Specific Capital and the Rise in Tobin’s Q*

Boyan Jovanovic† and Peter L. Rousseau‡

January 31, 2003

Abstract

Over the last century Tobin’s Q has tripled. Yet growth has not accelerated. The likely explanation is therefore one of rent re-distribution towards the shareholder rather than the growth of intangibles. We argue that this redistribution has occurred because capital has become more firm-specific.

1 Introduction

Tobin’s Q has tripled over the last 100 years. This has been a century-long trend, and not just a “new-economy” phenomenon. One possible explanation is growth in the quantity of unmeasured capital – “intangibles” – as Hall (2000, 2001), Laitner and Stolyarov (2002), and others have argued.

What is more likely, however, is that the shareholder now extracts a larger fraction of the rents from labor and capital. We argue this is because human and physical capital have become more firm-specific. The following three facts support this view:

1. Productivity has not risen by nearly as much as a rise in the quantity of “intangibles” should have produced. Our model, in contrast, easily generates permanent rises in stock prices and Tobin’s Q’s, and permanent drops in productivity.

2. The share of output retained by the firm has nearly doubled since 1920.

3. Labor turnover has declined by a factor of three or four over the century, and especially in the very sectors where Q has grown the most. Firm-specific capital inhibits labor turnover. Most of this specificity is present in a company’s infancy, i.e., at its IPO. Tobin’s Q’s of IPO-ing firms are, as we shall show, a little higher than the Q’s of older firms. This contradicts the view that specificity is created by firms investing in it – if it were, incumbents’ Q’s would exceed those of the IPO-ing firms.

*We thank A. Hortacsu, R. Lucas, and D. Neal for helpful comments.
†NYU and the U. of Chicago
‡Vanderbilt university
We do not explain the rise in specificity. It probably stems from the rise in diversification in technology among firms and human-capital among workers.\textsuperscript{1}

2 \textbf{The century-long rise in }Q\textbf{ }

Q-ratios are trending up. Figure 1 shows Q, as proxied by the aggregate market-to-book ratio of listed firms for which we have collected data since 1920, and for a selection of manufacturing and mining firms (listed and unlisted) back through 1900.\textsuperscript{2}

\textsuperscript{1}Equations (13)-(15) of Dagsvik, Jovanovic and Shepard (1985) show how the variance of match quality between two randomly chosen representatives of two groups can depend on the variances in the characteristics of members of each group.

\textsuperscript{2}We extended the CRSP files backward from 1925 by collecting year-end observations from 1885 to 1925 for all common stocks traded on the NYSE. Prices and par values are from the \textit{The Commercial and Financial Chronicle}. We obtained firm book capitalizations from \textit{Bradstreet’s}, \textit{The New York Times}, and \textit{The Annalist}. Our dataset, which includes 24,475 firms, though limited to annual observations, actually includes more common stocks than the CRSP files in 1925.
We obtain market-to-book ratios after 1961 from the Compustat database,\(^3\) and for the squares from 1920 to 1955 using prices and the number of outstanding shares from our backward extension of CRSP in conjunction with balance sheet items from Moody’s investor manuals.\(^4\) The first two squares are decadal averages centered on 1900 and 1910 using data on the book capitalizations and purchase prices of merger targets from worksheets underlying Ralph Nelson (1959).\(^5\)

The recent rise in \(Q\) is driven partly by the tendency for firms to reinvest a larger fraction of their earnings. But earnings also rise relative to output. The dashed line in Figure 1 shows the ratio of corporate earnings to GDP. Evidently, the fraction of output going to the owners has grown.\(^6\) The upward trend in earnings cannot be attributed to changes in the government component of GDP either, since this has been about 20 percent over the postwar period with only a very gradual downward trend while the opposite has been the case since 1900, when the government component was close to zero. Without this bias, the dashed line would be about 17 percent higher at the end. It also appears, however, (Moscowitz and Vissing-Jorgensen 2002, Table 3, p. 752) that the share of total equity value held by sole proprietors and partnerships in the United States has fallen steadily, at least since 1989, so that the contribution of corporations to the numerator (which includes only corporate earnings) of the dashed line in Figure 1 is larger than ever. This is consistent with evidence in Jovanovic and Rousseau (2001, Figure 1, p. 337) that the time from founding to incorporation of firms that ultimately list their shares on a stock exchange has fallen dramatically.

