Footnote:

[1] Capital sales include property, plant, and equipment (Compustat item 107). Acquisitions include funds used for and costs related to the purchase of another company in the current year or an acquisition in a prior year that was carried over to the current year (item 129). Investment is the sum of acquired capital (item 129) and direct capital expenditures (item 128). We compute the ratios in Figure 1 after summing each data item across active firms in each year.

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The *Q*-Theory of Mergers

By Boyan Jovanovic and Peter L. Rousseau*

The *Q*-theory of investment says that a firm's investment rate should rise with its *Q* (the ratio of market value to the replacement cost of capital). We argue here that this theory also explains why some firms buy other firms. We find that: (i) a firm's merger and acquisition (M&A) investment responds to its *Q* more (by a factor of 2.6) than its direct investment does, probably because M&A investment is a high fixed cost and a low marginal adjustment cost activity; (ii) the typical firm wastes some cash on M&A's, but not on internal investment (i.e., the "free-cash flow" story works, but it explains only a small fraction of mergers); and (iii) the merger waves of 1900 and the 1920's, 1980's, and 1990's were a response to profitable reallocation opportunities, but the 1960's wave was probably caused by something else.

There are two distinct used-capital markets. Used equipment and structures sometimes trade unbundled in that firm 1 buys a machine or building from firm 2, but firm 2 continues to exist. At other times, firm 1 buys firm 2 and thereby gets to own all of firm 2's capital. In both markets, the traded capital gets a new owner. In a sale of used "disassembled" capital, the capital also gets a new manager, whereas in the M&A market, capital gets a new manager when a merger entails a restructuring. Such a merger is reallocative in the same sense that a used-capital trade is.

Our model treats M&A's like used-capital-market transactions. This seems apt, since trading volume in the two markets for used capital (bundled and disassembled) move together. Figure 1 shows this fact. It plots acquired capital and direct purchases of used capital among exchange-listed firms as percentages of their investment. The series cover all firms common to the University of Chicago's Center for Research in Securities Prices (CRSP) database and Standard and Poor's Compustat.[1] The two series do not overlap in coverage, and so they add up to the fraction of investment spent on buying used capital. This fraction was 10 percent in 1975, and a much higher 43.5 percent in 2000. The correlation coefficient between the two series is 0.45. Clearly, the merger waves of the 1980's and 1990's coincided with waves of trading disassembled used capital.

High-*Q* firms usually buy low-*Q* firms. Gregor Andrade et al. (2001) report that, in more than two-thirds of all mergers since 1973, the acquirer's *Q* exceeded the target's *Q*. Henri Servaes (1991) finds that total takeover returns (defined as the abnormal increase in the combined values of the merging parties) are larger when the target has a low *Q* and if the bidder had a high *Q*. Thus, mergers are a channel through which capital flows to better projects and better management, and our model reflects that fact.

I. Model

A firm's state of technology is *z* and its capital stock is *K*. Its production function is

$$(1) \qquad \text{output} = zK.$$

The parameter *z* follows the Markov process

$$(2) \qquad \Pr\{z_{t+1} \le z' \,|\, z_t = z\} = F(z', z)$$

and it is firm-specific.

Firms can buy new or disassembled used capital at a price of unity. The cost of disassem-

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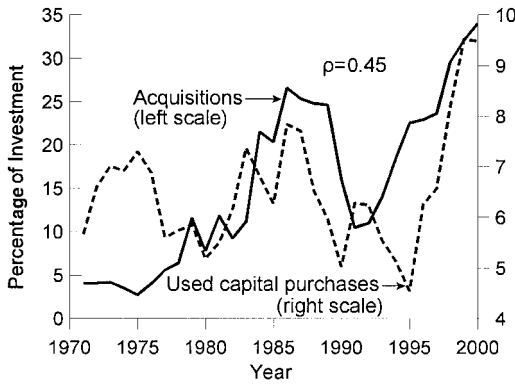
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FIGURE 1. USED AND ACQUIRED CAPITAL AS PERCENTAGES OF TOTAL INVESTMENT, 1971–2000

bly is $1 - s$ per unit of capital, and any firm that disassembles its K gets a salvage value of $s <$ 1 per unit of K. The firm can also place itself on the M&A market where all acquired capital trades at a common price of q per unit. If the salvage and the acquired-capital markets are both open, we must have $q = s$, and this is what we shall assume. The firm must accept whatever z draw that nature endows it with each period.

