firm, as employer, and its workers has replaced the traditional view of a firm that hires labor at fixed (or monopsonistically increasing) wages in well-defined labor markets with one in which firms actively manage long-term employment relationships, on average pay wages in excess of those available in the labor market at large, control workers with carefully designed incentive mechanisms, and often ration access to jobs.

Similar asymmetries of information between outside investors, who provide capital, and inside managers, who control its use, have led to comparable developments in the theory of how firms acquire and deploy capital. In both cases, there have been two dimensions to the theoretical developments involved. On the one hand, much recent attention has been paid to the internal structure of the firm—how rewards for individual workers should be designed, what constitutes appropriate hierarchical or reporting structures, and how the internal quality of life of the firm depends on these factors. On the other hand, a new view of the external aspect of the firm has developed—how it is likely to react to external environmental and policy changes. The focus of this paper is on the latter external dimension since developments in this area have begun to lead to a broadly common set of implications for firm behavior.

Among these developments, those with perhaps the most striking implications for external firm behavior have arisen from a reexamination of the role of financial variables (leverage, cash reserves, financial strength, etc.). The classical Modigliani-Miller approach to financial policy concluded that the financial structure of a firm was irrelevant to both its value and its operating decisions, and the neoclassical theory of the firm assumed further that its financial position was irrelevant. Yet both informal observations and systematic empirical evidence have suggested that financial structure and position are of considerable importance to firm behavior. For example, notions of deep pockets or financial strength, which have always played a significant role in qualitative observations of firm behavior, have no place in a classical Modigliani-Miller world. Nevertheless, recent empirical studies of investment have demonstrated the importance of financial variables.

Models of imperfect information in financial markets have altered the traditional view in two important ways. First, if information is asymmetrically distributed between the buyers and sellers of financial instruments, then certain financial markets, such as that for equities, may break down or be severely limited (a form of the lemons problem identified by George Akerlof, 1970), and accordingly the free access to all forms of financing envisaged by Modigliani-Miller may not exist. In loan markets, there may be credit rationing. In these cases, financial structure and position matter and affect firm behavior. Second, if information is asymmetrically distributed between those who make decisions (agents) and the theoretical bene-

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ficiaries of those decisions (principals), then the reward functions that govern firm decision making may not have the form of simple valuation maximization assumed in the neoclassical theory. This paper seeks to examine the consequences of both kinds of imperfections for the behavior of firms and their evolution over time. In doing so, it looks at an exemplary case of imperfect competition and explicit investment in long-run research and development. However, the lessons of that model point more broadly to the general direction in which informational imperfections in financial markets affect the external dimension of firm behavior.

I. The Model

We will assume for expository purpose that firm decision making takes place in two distinct stages. In the first, the firm decides on a level of productivity improving activity, x. This may be interpreted as either explicit *R&D* spending or as spending on an overhead establishment whose task is to improve the firm's productivity, broadly construed to include the efficiency of its marketing and general administrative activities. The activity reduces the constant marginal cost of output with which a firm enters the second stage of market activity, in which output is produced and sold. This constant marginal cost c will be assumed to depend on an inherited level of production knowledge, c_o, that depends on the spillover benefits of past economywide productivity improving activities; on first-stage overhead expenditures to improve productivity, x, which we will refer to for convenience as *R&D*; and on a random factor s, with expected value one, which determines the success of those efforts: $c = sg(x)c_o, E(s) = 1$, where the function g is assumed to be decreasing in x.

In the second stage of market activity, firms maximize profits, given their cost levels and the demand for their product, d, which we assume depends on both the firm's own price p, and the average price $\bar{p}$ charged by other firms. Formally, therefore, in the second stage, firms $\max \pi = (p-c)d(p,\bar{p})$, which leads to an optimal price and profit level: $p^* = mc, m = 1/(1-1/e)$ and $\pi^* = (m-1)cd(mc, m\bar{c})$, where $\bar{c}$ is the average of the cost of other firms and e is the own-price elasticity of the demand function, d, assumed to be a constant.