---

\(^3\)To compute market values from Compustat, we start with the value of common equity at current share prices (the product of items 24 and 25) and 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 observations with market-to-book values in excess of 100, since most of these are likely to be serious data errors.

\(^4\)To be precise, we draw balance sheet information from Moody’s Industrial Manual, Moody’s Public Utilities Manual, and Moody’s Transportation Manual. Since balance sheet items are not defined as uniformly across firms in the early Moody’s manuals as they are in today’s Compustat, we must compute market-book ratios for the 1920-1955 period a bit differently. In this case, the numerator is the book value of common equity (including surplus and retained earnings) less the book value of common shares, to which we add in the market value of common shares and the book value of long-term debt. The denominator is the sum of the book values of common equity and long-term debt. The difference in the computation between the "Moody’s" years and 2000, then, is the inclusion of short-term debt in both numerator and denominator of the ratio in 2000. The omission of short-term debt from 1920-1955 imparts an upward bias to the market-book ratios computed in those years.

\(^5\)These written worksheets include the book capital and purchase price of all merger targets in manufacturing and mining as announced in individual issues of the Commercial and Financial Chronicle from 1895-1930. Since wide coverage of industrials in the Moody’s manuals goes back only to 1920, we have built the 1900 and 1910 observations for average \(Q\) from Nelson’s data, using the total purchase price and book capital for all targets between 1895 and 1904 to build the an average centered on 1900, and between 1905 and 1914 to construct an average centered on 1910.

\(^6\)We construct corporate earnings from the National Income and Product Accounts (Bureau of Economic Analysis, 2002) as the sum of corporate profits before tax (table 6.17), net interest (table 6.15), and corporate capital consumption allowances (table 6.22). GDP is from NIPA table 1.
since the early 1960’s. If this bias were removed, the dashed line would be flatter after 1960, though we do not know by how much. On the other hand, the removal of the bias would make the line somewhat steeper before 1960. Finally, neither the growth of the government nor the growth of the corporate sector introduces a bias in the $Q$ series.

2.1 Problems with the “Intangibles” explanation

A key component of the “intangibles” explanation for the post-war rise in $Q$ is Information Technology and the impact that it has had on $Q$’s since the 1970’s (Brynjolfsson and Yang 2000, Hall 2000, Atkeson and Kehoe 2000, Laitner and Stolyarov 2002). But this is probably not the main reason why $Q$ has risen. Productivity growth has not accelerated over the century so that we can now say that intangibles seem to be everywhere except in the productivity statistics. Moreover, missing capital is not much associated with IT – $Q$ has risen quite broadly and, in particular, in the traditional manufacturing sectors. We document this next.
2.1.1 The century-long and even rise in sectoral $Q$’s.

Figure 2 shows the evolution of $Q$ for fourteen manufacturing sectors between 1920 and 2000, and the upward trends for these sectors through the century move very closely with the aggregate $Q$’s in Figure 1. Since many of the lines in Figure 2 are close together, in Table 1 we report the ratio of $Q$ in 2000 to 1920 for each sector. $Q$ more than doubles in all but two of the fourteen sectors, and triples in six of them.

<table>
<thead>
<tr>
<th>Sector</th>
<th>Ratio</th>
<th>Sector</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>paper</td>
<td>3.3*</td>
<td>electric equipment</td>
<td>3.7</td>
</tr>
<tr>
<td>leather, leather products</td>
<td>4.1</td>
<td>metals</td>
<td>2.4</td>
</tr>
<tr>
<td>stone, clay, glass</td>
<td>2.0*</td>
<td>food, tobacco</td>
<td>2.7</td>
</tr>
<tr>
<td>lumber, wood products</td>
<td>0.8**</td>
<td>industrial machinery</td>
<td>3.1</td>
</tr>
<tr>
<td>textiles, apparel</td>
<td>5.0</td>
<td>rubber</td>
<td>2.2</td>
</tr>
<tr>
<td>chemicals</td>
<td>6.2</td>
<td>printing</td>
<td>1.2*</td>
</tr>
<tr>
<td>petroleum, coal</td>
<td>2.3</td>
<td>motor transport</td>
<td>2.0</td>
</tr>
</tbody>
</table>

*- ratio from 2000 to 1930, **- ratio from 2000 to 1950.