Let X be the firm's direct investment in capital (new or used but unbundled), and let Y be its acquisitions of bundled capital. Next period, its capital stock will be

$$(3) \qquad K' = (1 - \delta)K + X + Y.$$

Aside from the payment for X and Y, the firm also faces the following forgone-output cost of growth:

$$(4) \qquad C(x, y)K$$

where $x = X/K$ and $y = Y/K$.

The firm transfers its z to all new and all used capital that it buys. The joint gains to a merger are thus largest when the target's z is low, and the buyer's z is high. Let the bidder's state be (z_1, K_1), and let the target's state be (z_2, K_2). The output of the combined firm would be $z_1(K_1 + K_2)$, which is higher than the sum of the two firms' pre-merger outputs by the amount $(z_1 - z_2)K_2$.

Because (1) and (4) are homogeneous of degree 1 in K, X, and Y, the aggregation condition of Fumio Hayashi and Tohru Inoue (1991) [their eq. 2.8] holds. The value of K inside a firm is of the form $Q(z)K$. The price of new capital is unity, and the price of used capital is $q < 1$. A unit of K has a profit of $z - C(x, y) - x - qy$, and a market value of

$$(5) \quad Q(z) = \max_{x \geq 0, y \geq 0} \{z - C(x, y) - x - qy$$
$$+ (1 - \delta + x + y)Q^*(z)\}$$

where $Q^*(z)$ is the discounted expected present value of capital tomorrow given the firm's z today. Since the firm has the option of selling its capital in the next period on the merger market at a price of q dollars per unit of capital,

$$(6) \quad Q^*(z)$$
$$= \frac{1}{1 + r} \int \max\{q, Q(z')\}dF(z', z).$$

At an interior maximum, the optimal x and y satisfy the first-order conditions

$$(7) \qquad c_1(x, y) = Q^*(z) - 1.$$

$$(8) \qquad c_2(x, y) = Q^*(z) - q.$$

If z is positively autocorrelated, Q^* is increasing in z, and high-z firms will grow faster and, if there are no fixed costs of investment, use both x and y to achieve that growth. If we control for Q^*, K does not matter. That is, a larger firm grows as easily as a small one, and no optimal firm size exists—just optimal growth.

Assume a fixed cost, ϕ, of acquiring the capital of other firms:

$$C(x, y) = \begin{cases} c(x, y) + \phi & \text{if } y > 0 \\ c(x, 0) & \text{if } y = 0. \end{cases}$$

This cost is per unit of K, and therefore returns to scale remain constant. Let $i = x + y$ be the gross investment rate in efficiency units. A
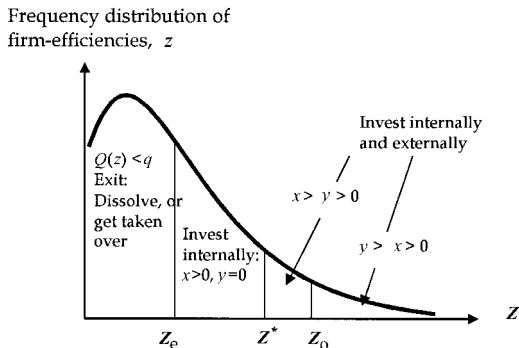
Frequency distribution of
firm-efficiencies, z

FIGURE 2. THE FOUR REGIONS OF z

low-i firm will avoid the cost ϕ by setting $y = 0$ and using only x, whereas a high-i firm will use both margins. The value of i, call it i^*, at which the firm is indifferent between buying in the acquisitions market and staying out of it, solves for i the equation

$$(9) \qquad i + c(i, 0) = \phi + \min_{y}\{(i - y)$$

$$+ qy + c(i - y, y)\}.$$

The left-hand side of (9) is lower when i is small, and the right-hand side is lower when i is high. Of course, i itself depends on the firm's z.