The payoff function to first-stage *R&D* activity is, therefore,

$$\pi(x) = (m-1)sg(x)c_o d(msg(x)c_o, m\bar{c}).$$

If there are a large number of competing firms, then $\bar{c}$ will be approximately equal to $\bar{g}c_o$, where $\bar{g}$ is the average of $g(x)$ over other firms and c_o, the initial inherited technology, is assumed to be the same for all firms (i.e., technologies fully spill over into the public domain after a single period). The second-stage profit function can, thus, be written

$$\pi(x) = (m-1)sg(x)c_o d(sg(x),\bar{g}),$$

where the m and c_o terms in the demand function have been suppressed for notational convenience. Profits are a random variable looking forward from the beginning of the first stage in which x has been chosen.

The choice of a level of research activity in stage one depends on the objective function of a firm at that time and, in particular, on its attitude toward risk. We assume that the firm in question is owned and managed by an individual who maximizes the utility of end-of-period wealth, having sold a fraction $(1-a)$ of the firm to outside investors. Thus, in stage one, the firm decision maker maximizes expected utility:

$$\max_x E[u(w+(\pi(x)-x)a)], \tag{1}$$

where we assume that u is characterized by decreasing absolute risk aversion and w, initial wealth, includes the proceeds from the sale of the fraction $(1-a)$ of the firm. For the case in which the risks associated with x are unsystematic, such an entrepreneur, in a world of perfect information, would diversify completely and simply maximize the expected value of $\pi(x)$. However, if he both is and is known to be better informed about his own prospects for productivity improvement than investors at large, then the firm's owner/manager will be constrained to hold an excessive fraction of the firm in order to signal confidence in his own prospects. (See Hayne Leland and David Pyle, 1977.) And firm behavior, even with respect to the unsystematic risks that are associated with active productivity improvements, will be governed by the risk aversion implied by the utility function in equation (1).

An objective function similar to that of equation (1), or at least with similar implications, emerges from a wide range of imperfect information models. For example, the distinction between owner-managed and professionally managed firms is not especially significant here. When professional managers' actions are unobservable, in effect managers become part owners of their firms' equity capital. The managers' wealth then consists of their private holdings, w, plus the fraction a of the terminal equity (profit) of the firm that they are able to appropriate to their own use. Since this latter part of their wealth is nonfungible, and since the managers, like owners, should be deterred from issuing shares by informational considerations, managers will be maximizing a function similar to that of equation (1). Alternatively, if agency arrangements are made with risk-averse managers and these arrangements are limited for practical reasons to payoffs that are linear in the profits of the firm, an objective function identical to that of equation (1) will emerge, with the variable a now representing the slope of the payoff function and w now being the returns to safe projects (i.e., liquid investments).

Similarly, since the fact that issuing shares has a negative impact on the market value of the firm makes the firm reluctant to issue shares, if external funds are raised, it will in theory be (and in practice is) predominantly through loans. But this makes the firm face a risk of bankruptcy, a risk that is affected by firm behavior. We can show that the behavior generated by maximizing expected profits minus an expected cost of bankruptcy (the cost of bankruptcy times the probability of bankruptcy) is similar to that generated by equation (1) under plausible restrictions on the firm's cost and probability of bankruptcy. Thus, if professional managers are subject to an agency arrangement that either explicitly or informally rewards them with a share of profits, but imposes a large penalty in the event of bankruptcy (i.e., dismissal with a stigma that significantly impairs future earnings), then the resulting objective function produces behavior almost exactly identical with that of equation (1),[1] when (as we assume here) the utility function is characterized by decreasing absolute risk aversion.

The first-order condition for the problem of equation (1) can be written

$$(2) \qquad c_o\bar{d}(-g_x) = \bar{d} + \text{cov}(u'; ds) + \text{cov}(ds),$$

where E has been normalized to equal one, both covariances are negative (since better outcomes for research activities are correlated with higher sales and sale revenues), and $(-g_x)$ is positive. The right-hand side of this equation is the risk-adjusted cost of research investment at the margin. It is least when the firm is risk neutral (i.e., $\text{cov}(u'd, s) = 0$), and increases with firm risk aversion. The left-hand side is the marginal return to research expenditures. Assuming the appropriate second-order condition is satisfied, the behavior of a finance and/or agency constrained firm can be derived straightforwardly from equation (2).[2] Broadly speaking, these firms act as if they are risk-averse individuals, which is not surprising since one basic impact of imperfect information is to interfere with the proper distribution of risk.