2.1.2 The post-1960 uneven adoption of IT over sectors

Figure 3 shows the share of real IT equipment and software in the real net capital stocks of 62 industrial sectors from 1960 to 2001 plotted as annual percentiles. Regression analysis indicates little relation between IT shares and the rise in $Q$’s. For example, we regressed the rise in $Q$’s from 1960 to 2000 by sector on IT shares in 2000 and got

$$\frac{Q_{2000}}{Q_{1964}} = 0.970 + 2.180 IT_{2000},$$

with t-statistics in parentheses, $N = 43$ and $R^2 = 0.035$. Indeed, Hobijn and Jovanovic (2001, Tables 3 and 4) show that it is, in fact, the sectoral drop in $Q$’s around 1974 that relates positively to subsequent IT investment within sectors. We also find this to be the case when running the above regression using the change in sectoral $Q$’s from 1970 to 1975 as the dependent variable.

The point is that if intangibles are missing from the denominators of the sectoral $Q$’s in Figure 2 and are related to IT or “e-Capital”, the evidence in Figure 3 suggests that the distribution of such e-Capital has been uneven across sectors. A purely intangibles explanation is thus hard to reconcile with Figure 2, which shows relatively balanced increases in $Q$ across manufacturing sectors.

7The sectoral capital stocks are from the detailed non-residential fixed asset tables in fixed 1996 dollars made available by the Bureau of Economic Analysis (2002).
3 Rising firm-specificity of assets

We argue that some of the rise in $Q$’s is due to a steadily rising firm-specificity of assets. A rising specificity of assets makes it easier to transfer more rents to the owners of the firm, and we argue that the rise of management played a key role. The evidence on these two points is

1. The rise of firm-specific capital.—Labor turnover was much higher early in the 20th century than it is today. Figure 4, which shows annual job separation rates from 1910-2000 using various sources, demonstrates this fact. The turnover data are from four sources. For 1910-1918, they are annual job separation rates from Owen (1995, table 1, p. 827). For 1919-70, they are separation rates from Historical Statistics (U.S. Bureau of the Census, 1975, series D-1024, pp. 181-2), which are based on data from the Bureau of Labor Statistics. After 1970, we extend the BLS data based upon the only available later annual observation in 2001 (the BLS has only recently begun to collect turnover data once again). The dotted line from 1968-1980 is job separations in which a worker changed sectors from Jovanovic and Moffitt (1990, table 4, p. 844), and has been joined with the BLS series in 1968. After 1980, we use separation rates based on the March CPS from Stewart (2002, table 1).
turnover also suggests that human capital is more firm-specific now than it was 100 years ago.\footnote{Labor mobility may have declined for other reasons too, for instance the rise of labor force participation of married women, but quantitatively this effect would be relatively minor (Mincer 1978). The spikes in the 1910’s and the early 1940’s are caused by the two world wars, when workers were shifted towards wartime production and then returned to peacetime activities (Parnes 1954).} The entry and exit of firms was also higher in the real economy (David 1990, p. 358) and in and out of the stock market (Jovanovic and Rousseau 2002, Figure 1, p. 199).

2. *The rise of professional management.*—Nelson (1995, Ch. 4) describes the post-WW1 growth of product differentiation, research and product development activities, and how company management became more aware about the manufacturing process itself.

In our model management will be the instrument that effects the transfer of the rents from capital the owners of the firm. A firm’s profits depend on how efficiently its managers can acquire the human and physical capital that the firm specifically
needs. The specificity of the assets to the firm will mean that there will be a rent that is split between the firm and the factors in question. We shall then argue that specificity has grown and that the shareholder now gets a larger fraction of those rents.