A firm may disappear either by exiting and disassembling its capital or by being acquired. Either way, it gets q per unit of K. Let z_e be the point of indifference between staying in business and exiting. Then,

$$Q(z_e) = q.$$

Figure 2 portrays a steady state in which the distribution of z over firms replicates itself period after period. Sustaining such a steady state requires an entry process as modeled by Hugo A. Hopenhayn (1992). Our focus is on the fate of the incumbents. As the figure shows, there are four regions for z. Each period, firms with z's below z_e dissolve or are acquired. In the region between z_e and z^* firms remain in the market but invest only in x because the fixed cost ϕ deters them from setting a positive y. Beyond z^* (the value of z that corresponds to i^*) they also set $y > 0$, and beyond the "overtaking" level z_o, y exceeds x.
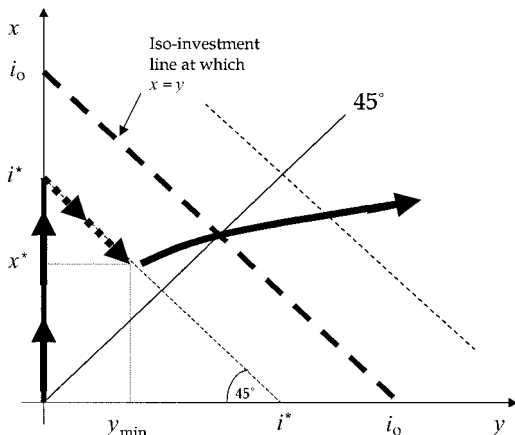

FIGURE 3. THE EXPANSION PATH OF x AND y
AS THE GROSS INVESTMENT RATE, i, RISES

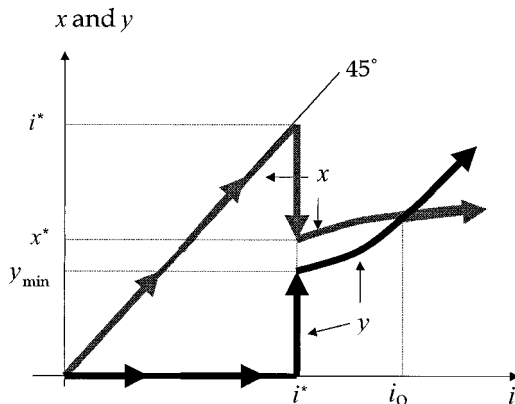

FIGURE 4. THE POINT OF OVERTAKING, i_o

Figure 3 shows the expansion path for x and y as the efficiency-units-investment rate i, represented by the parallel dashed iso-investment lines, rises. At i^*, x drops from i^* to x^*, and y jumps from zero to y_{min}. The figure reflects the assumption that c_y is small relative to c_x, so that the share of y in the firm's investment portfolio grows, and the expansion path approaches the 45° line. At the overtaking point, $x = y = i_o/2$. Beyond i_o, in Figure 3, y exceeds x.

Figure 4 shows how investment in x and y varies with i. The two schedules add up to the 45° line. When i reaches i_o, y overtakes x.

