Specific Capital and the Division of Rents*

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Abstract

The NIPA and stock-market data both show that firm owners keep a larger fraction of output today than they did 75 years ago. We argue that a rising specialization of human and physical capital has raised the rents in the average match between a firm and its human and physical capital. As those rents have grown, the firm's share of those rents has also grown. We present and estimate a model that explains how this shift may have taken place.

1 Introduction

The past century has produced a high rate of growth in the variety of products and in the variety of technologies that we use to produce them. For the period 1929-2001, annual growth in the stock of patents (which start cumulating in 1790) is 1.8 percent. For trademarks, the cumulation begins in 1870 and the annual growth rate is 3.3 percent. Alternatively, patenting flows grew at 2.8 percent and trademarking flows at 4.9 percent per year. By contrast, the number of business concerns grew at the considerably slower rate of 1 percent per year.[1]

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[1] Patents and trademarks are noisy measures of innovation. Not every patent represents something new, and some patents duplicate other patents, yet the differences in growth rates between these measures of innovation and business enterprise are so large that they are unlikely to be driven by this noise. To compute the growth rates, we use the total number of "utility" (i.e., invention) patents from the U.S. Patent and Trademark Office for 1963-2001 (*www.uspto.gov*) and the *Historical Statistics*

Since the number of patents and trademarks held by the average business concern has risen, it would seem that the technological distance between firms has risen. It then seems likely that the physical and human capital that firms need to operate their technologies has become more specialized. This may also imply that capital is now more *firm* specific. We argue that such a rise in the firm specificity of capital may explain why over the past seventy-five years

1. Firms' earnings have risen while their profits have remained flat,

2. Tobin's Q and the skill premium have risen with no accompanying rise in productivity growth,

3. Labor turnover has declined,

4. Management plays a more important role in the economy, especially at the firm's formative stage,

and several other phenomena.

A summary of the argument.—Our argument is as follows: Rising specialization of firms and inputs has forced firms to try harder to hire those inputs that suit their needs the best. Management has the task of finding the right inputs; its role and its reward have therefore risen. When a firm has its IPO or when it is acquired, its price is now higher because it includes this (now higher) "assembly fee." This rise in price is financed largely through additional debt that the new entity inherits. And that is why firms' earnings (which include payments to debt-holders) have risen while firms' profits (which exclude them) have remained relatively flat.

The plan of the paper.—Section 2 documents the four facts listed above. Section 3 gives a simple example around which the model revolves. Section 4 presents the model itself. Section 5 simulates the model and compares it to data. Section 6 presents some regressions. Section 7 concludes the paper, and the Appendix contains technical arguments and data descriptions.

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of the United States (U.S. Bureau of the Census, 1975, series W-96, pp. 957-959) for 1790-1962. The number of registered trademarks are from *Historical Statistics* (series W-107, p. 959) for 1870-1969 and various issues of the Census Bureau's *Statistical Abstract of the United States* for later years. The number of business concerns is from *Historical Statistics* (series V-20, p. 912) for 1929-70 and various issues of the *Statistical Abstract* and the *County Business Patterns* release for later years.