But why emphasize assembly rather than subsequent nurture of the firm’s capital and its gradual differentiation into a firm-specific asset as the literature tends to do? Evidence suggests that the quantity of firm-specific training or learning on the job has also increased. Bahk and Gort (1993), e.g., find that inputs seem to become more productive as a plant ages. Such a rise in productivity could be labelled as unmeasured human capital, a part of which may be firm specific and that is grown after the firm has formed. But this cannot explain why the Tobin’s Q’s of IPO-ing firms are so high soon after their start-up, before the bulk of a firm’s physical investment and before the learning and accumulation of experience of its labor have taken place. This, too, is why we stress not the training of labor and the growth in its experience, but the assembly of the firm’s factors of production.

Figure 5 shows the aggregate market-to-book ratio for IPO-ing firms in each year from 1960, where the IPO year is given by the firm’s entry to Compustat, along with
the aggregate $Q$ of listed firms (repeated from Figure 1). The figure suggests that IPO-ing firms have in general not had to wait long for the assembly of their ideas and factors of production to be impounded into their market values. And though the $Q$'s of IPO-ing firms are highly correlated with the aggregate $Q$'s (correlation coefficient of 0.71), the IPO-ing $Q$'s are considerably higher most of the time. This contradicts the view that specificity is created as a result of experience – if it were, incumbents’ $Q$'s would exceed those of the IPO-ing firms.

The sectors where labor mobility is now lowest are also the ones where $Q$ has risen the most. To show this, we run a "value-weighted" least squares regression of appreciation in $Q$ by sector from 1920 to 2000 on measures of sectoral job mobility from Table 3B of Neal (1998). The value weighted least squares is simply generalized least squares with each moment condition weighted by its sector’s share in stock market capitalization, where we compute the shares as the average of observations in 1920 and 2000. Neal’s specificity measures, "SEC", are dummy coefficients from a hazard regression of interindustry job changes from 1979 to 1990. This means that negative coefficients reflect a lower probability of a sectoral job change and thus lower turnover and higher specificity. The regression results are

$$
\frac{Q_{2000}}{Q_{1920}} = 2.75 - 1.09 \ SEC,
$$

with t-statistics in parentheses and $N = 18$. The fit is not very good in this small sample, but the sign is correct. We infer that sectors with lower interindustry job mobility have more specific capital. Figure 6 is a plot of the regression with the areas of the circles reflecting the sectoral weights.

**Examples of bidding for specific capital**  
Banking provides examples of firm-specific capital, both physical and human. When buying a building, a retail bank first investigates the demographics of a location to see if the likely customers will value the products that the bank specializes in. A large bank will have an in-house staff that collects information on demographics, whereas smaller banks buy such information from consultants. Better signals lead to a better match between the location and the bank’s product. This is an example of physical capital that is specific at purchase.

An investment bank will sometimes lure an entire team of analysts from another bank. When bidding for the team, the bank will need to consider the match between the type of analysis that the team is good at (e.g., whether its advice is relevant to institutional investors like Fidelity or TIAA-CREF, or to the individual investor) and the expertise and clientele of its sales force. Better signals of what the analysts actually do will lead to a better match between the analysts and the salespeople. This is an example of human capital that is firm-specific at the time it is first employed.

Another example is a venture capitalist who, together with the founder of a firm, assembles the assets around an idea. The idea belongs to the firm, and the people
Figure 6: The value-weighted regression of appreciation in Q from 1920 to 2000 on sectoral job mobility.

and assets should be suited to the implementation of that idea. If the right team and right assets are assembled, the market-book value of the firm at IPO will be high.

If the market for used capital was liquid, evaluative expertise would not matter – buying a building in the wrong location or hiring people with the wrong type of expertise could be reversed on the secondary market for capital. But informational and other frictions make it costly to trade used equipment and to move people around. Top management usually comes in under a contract that is guaranteed, together with bonus, for several years, and perhaps a severance package. And even though physical capital does not “grow” inside a manufacturing plant, it too is also highly firm-specific, as we have learned from Ramey and Shapiro (2001), which suggests that some of it is tailored to the firm’s needs.