A first consequence of this is that an increase in the wealth of firm owners (financial strength of the firm) leads to reductions in the size of the covariances and hence a reduction in the risk premium associated with overhead investment. Thus, as a rule, in-

[1]See our 1987 paper. This requires that bankruptcy costs increase with the size of the firm (as they appear to do in practice).

[2]The discussion below assumes implicitly that the ownership factor a does not change with the exogenous variables. In the pure finance-constrained interpretation, this is appropriate. In the agency interpretations, a may change. However, the basic comparative static properties of the model are unaltered.

creases in historical firm profitability and/or temporarily high current profitability (increasing w) lead to higher levels of research investment (or investment generally), more rapid expected productivity growth for each firm, and, through future spillover effects, higher productivity for the economy as a whole. Consequently, temporary demand disturbances which reduce current profitability will lead to effective supply contractions (as in a standard Keynesian model) as firms reduce investment activity ($R\&D$ etc.) and these, in turn, lead to permanently lower future output. Not only is the informal notion of the importance of the strength of a firm's financial position validated in these imperfect information models, but they also provide a mechanism for the propagation of macroeconomic demand disturbances and the persistence of their effects.

Increases in the uncertainty of the technological or future market environment (i.e., in the variance of s) have a similar impact. The risk premium associated with investment rises, even when the risks involved are unsystematic, and the level of research investment falls. Ultimately, therefore, productivity growth declines across the economy as a whole. The imperfect performance of financial mechanisms for risk distribution means that an economy may react negatively to increases in variables like relative price uncertainty (that affect the uncertainty of returns to productivity improvement). These are all, it should be noted, effects that are not part of the responses of the traditional firm.

II. Dynamics

Another significant aspect of the finance constrained firm is that it is characterized by a well-defined dynamic evolution, that depends on the evolution of the owner/manager's wealth (or in the case of a managerial firm, the accumulated retained earnings of the firm). The wealth of a firm's owner in period t is determined by the relationship

$$(3)\quad w_{t+1} = a\pi(x_t) + (w_t - ax_t)(1+r_t) - y_t(w_t),$$

where r_t is a safe rate of return on assets not invested in the firm at stage one, y_t is consumption in period t that is an increasing function of wealth in period t, and, as described above, x_t is the level of investment in research and development which depends positively on w_t; namely, $x_t = h(w_t), h' > 0$.[3] For an individual firm, equation (3) is a stochastic difference equation, since $\pi(x_t)$ is a random variable, depending on the random return variable s_t. Under reasonable circumstances (a bounded distribution of s, sufficiently rapidly diminishing returns to x and sufficiently concave preferences) a limiting distribution of w_t, independent of initial wealth, will exist.[4]

Among other factors, this limiting distribution will depend in the present model on the wealth levels of other firm owners. Higher economywide wealth levels imply higher economywide levels of $R\&D$ spending, lower expected costs and hence prices for competing firms, lower expected demand at each own-price level for any single firm, and therefore, lower expected profits for each firm. Thus, for the economy as a whole, there will be in equilibrium (again under reasonable circumstances) a limiting distribution of wealth across firms which implies a limiting distribution across firms of research and development expenditures.

Finally, the long-run evolution of the model depends on the evolution of c_o that embodies the inherited technology in each period. In order to simplify matters as far as possible, we will assume that the demand function at t, $d_t(p_t, \bar{p}_t)$, has the form $d_t(p_t, \bar{p}_t) = (1/c_o(t))d(p_t/\bar{p}_t)$.

As inherited costs fall, real income rises, demand increases proportionately and the share of demand served by each individual firm depends on its price relative to the average price of all other firms. Under these

[3]In a more general model, we can derive the equilibrium $y_t(w_t)$ function also.

[4]This holds as long as the basic firm decision problem is unaltered by changes in c_o; which requires that the demand function facing each firm increases linearly with $1/c_o$ (i.e., real income).

conditions, $\pi(x_t)$ and the level of x_t chosen by each firm is independent of $c_o(t)$. Thus, the analysis of the dynamics of the model can be separated into 1) an analysis (described above) of the evolution of the wealth and *R&D* expenditures of individual firms, and 2) an analysis of the overall improvement in the baseline technology of the economy, embodied in c_o, as a function of the wealth and *R&D* spending distributions. Formally, that second step can be described by an equation of the form $c_o(t+1) = c_o(t)G(\bar{x}_t)$, which describes the process of technology spillovers where $\bar{x}_t$ is a vector whose elements are the levels of x_t for the individual firms.