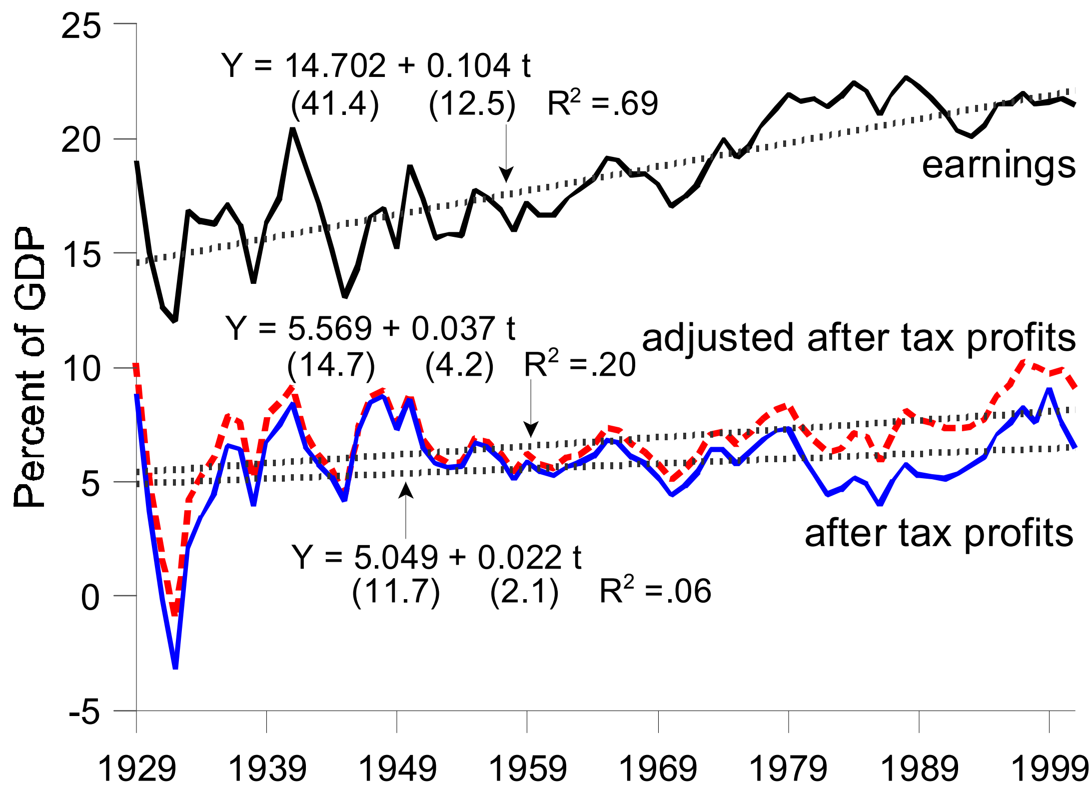


Figure 1: Adjusted earnings and profits in the corporate sector, 1929-2001.

2 The main facts

This section documents the four claims listed in the introduction. Here we are stressing trends, not waves.

2.1 Earnings vs. profits

The top series in Figure 1 and its accompanying regression line (with t-statistics in parentheses) show an upward trend in corporate earnings as a percentage of gross domestic product (GDP) from 1929 to 2001. These earnings, however, do not translate directly into accounting profits for shareholders. It is only after deducting interest payments on debt, taking out capital consumption allowances and taxes, and adding repurchases of a firm's own shares back in that we arrive at accounting profits.[2] These

[2]We compute corporate earnings from the National Income and Product Accounts (NIPA) tables

after-tax profits, shown by the lower series in Figure 1, are relatively flat. But to calculate the earnings that actually accrue to firm owners, we must still account for pre-IPO debt and mergers. For example, a firm may issue debt during its pre-IPO phase that ends up getting sold by the original entrepreneurs to the new owners at the time of IPO. In effect, the original entrepreneurs are paid for this debt when they sell their shares, and subsequent interest on this permanent debt are these payments.[3] It is also common for mergers to be financed by debt, and the interest paid on the additional debt incurred by the acquirer are also profits that go to the owners.[4] The dashed line in Figure 1 shows profits after adjusting for interest payments related to mergers and pre-IPO debt, and its stronger upward trend indicates that owners have indeed received a larger share of earnings since 1929.

2.2 The skill premium and Tobin's Q

The solid line in Figure 2 shows that Tobin's Q's among exchange-listed firms has risen. We proxied for Q using market-to-book ratios.[5] For 1955-2001 these are from

published by the Bureau of Economic Analysis (BEA, 2003) as the sum of profits before taxes (table 6.17), net interest (table 6.15), and capital consumption allowances (table 6.22). GDP is from NIPA table 1. Repurchases are the sum of data item 115 from Standard and Poor's Compustat across all firms in the database, and does not include repurchases by unlisted firms.

[3] See section 8.1 of the Appendix for a description of how we made this adjustment.

[4] Had the merger not occurred and been leveraged by new debt, equity would have been higher by the amount that we are adding back in. We make this adjustment for 1961-2001 using the University of Chicago's Center for Research in Securities Prices (CRSP) database to identify merger targets and acquirers among listed firms, and Compustat to obtain their debt levels before and after the merger. We then compute net new debt incurred in the year of a merger and cumulate this amount over time for merging firms as a share of total debt, and deduct this part of interest payments from earnings after interest and, after correcting for taxes, from after-tax profits. Merger activity among listed firms between 1930 and 1960 was negligible (see Jovanovic and Rousseau, 2002, Figure 1).

[5] In our model a firm's average Q is the same as its market-to-book ratio, but this is not true in fact as the two may diverge significantly due to the effects of changing tax rates on market values and depreciation on book values. Since these adjustments would affect firms and investors differently and over time, we prefer to derive market-to-book ratios directly from our micro-based balance sheet data in a manner that is consistent across the past 75 years.