Our model will assume that specific capital is created at assembly. The higher Q’s at IPO in Figure 5 suggest that if we distinguish two opposing cases as in Figure 7, the relevant case is Case 2, in which the firm Q peaks at the time of entry rather than rising through a slow development of intangibles.
Figure 7: Continual growth of intangibles (Case 1) vs. creation of intangibles before IPO (Case 2)

4 Model

Here now is a simple model of management aiming to analyze the rent-division issue, and to study how likely parameter changes may have affected what the factors of production and the residual income recipients receive. The model explains how, over time, managers have gotten to extract more of the rents and transfer them to the owners of the firm. The theory will be compatible with an “AK” aggregate technology. The model resembles Mailath and Postlewaite (1990) who use a bargaining approach to dividing the rent between the firm and its workers.

The model is easiest to present if we first think of a one-period world in which the participants in each auction for capital goods are exogenously given. The bidders for the capital goods will be “managers”, although the model will ultimately have no people, only capital which will divide into management capital, $M$, and “other” capital, $K$. We shall state how $M$ and $K$ are determined at the end of this section.

A firm’s production function.—We do not distinguish capital from labor in this model, so that $k$ stands for an aggregate of human and physical capital that a firm employs. The production function of a firm is

$$y = xk,$$

where $x$ is the quality of the capital stock.
The role of the manager.—As in Lucas (1978), \( x \) will have the interpretation of managerial ability. The manager’s task is to buy the best inputs as cheaply as possible. Capital is heterogeneous; let \( z_i \) be the quality of the \( i \)'th unit of the capital that the firm owns. A manager’s task is to evaluate and buy the inputs that his firm needs. For each unit of capital, \( z_i \) is purely firm-specific, so that capital has no hierarchical quality dimension. The productivity of the broad capital or “TFP” is

\[
x \equiv \frac{1}{k} \sum_{i=1}^{k} z_i.
\]

Then the average quality of capital that we may expect this manager to obtain, \( E(x) \), can be thought of as that manager’s ability. In this version of the paper we shall assume that all management is equally efficient at the time that it bids for assets, and, moreover, that it has a perfect private signal on the quality with which the asset in question will match with its firm.

Ex-ante identical managers.—The parameter \( x \) surely varies a lot in the population of entrepreneurs, but here we shall stress its variation over time, not in the cross-section. Therefore we have assumed that there is no limit to the span of control and, instead, that all managers are ex-ante identical. The size of firms is then indeterminate. All capital and all firms are assumed to be ex ante the same, but the quality of the match between assets and managers is random and unknown. In this model managers can be seen as solving this economy-wide assignment problem.

Second-price auctions.—Each unit of capital sells individually in a second-price auction unrelated to any other auction. Consider such an auction in which there are \( m \) firms bidding. Suppose there are \( K \) units of capital in the economy, and there are \( M \) managers who also own their firms or operate them in the interest of their shareholders. Assume that every manager takes part in the same number of auctions, \( \lambda \). Then the total number of bidders in the economy is \( \lambda M \). Therefore, each unit of capital will have \( m \) firms bidding for it, where

\[
m = \frac{\lambda M}{K}.
\]

A manager maximizes the expected dividends and, hence, the value of the firm to the risk-neutral shareholders. So, \( m \) managers bid for a single unit of capital in a second-price, sealed-bid auction.\(^{10}\) The object goes to the highest bidder who pays the second-highest bid.

Idiosyncratic match quality.—Let \( F(z) \) be the distribution of \( z \). All variation in \( z \) is purely match-specific. Managers value the unit of capital in question differently, and this is what we mean by the “firm-specificity” of capital in this context. A manager

\(^{10}\) This is the easiest for us to analyze here, but some of the results, at least, would carry over to other types of auctions. For example, a first-price auction would have similar properties in terms of the effects of \( \sigma_x \) on the shares of firms and of capital.
privately learns $z$ only after he is irrevocably committed to attending an auction. Before that, however, there is complete ex-ante symmetry among bidders, as well as among capital-goods in the different auctions. The social problem is therefore one of matching capital to the firms that value it the most. We index the specificity of capital by $\sigma_z$ — the standard deviation of $z$ in the population of firms.