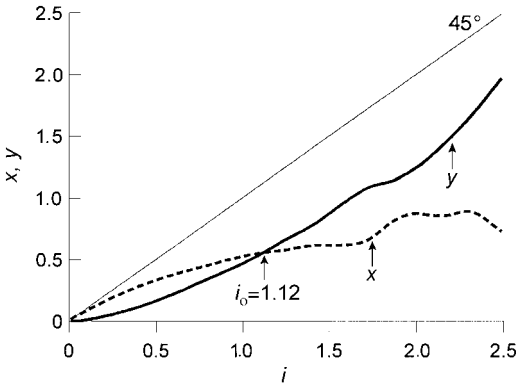The prediction of Figure 4 is confirmed by the evidence in Figure 5. Between 1971 and

FIGURE 5. DIRECT CAPITAL PURCHASES (x) AND ACQUIRED CAPITAL (y), BY INVESTMENT RATIO, $i = x + y$, 1971–2000

FIGURE 6. Q'S, BY INVESTMENT SUBGROUP, 1972–2000

2000, small expansions did, indeed, come mainly through x, while large expansions came mainly through y. The vertical axis measures the HP-filtered means of x and y for firms that fall within each percentage point of the range of i.[2] Overtaking occurs at $i_o = 1.12$, which, after depreciation, is roughly a doubling of capacity. Data on individual years (not shown) indicate that i_o has fallen over the past two decades from 1.43 in 1980, to 1.09 in 1989, and to just 0.5 in 1998. This suggests that ϕ has also been falling.

The acquirer's y is its M&A spending divided by q. In the model, q is the targets' market values divided by their K's. A measure of q is market-to-book value of the acquired firms, but since firms usually write down the capital on their books as quickly as possible so as to bring the depreciation allowances forward, their market-to-book ratios are often much higher than unity. This is true for each subgroup of firms pictured in Figure 2. In Figure 6 we plot the average Q's for these groups, while pooling the middle two into a single "$x \geq y$" group, and

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[2] In Figure 5, we pool 118,127 observations from 1971–2000. The sample thins out as i^* gets large: only 193 observations involve $x + y$ between 1.5 and 2, and 96 observations lie between 2 and 2.5. Another 182 observations, not shown in Figure 5, involve $x + y > 2.5$. We use book value of assets (Compustat item 6) in the previous year to proxy for K, and we linearly interpolate for missing points in the range of i^* before filtering. We interpolated five annual averages in building x and 10 annual averages in building y. In all cases, the interpolations involved $x + y > 1.5$.
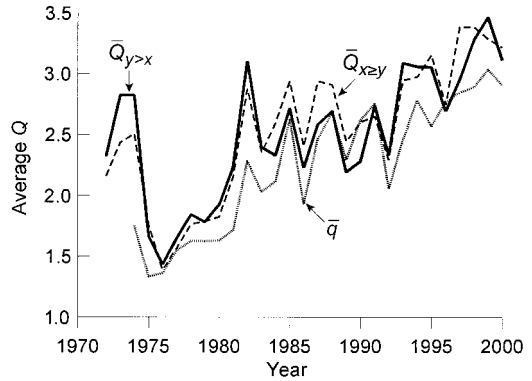
we denote these averages by $\bar{q}$, $\bar{Q}_{x \geq y}$, and $\bar{Q}_{y > x}$, respectively. All three averages stay well above 1, probably because the targets' books underreport their capital. If so, the $\bar{q}_t$ series plotted in Figure 6 badly overestimates the price of used capital on the acquisitions market, and we prefer not to use it as a deflator. Instead we assume in Figure 5 and in the regression analysis below that a dollar spent on x buys the same efficiency units of capital as a dollar spent on y.

II. Estimates of Investment and Acquisitions Equations

Assume that $c(x, y)$ is additively separable. Then equations (7) and (8) are of the form $x = f(Q^*)$, and $y = g(Q^* - q)$. The Q's may all be biased upward, but $Q_j - \bar{q}$ should still measure firm j's incentive to acquire capital from other firms at the price $\bar{q}$. Linearized, f and g assume the same form as equation (30) of Hayashi (1982):

$$(10) \quad x_{j,t} \equiv \frac{X_{j,t}}{K_{j,t-1}} = \alpha_0^x + \alpha_1^x Q_{j,t-1} + \alpha_2^x t$$

$$y_{j,t} \equiv \frac{Y_{j,t}}{K_{j,t-1}} = \alpha_0^y + \alpha_1^y (Q_{j,t-1} - \bar{q}_{t-1})$$

$$+ \alpha_2^y t$$

where t is a linear time trend. The model predicts that α_1^x and α_1^y should be positive. Table 1 presents the results for our panel of pooled