In order to trace the long-term consequences of any environmental or policy change within this context, its consequences for the evolution of both the wealth distribution of firm owners and technology must be examined. For example, an unexpected increase in the wealth of firm owners (due, for example, to an unexpected increase in demand) in a single period will not alter the limiting distribution of firm-owner wealth or *R&D* expenditures. It will not, therefore, alter the long-run growth rate of productivity. However, it will temporarily increase *R&D* expenditures, leading to an increase in the level of productivity. Consequently the new limiting growth path will involve a permanently higher level of output.

An increase in environmental uncertainty (due, for example, to greater policy instability or to greater uncertainty in the results of research efforts) will in the short run lead to a reduction in *R&D* efforts at the initial existing levels of firm-owner wealth. However, the decline in economywide *R&D* expenditures will tend to increase the profitability of such efforts by individual firms both on average and at the margin. The marginal effect involved, will, in the short run, partially offset the original impact of greater uncertainty on risk-averse firm-owners. The increase in average profitability will lead to wealth accumulation by firm-owners and, over time, to a partial restoration in *R&D* expenditures. On balance, the increase in uncertainty is still likely to lead to lower *R&D* expenditures and lower growth rates of productivity. However, the extent of the initial decline will be partially offset by subsequent wealth accumulation. Thus, analysis of both the ultimate size and the temporal pattern of the response of the economy to a change in uncertainty (or to a deliberate policy change, like a tax increase) requires that the long-term effects of firm-owner wealth change be taken into account.

III. Conclusion

Imperfect information affects both the internal organization of firms and its external relations with labor, capital, and product markets. The new theory of the firm is built on these foundations. This theory has important behavioral implications that distinguish if from earlier neoclassical theories. This paper, focusing on informational problems in the capital market, including asymmetries of information between providers of capital and firm managers, has argued that as a result firms will act in a risk-averse manner. Several consequences follow: (*i*) the firm will be concerned with its financial structure, and financial structure affects behavior; (*ii*) changes in financial strength (the firm's net worth) have real consequences; and (*iii*) mean-preserving changes in distributions of prices and sales have real effects. Elsewhere (1989) we have shown that the appropriate way to look at the whole set of firm decisions (including those relating to employment, production, pricing, investment that includes inventory changes, and research) is as a dynamic portfolio problem. The results of that model can be contrasted both with the simple neoclassical model of the firm and with attempts to make that model accommodate more of the facts concerning firm behavior, in particular, those postulating costs of adjustment. In some cases, to attain patterns of behavior consistent with the facts (such as the greater variability in quantities than in prices) requires implausible assumptions concerning adjustment costs. But, even in those cases where the neoclassical models and their extensions yield results that are consistent with observation, they fail to account for the facts that firm output and investment spending (in *R&D* and of other sorts) respond directly to changes in firm wealth and to environmental uncertainty of an unsystematic sort, while our models support much of the empirical literature that relates variables like investment directly to firm financial conditions, and more informally, to conditions of uncertainty (due, for example, to high inflation or unstable government policy) in the economy at large (even when these appear unlikely to lead to increases in systematic risk). Here we have used the theory of the finance-constrained firm to explore the dynamics of firm and economy-wide growth. These models have strong policy implications that, while corresponding to widely held informal views, often differ markedly from those based on the neoclassical theory of the firm and its derivatives.

REFERENCES

Akerlof, George, "The Market for Lemons: Qualitative Uncertainty and the Market Mechanism," *Quarterly Journal of Economics*, May 1970, *84*, 288–300.

Greenwald, Bruce and Stiglitz, Joseph E., "Toward a Theory of Rigidity," *American Economic Review Proceedings*, May 1989, *79*, 364–69.

______ **and** ______, "Financial Market Imperfections and Business Cycles," NBER Working Paper No. 2494, 1987.

Leland, Hayne E. and Pyle, David H., "Informational Asymmetries, Financial Structure and Financial Intermediation," *Journal of Finance*, May 1977, *32*, 371–87.

Williamson, Oliver, *The Economic Institutions of Capitalism*, New York: Free Press, 1985.