4.0.3 Analysis of an individual bidding game

Let the subscript $i \in \{1, ..., m\}$ now index the bidders in the auction for this object. A manager has a private signal about the productivity (in his firm only) of the capital good. Each manager has a perfect private ex-ante signal about his ex-post private value $z_i$ of owning the object. In a second-price auction the firm’s own bid affects only the probability that it wins the object, but not what it actually pays. Moreover, the $z_i$ do not have an unknown common component. Hence, the dominant strategy for manager $i$ is to bid

$$b_i \equiv z_i. \quad (2)$$

If firm $i$ wins the auction, the price it pays is

$$q_i = \max_{j \neq i} z_j.$$

The winning firm’s profit and dividend is

$$\delta_i = z_i - q_i.$$

**Determining the division of the rents.**—Let

$$F(z) = \text{C.D.F. of } z \text{ in the population of all matches}$$

The distribution of the winning firm’s $z$ is $F^m(z)$. Therefore the expected output of the winning firm’s unit of capital is

$$y(m) = \int_0^\infty zdF^m(z).$$

Conditional on a particular winning $z$, the C.D.F. of the price paid, $q_i$, is

$$\frac{1}{1 - F(z)^{m-1}} F^m(q) \text{ for } q \in [0, z].$$

Therefore, the expected payment to the capital purchased is

$$\alpha(m) = \int_0^\infty E(q_i \mid q_i < z) dF^m(z)$$

$$= \int_0^\infty \left[ \frac{1}{1 - F^m(z)} \int_0^z q dF^m(q) \right] dF^m(z).$$
The *ex-ante* expected profit on the deal, $\delta (m)$, going to the winning bidder is determined from the identity

$$\alpha (m) + \delta (m) = y (m),$$

**Remark 1** $\alpha$ is increasing in $m$, and $\delta$ is decreasing in $m$.

### 4.0.4 Aggregation over all auctions

If every unit of capital has $m$ managers bidding for it, then by the law of large numbers, TFP is

$$\frac{Y}{K} = y (m).$$

The share of $K$ in output is

$$\alpha = \frac{\alpha (m)}{y (m)},$$

and the share of firm owners would be

$$\delta = \frac{\delta (m)}{y (m)}.$$

Evidently,

$$\alpha + \delta = 1$$

**Tobin’s $Q$.**—The individual firm’s $Q$ is simply the expected value of a firm’s dividends divided by the purchase price of its capital:

$$Q \equiv \frac{\tilde{z}}{q} \geq 1. \quad (3)$$

The aggregate Tobin’s $Q$ is just

$$E (Q) = \frac{\alpha + \delta}{\alpha}. \quad (4)$$

This is not an unweighted average of individual firm values but, rather, the sum of share values divided by the sum of book values and corresponds to how Figure 1 was done.

### 4.1 Endogenizing $M$ and $K$

There are two periods and there is no aggregate risk. Agents are born alike, with a utility function

$$U (c_0) + \beta U (c_1)$$

where $c_0$ and $c_1$ are the first and second period consumptions. A safe asset exists and the rate of interest is $r$. There is a first-period economywide endowment $\omega$
of a single good that can be consumed immediately, or converted one-for-one into $K$, or converted into $M$ at a cost of $\phi (M)$. This is the cost of creating $M$ units of management capital, where $\phi ' > 0$ and $\phi '' > 0$. Choosing one’s $M$ really means choosing one’s span of managerial control, because the number of auctions that the agent can bid in is proportional to $M$.

**Building $K$.**—Competitive auction dealers in $K$ will pay

$$p_K = \frac{1}{1 + r} \alpha (m)$$

(5)

for a unit of $K$ today and earn an expected sale of $\alpha (m)$ in the second period for each unit of $K$ that they now buy. As in Diamond (1982), a person cannot use his own $K$ in his production function – he must go to up to $\lambda$ auctions and buy the capital there in the way that we have described. Then he and all other entrepreneurs produce output all of which is consumed in the second period. Each unit of $M$ takes part in $\lambda$ auctions and expects to win $\lambda / M$ of them where $M$ is the $M$ chosen by everyone else.