TABLE 1—INVESTMENT REGRESSIONS

	Dependent variable	
Independent variable	$100x_{j,t}$	$100y_{j,t}$
$Q_{j,t-1}$	0.746 (35.71)	
$Q_{j,t-1} - \bar{q}_{t-1}$		2.220 (18.42)
Time trend	−0.120 (13.29)	0.0308 (7.32)
R^2:	0.0479	0.0206
N:	111,039	26,383

Notes: The table presents estimates for equation (10) with *t* statistics in parentheses. The regressions include dummy variables for two-digit SIC's (not reported).

TABLE 2—INVESTMENT REGRESSIONS WITH CASH

	Dependent variable	
Independent variable	$100x_{j,t}$	$100y_{j,t}$
$Q_{j,t-1}$	0.738 (34.41)	
$Q_{j,t-1} - \bar{q}_{t-1}$		1.916 (15.43)
$100 \times \text{cash}_{j,t-1}$	0.006 (1.32)	0.220 (9.82)
Time trend	−0.121 (13.38)	0.277 (6.59)
R^2:	0.0479	0.0241
N:	111,039	26,383

Notes: The table presents estimates for equation (10), with the ratio of cash to total firm assets as an additional regressor, with *t* statistics in parentheses. The regressions include dummy variables for two-digit SIC's (not reported).

observations from 1971–2000. We use the market-to-book ratio for Q.[3] For $\bar{q}_t$ we use average market-to-book value of disappearing firms, the series plotted in Figure 6.

The results support the Q-theory. Hayashi (1982) had estimated the effect of Q on investment at 0.045, and so our dependent variables are multiplied by 100. Our estimate of the effect of Q on x is one-sixth as large as Hayashi's, perhaps because we use total firm assets as the denominator (K) rather than the stock of durable equipment and structures. More to the point, our estimate of the effect of $Q - \bar{q}$ on y is highly significant and nearly three times the coefficient-estimate of Q in the x equation.

A firm's manager may try to pursue his own objectives (e.g., growing the size of his firm) at shareholders' expense. Direct investment cannot expand a manager's empire as fast as a merger can, and Michael C. Jensen (1986) argues that managers of firms with excess cash on hand are more likely to spend it on acquisitions than to pay it out in dividends, even if an acquisition has a negative net present value.

Do firms spend their extra cash on mergers? It seems so. We add cash (Compustat item 1) normalized by firm capital (again proxied by item 6) to the regressions described in equation (10). The results are in Table 2. Cash has little effect on x, but a positive, significant effect on y. Still, Q retains the lion's share of explanatory power.

III. Merger Waves as Reallocation Waves

If firms all had the same z, Q would equal q, and no M&A's would take place. M&A's should rise, says the model, when the interfirm dispersion of Q is high. We now ask: Was Q more dispersed during merger waves? We confirm this in two different ways. The first test is summarized by Figure 7, which shows that $\bar{Q}_{y>x} - \bar{q}$ leads movements in acquisitions.[4] The correlation between $\bar{Q}_{y>x} - \bar{q}$ at the end of year t and acquisitions in the following year, which is the timing shown in Figure 7, is 0.12, but the correlation rises to 0.22 if we lag $\bar{Q}_{y>x} - \bar{q}$ by another period, and it rises to 0.31 if we lag it yet again.

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[3] To compute market values from the Compustat files, we start with the value of common equity at current share prices (the product of items 24 and 25), and then add in the book value of preferred stock (item 130) and short- and long-term debt (items 34 and 9). Book values are computed similarly but use the book value of common equity (item 60) rather than the market value. We omitted firms with negative values for net common equity from the plot since they imply negative market-to-book ratios, and we eliminated observations with market-to-book values in excess of 100, since many of these were likely to be serious data errors.