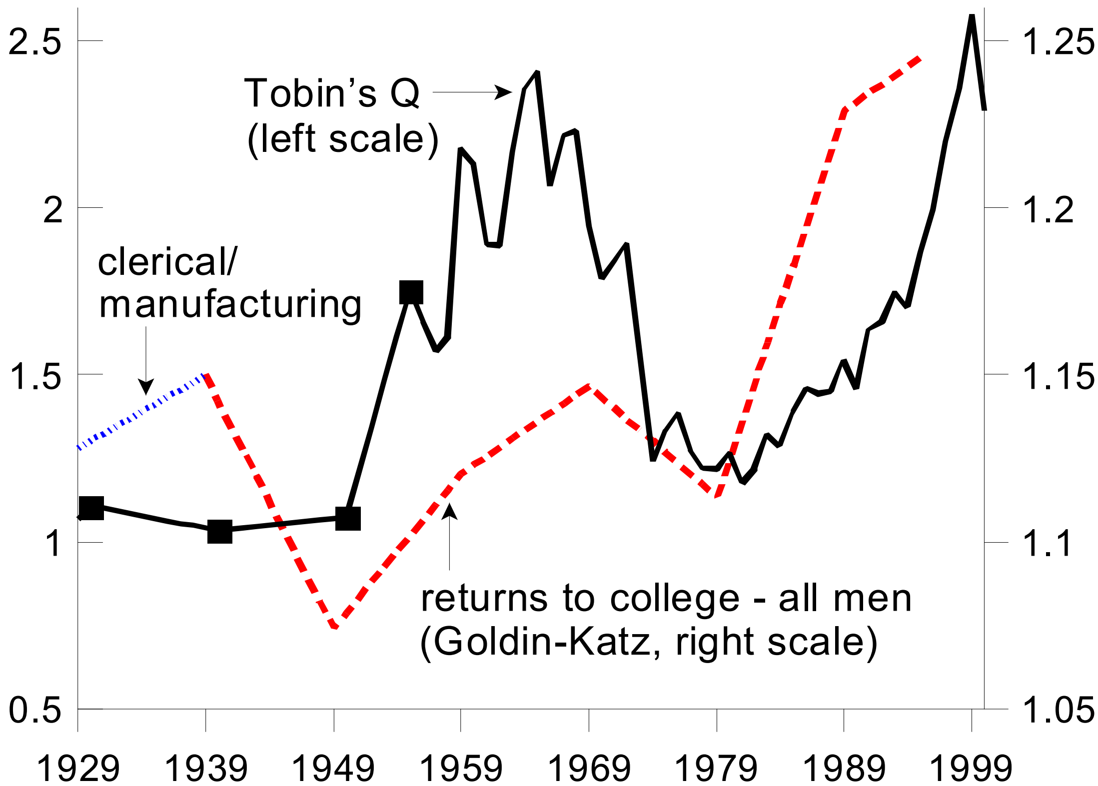


Figure 2: The skill premium and Tobin's Q.

Compustat.[6] For the squares from 1929 to 1955 we use prices and the number of outstanding shares from the CRSP stock files in conjunction with balance sheet items from Moody's investor manuals.[7] Since the book capitalizations that appear in the

[6] To compute market values using Compustat, we start with 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 debts (items 34 and 9). Book values are computed similarly, but with the book value of common equity (item 60) rather than market value. We omit observations with market-to-book ratios in excess of 100, since most are likely to be data errors.

[7] The balance sheet data are from Moody's *Industrial Manual* and Moody's *Public Utility Securities Manual*. Balance sheet items were not defined as uniformly across firms in the early Moody's manuals as they are in today's Compustat, and we must compute market-to-book ratios differently for 1929-55. 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 the market value of common shares and the book value of long-term debt. The denominator is the sum of book values of common equity

denominator of our Q's are historical, and thus not corrected for inflation, we make this adjustment before computing the ratios in Figure 2.[8]

Over the century, the skill premium is U-shaped, as we have reported in Jovanovic and Rousseau (2003, Figure 18, p. 26), but the data that lead to this conclusion were joined from several disparate sources.[9] If we use a consistent series we reach a different conclusion: The skill premium has risen and is correlated with the rise in Q. Figure 2 shows the relative returns to 16 versus 12 years of schooling for men from 1939 to 1995 from Goldin and Katz (1999) along with Tobin's Q over the same period.[10] The two series have a correlation coefficient of 0.34.

2.3 Labor turnover

Labor turnover fell dramatically during the 20th century. Figure 3, which shows annual job separation rates from 1929 to 2001 using various sources and excluding the World War II years, demonstrates this fact for the United States.[11] Figure 4,

and long-term debt. The difference between the 1929-55 period and later years, then, is the inclusion of short-term debt in both numerator and denominator after 1955. This imparts a small upward bias for the pre-Compustat years.

[8] Section 8.2 in the Appendix describes how we made the inflation adjustment.

[9] For example, for 1870-96 we used the ratio of wages for skilled and unskilled urban workers, and for 1897-1938 we used the ratio of clerical to manufacturing production wages. Only from 1939-95 do we have a consistent series for the returns to a college education.