**Firm formation and “IPO”**.—The agent compiles $M$ units of management capital in period 1 and at once floats his firm in an IPO in period 1. The firm’s price at IPO is just the first-period value of the claims that the agent’s firm fetches in the first period; this is $p_M M$, where $p_M$ is the price per unit of $M$:

$$p_M = \frac{1}{1 + r} \delta (m) \frac{\lambda}{M}$$

(6)

**Lifetime budget constraint.**—The numeraire in the lifetime constraint is current consumption. The RHS of (7) are resources, and the LHS are expenditures. The agent’s resources are his endowment, $\omega$, and the proceeds from his two types of entrepreneurial activity, i.e., $p_K K + p_M M$. This is the RHS of (7):

$$c_0 + \frac{1}{1 + r} c_1 + K + \phi (M) = \omega + p_K K + p_M M.$$  

(7)

On the LHS of (7) are the first period costs of $c_0$ and $c_1$, and the resources withdrawn for making $K$ and $M$, namely $K + \phi (M)$.

**First-order conditions.**—The FOC w.r.t. $K$ is,

$$\frac{1}{1 + r} \alpha (m) = 1;$$

(8)

w.r.t. $M$ it is

$$\frac{1}{1 + r} \delta (m) \frac{\lambda}{M} = \phi ' (M),$$

(9)

and w.r.t. $c_0$ and $c_1$ (upon getting rid of the Lagrange multiplier) it is

$$\frac{1}{1 + r} = \beta U' (c_1) \frac{\beta U' (c_0)}{U' (c_0)},$$

(10)
Demand = Supply. — Since all agents will consume the same, \( c_0 \) and \( c_1 \) also denote aggregate consumption in the two periods. In the last period the goods market clears and all output is consumed:
\[
c_1 = y(m) K. \tag{11}
\]

The lifetime budget constraint must hold when aggregate values of the variables are substituted into it. Finally the asset market must be in equilibrium when the values of aggregate consumption are substituted into the first-order condition (10) for \( c_0 \) and \( c_1 \). A further condition is the bidding proportions equation (1), i.e.,
\[
m = \lambda \frac{M}{K}.
\]

The effect of a rise in \( \sigma_z \). — If production tasks have become more complex and human and physical capital have become more firm-specific, this means a rise in \( \sigma_z \). A rise in \( \sigma_z \) (or, more accurately, in the variance of \( \ln z \) which is a stronger requirement) raises the share of output going to capital by raising the productivity of the winning manager relative to the manager with the next-highest productivity and, hence, relative to the wage. In this sense, a higher specificity of capital is good for the winning manager, and it raises the share of dividends, \( \delta \). We shall show this by example shortly. The effect of a rise in \( \sigma_z \) is illustrated in Figure (8).
5 Example

To illustrate the mechanism at work, we assume that $M = K$ and that they are given exogenously. We take $\lambda = 2$ so that each piece of capital has two firms bidding for it. Let us assume that there are two types of matches. The random variable $\tilde{z}$ has the same chance of being high or low. The high value is normalized to unity. So each bidder draws his value from the following distribution of $\tilde{z}$

$$\tilde{z} = \begin{cases} 
1 & \text{with prob } p \\
 z & \text{with prob. } 1 - p
\end{cases}$$

Therefore we have the following three types of auctions.

1. Both firms draw $\tilde{z} = 1$. This happens in $\frac{1}{4}$ of the auctions. The productivity of the capital is 1, and, since both firms bid unity, all the output goes to capital and the winning firm gets nothing.

2. Both firms draw $\tilde{z} = z < 1$. This also happens in $\frac{1}{4}$ of the auctions. The price and productivity of the capital is $z$. Once again, all the output goes to capital, and the winning firm gets nothing.

3. One firm draws $\tilde{z} = 1$, the other draws $\tilde{z} = z$. The price of the capital is $z$, but its productivity is 1. The winning firm gets $1 - z$, and capital gets $z$.

In cases 1 and 2 all the output goes to capital. Only in case 3 does the firm get a fraction $1 - z$ of the capital. The situation is:

- Aggregate output $\frac{(3 + z) K}{4}$
- The share of $K$ $\frac{1 + 3z}{3 + z}$
- The firm’s share $\frac{2(1 - z)}{3 + z}$

Assuming that $K = 1$, we plot these three quantities on $z$ in Figure 9.

