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11 Market Value, R & D, and Patents

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To the extent that R & D investments create "intangible" capital for a firm, it should show up in the valuation of the firm by the market. Such a valuation need not occur only after the long lag of converting an invention into actual product sales. It will, instead, reflect the current present value of expected returns from the invention (and from the R & D program as a whole). Thus, it is both possible and interesting to use the market value of the firm as a partial indicator of the expected success of its inventive efforts.

In a first effort to explore this topic, I start from the simplest "*definitional*" model:

$$V = q(A + K),$$

where V is the current market value of the firm (equity plus debt) as of the end of the year, A is current value of the firm's conventional assets (plant, equipment, inventories, and financial assets), K is the current value of the firm's intangible "stock of knowledge," to be approximated by different distributed lag measures of past R & D and the number of patents, and q is the current market valuation coefficient of the firm's assets, reflecting its differential risk and monopoly position.

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Writing

$$q_{it} = \exp(m_i + d_t + u_{it}),$$

where m_i is the permanent firm effect, d_t is the overall market effect at time t, and u_{it} is an individual annual disturbance or error term assumed to be distributed independently across firms and time periods. Defining $Q = V/A$, substituting, and taking logarithms, we get

$$\ell nQ = \ell n V/A = m + d + \ell n(1 + K/A) + u.$$

Substituting $\Sigma b_h R_{t-h}$, a distributed lag term of past R & D expenditures (R) for the unobserved K (or a similar additional term involving patents) and approximating $\ell n(1 + x)$ by x, we get

$$\ell nQ \simeq m + d + (\Sigma b_h R_{-h})/A + u,$$

which is the general form of the equation estimated in the first round of this study.

For a sample of 157 firms, we constructed the Q measure from the information given in Standard and Poor's Compustat tape, adapting for this purpose both the procedures and the program used by Brainard, Shoven, and Weiss (1980).[1] Using annual observations for the years 1968–74 but excluding observations with missing R & D data, large mergers, and large outliers ($|\ell n Q - \ell n Q_{-1}| > 2$), the final sample consisted of approximately 1000 observations with up to six lags for R & D and two lags on patents (we do not have valid patent data before 1967).

The results of estimating such an equation are given in table 11.1. To allow for interfirm differences in other unmeasured capital components, such as advertising or monopoly power, all the estimates are based on "within" regressions, on deviations around the individual firm means. Because of this preprocessing, what remains reflects largely shorter run fluctuations in R & D intensity and patent behavior and may be affected by errors of measurement and other transitory influences. In spite of these problems, we do find significant and positive effects of R & D and the number of patents applied for on the value of the firm.

To allow for both serial correlation and a more complicated lag structure, I added the lagged value of Q to the regressions. (This raises statistical problems because of the potential endogeneity of Q_{-1}, the Nerlove-Balestra problem, but that is a relatively minor issue when T is not too small. Moreover, all this is at an exploratory stage anyway.) The lagged value of Q is highly significant, and the models reported in lines (2)–(4) of table 11.1 imply that the long-run effect of \$1 of R & D is to add about \$2 to the market value of the firm (above and beyond its indirect effect via patents), while a successful patent is worth about \$200,000.

1. See Pakes and Griliches (this volume) for a more detailed description of the provenance of this sample.

Table 11.1 **Market Value as a Function of R & D and Patent Variables: 1968–74**

Equation and Dependent Variable	Coefficients of: RD			Patents				Other Variables in Equation	SEE
	$\Sigma_0^5 b$	SRD	PRD	P_t	SP_t	PP_t	$\log Q_{-1}$		
$\log Q$ (1)	1.33	—	—	24.9 (4.8)	—	—	—	TD's & FD's	.319
(2)	2.63	—	—	10.8 (3.9)	—	—	.54 (.02)	TD's I FD's	.261
(3)	—	1.17 (.39)	—	—	11.6 (3.5)	—	.56 (.02)	TD's & FD's	.263
(4)	—	1.08 (.38)	—	—	8.4 (3.4)	—	.55 (.02)	TD's & FD's β's	.251
(5)	—	1.58 (.44)	1.23 (.54)	—	10.1 (3.9)	5.5 (5.2)	.54 (.02)	TD's & FD's β's	.251
$d\log Q$ (6)	—	1.93 (.45)	—	—	9.4 (4.1)	—	—	TD's & FD's	.304

Note: Estimated standard errors in parentheses. $N = 1091$; approximate degrees of freedom, 920.

Σb = sum of the coefficients of six R & D variables, e.g., in equation (2):

$$\underset{(.5)}{2.0r_0} - \underset{(.6)}{.8r_{-1}} + \underset{(.6)}{.5r_{-2}} + \underset{(.6)}{.2r_{-3}} - \underset{(.8)}{1.7r_{-4}} + \underset{(.7)}{2.4r_{-5}}.$$

SRD = "Surprise" in R & D. RD − PRD = SRD.
PRD = Predicted R & D. Predicted from a regression using RD_{-1}, P_{t-1}, and $\log Q_{-1}$.
$SP_t = P_t - PP_t$; "Surprise" in patents.
PP_t = Predicted patents using P_{-1}, RD_{-1}, and $\log Q_{-1}$.
TD's = Year dummies.
FD's = Firm dummies.
β's = Individual estimated market β's (from *Value Line*, as of 1973) times the TD's.
SEE = Standard Deviation of the Estimated Residuals.

The estimated lag structure makes little sense, however, at least on first sight (see note at the bottom of the table 11.1). Except for the first coefficient, which is positive and highly significant, the subsequent coefficients change sign and are often insignificant. One possible interpretation of these results is that, in the presence of the lagged value of the firm in the equation, past R & D should not have any direct effect on V or Q. All of its anticipated effect should already be reflected in Q_{-1} as well as the effects of current and future R & D to the extent that they can be anticipated. What should *change* the market value is the inflow of news about new actual or potential discoveries. In short, only *unanticipated* R & D expenditures and patents should have positive effects in such an equation.

Equations (3)–(6) follow up this idea by using as their main variables the "surprise" components of R & D and patents, the changes that could not be predicted given historical information alone (the actual variables are constructed using a relatively simple equation containing lagged values of R & D, patents, and Q). Lines (3)–(4) show that such constructs do about as well in terms of fit as six separate lagged terms. Line (6), which is perhaps the easiest to interpret, says that a surprise \$1 move in R & D results is equivalent to a \$2 change in other assets. For patents there is little difference between using the actual number versus the nonpredictable component. Apparently most of the relevant variance in patents is unpredictable.

We do have the problem, though, that our patent variable is by the date applied for rather than by the date granted. The first is not fully public information and there may be quite a bit of uncertainty ex ante if a particular application will be, in fact, successful. We intend, therefore, to experiment also with the patents by date granted variable.

Current work is proceeding along the lines of incorporating rational expectation assumptions explicitly into our model and using modern time-series methods (a la Sims) to estimate it.[2] Such work needs to be based on larger samples than we have used to date. The second thrust of our work, therefore, is to expand our sample size significantly.

Reference

Brainard, W., J. Shoven, and L. Weiss. 1980. The financial valuation of the return to capital. *Brookings Papers on Economic Activity* 2:453–502.

2. See Pakes (this volume).