[4] We project mergers for 2001 by observing that their value fell by 57 percent between 2000 and 2001 (Robin Sidel, 2002) and by assuming that firm assets in our Compustat sample grew at the same rate as GDP between the second quarters of 2000 and 2001.
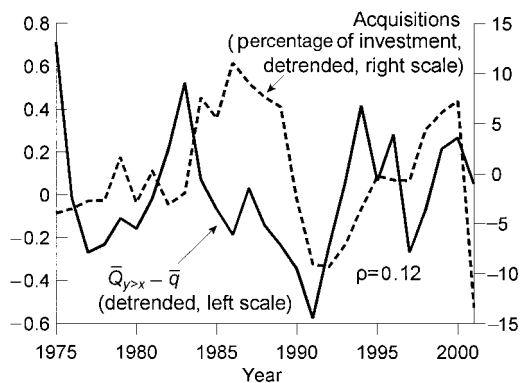
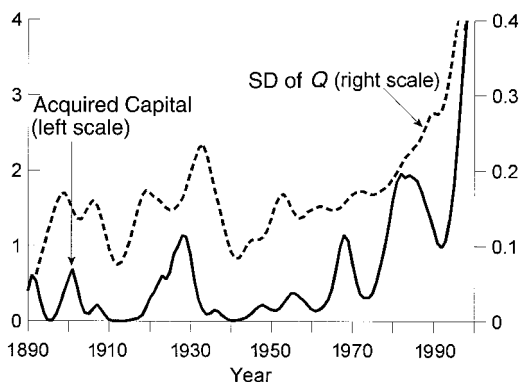FIGURE 7. ACQUIRED CAPITAL AND THE DISPERSION OF Q, 1975–2001

FIGURE 8. ACQUIRED CAPITAL (AS A PERCENTAGE OF TOTAL STOCK-MARKET CAPITALIZATION) AND THE DISPERSION OF Q (BY VINTAGE), 1890–1998

Our second, and less direct, test is in Figure 8. Compustat covers too few book values before 1975 to allow a reliable estimate of the dispersion of Q before then. Instead, we infer the dispersion of Q in year $t < 1998$ by computing the standard deviation of the year-1998 Q's among firms of vintage t, and then repeating this exercise for each t between 1890 and 1998. If the distribution of entrants' Q's is more dispersed in years when the market at large has more dispersion of Q, and if the z process is fairly persistent, this estimate will provide a useful rough guide to waves of dispersion of Q. However, because high-z firms are more likely

to survive, our estimator is biased increasingly toward zero, the older the vintage of the firms.

Our estimate of Q-dispersion is the dashed line in Figure 8. This HP-filtered series is indeed upward sloping as a function of *vintage.* The solid line in Figure 8 shows the HP-filtered acquisition series as a fraction of total stock-market capitalization, as a function of *time.*[5] Thus, the two series derive from two different populations. The solid line is a historical series, whereas the dashed line is a vintage representation of the 1998 cross section. Both lines may trend upward for reasons that the model leaves out, but even the detrended series have a correlation coefficient of 0.64! But for the "hubris" wave of the 1960's, each merger wave was preceded by a rise in the dispersion of Q. Thus, the waves of 1900, the 1920's, the 1980's, and the 1990's were probably reallocation waves.

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[5] The dashed line in Figure 8 is reproduced from Figure 2 in Jovanovic and Rousseau (2001b pp. 338, 340). The solid line is based primarily on merger data from CRSP for 1926–1998, and from work sheets for the manufacturing and mining sectors underlying Ralph L. Nelson (1959) for 1890–1930. The series includes the market value of targets acquired by exchange-listed firms in the year prior to merger. Market values after 1925 are from CRSP. Before that, they are from our extension of CRSP backward through 1885 using newspaper sources. See footnotes 1 and 4 of Jovanovic and Rousseau (2001a) for a detailed description of these data.

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