The specificity of capital can be measured as $1 - z$. As the capital gets more specific, we move towards the left of the figure. Output falls, but the share of the firm rises more than enough to offset this decline. Thus the example shows that we can at once have a permanent fall in output and a permanent rise in the value of firms, both occurring at the same time. This explains Figure 1 as well as the failure of productivity growth to rise and perhaps even its tendency to slow down of late.

6 Empirics

Like the intangibles hypothesis, ours also implies that as a percentage of the tangible capital stock earnings ought to have risen. The first is a case of missing capital,
Figure 9: The shares of the firm and of $K$ in the specific example.

whereas the second is a case of capital that costs less per efficiency unit. Figure 1 of Hall (2002) shows a 20 percent rise since 1946, but this does not help disentangle the two.

According to the example above, a rise in $\text{Var}(q)$ indicates a rise in $\sigma_z$, and implies a transfer of rents to the shareholder. Here we run a preliminary statistical horse race between our hypothesis and the “intangibles” hypothesis. For the latter, we use the number of patents per thousand business concerns.\textsuperscript{11} To test our hypothesis, we use our earlier result to argue that $\text{Var}(q)$ is a good proxy for $\sigma_z^2$. We do not have the distribution of all bids, but we do have the variance of $q$ on the stock market at each date, and this should be a monotone function of $\text{Var}(q)$.

Letting $Pat_t$ represent the number of patents per business concern, and weighting our decadal observations to combine them with our later annual data so as to treat each year equally, our benchmark regressions for average $Q$ over the century gives

\textsuperscript{11}We use the total number “utility” (i.e., invention) patents from the U.S. Patent and Trademark Office for 1963-2000, and from Historical Statistics (U.S. Bureau of the Census, 1975, series W-96, pp. 957-959) for 1900-1962. The number of concerns in business is also from Historical Statistics (series V-20, p. 912) for 1900-1970, and from various issues of the Statistical Abstract of the United States for later years.
\[ Q_t = 1.262 + 0.012 \ Pat_t + 0.012 \ var(q_t) \quad N = 101, \ R^2 = .211, \]

with t-statistics in parentheses. In this specification, \( Pat_t \), or the number of patents per concern, has the expected positive sign (under the intangible hypothesis) but is not statistically significant. The cross-sectional variance of \( Q \), on the other hand, is significant at the one percent level. This is consistent with our proposition that a rise in \( \sigma_z \) raises \( Q \).

To check the sensitivity of our results to the choice of the sample period and the simple weighting technique that allowed us to use all of our data, we next limit the sample to annual data from 1950-2000 and get

\[ Q_t = 1.473 + 0.010 \ Pat_t + 0.393 \ var(\ln q_t) \quad N = 51, \ R^2 = .125. \]

This time, the coefficient on patents is positive with a t-statistic that is just above unity, but, more importantly, the coefficient on the variance of \( Q \) is again statistically significant, though now at the five percent level. This result is also consistent with our model's implications for \( \sigma_z \).

At this stage, the regressions show only that some kind of a test is possible, and not much about what the outcomes of more carefully designed tests are likely to be. We do not believe, for example, that patents adequately express the traditional “intangibles” hypothesis, and we intend to look further for good proxies for it.

7 Appendix

The series in Figure 10, which extends Figure 1 of Hall (2002) back to 1929, has risen by some thirty percent between 1947 and 2000, from 0.16 to 0.21, and by more than sixty percent since the eve of the Great Depression in 1929. This may reflect that some capital is missing from the denominator. But it simply could be that capital earns less than it used to.\(^{12}\)

\(^{12}\)Following Hall (2002), we construct corporate earnings as in footnote 1. Corporate tangible assets are the sum of the net stock of private corporate fixed assets (Bureau of Economic Analysis, 2002, Fixed Asset Table 6.1) and private business inventories (NIPA table 5.12). Since the level of inventories begins in 1947, we use the change in business inventories (NIPA table 1) to extend it backwards through 1929. The series for inventories does not specify the part which is held by corporations, so we compute the ratio of corporate to total capital consumption allowances and multiply this share by the published inventory figures. The dashed line in Figure 1 is the ratio of corporate earnings to corporate tangible capital as defined above.
Figure 10: Aggregate Tobin’s Q and the ratio of corporate earnings to tangible assets, 1900-2000.

References