[10] Since the Goldin and Katz observations are generally decadal, we interpolate between them to obtain an annual series for 1939 to 1995. To extend the series back another nine years to correspond with our observations on Tobin's Q, we join it with the ratio of clerical to manufacturing production wages for 1929-38, also from Goldin and Katz.

[11] The turnover data given by the solid line are for the manufacturing sector and include job separations due to quits, layoffs, and discharges. They are from *Historical Statistics* (U.S. Bureau of the Census, 1975, series D-1024, pp. 181-2), which draw from the Bureau of Labor Statistics (BLS), for 1919-70, and from the BLS's *Monthly Labor Review* for 1970-80. We linearly interpolate between the observation for 1980 and the next available BLS estimate in 2000, which marks the start of a new initiative at the BLS to collect job turnover data. The dotted line from 1968-1980 shows 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 for manufacturing in 1968. We continue this series after 1980 using separation rates for all sectors based on March issues of the *Current Population Survey* (CPS) from Stewart (2002, table 1). Thus, after 1968, the lower line in Figure 3 becomes an index

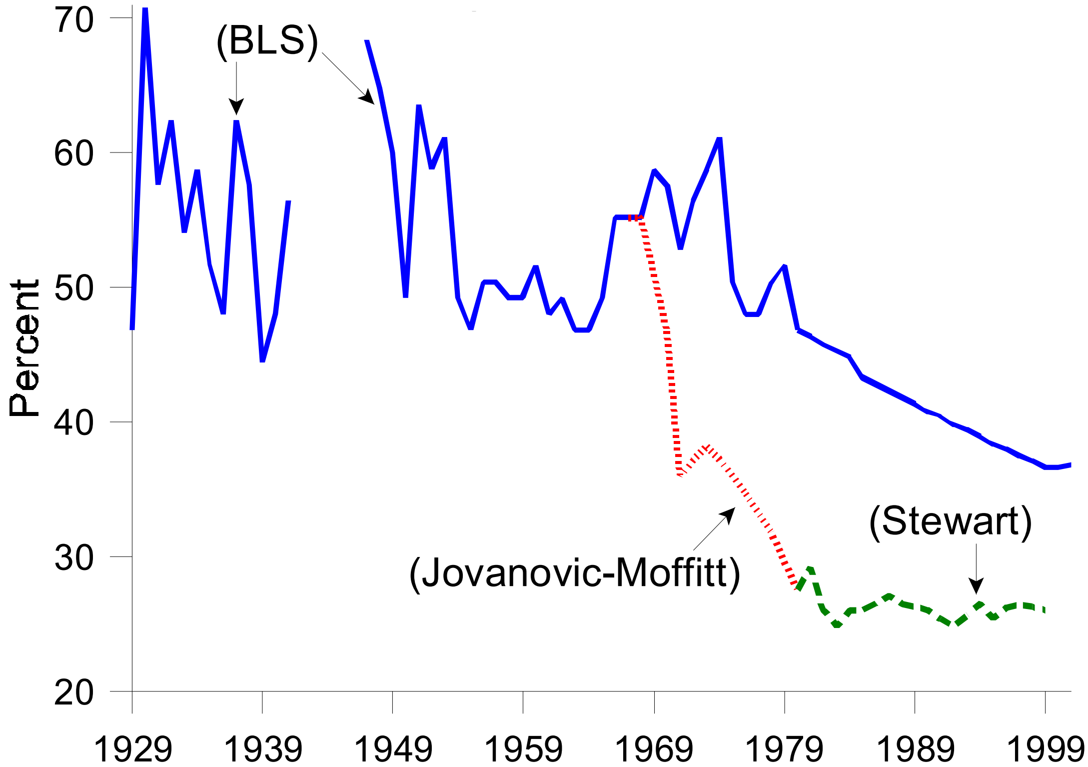


Figure 3: Annual labor turnover rates, 1929-2001.

reproduced from Mincer and Higuchi (1988), shows it for Japan.[12] We interpret this rising attachment of workers to firms as the result of a rising specificity of their human capital which, itself, derives from the rise in technological variety. Equations (13)-(15) of Dagsvik, Jovanovic and Shepard (1985) show how the variance of match quality between a firm and a worker rises with the heterogeneity of the technologies that firms use.

of turnover rates. A recent paper by Moscarini and Vella (2003), also using the CPS, finds that mobility across 3-digit sectors has declined from 1971-2000, which is consistent with the series that we use in Figure 3. Kambourov and Manovskii (2002), however, using a smaller sample from the Panel Study of Income Dynamics (PSID) that excludes public employees, report a modest increase in occupational mobility over the same period.

[12]In Figure 4, the series labeled "Japan (I)" shows average monthly separation rate in plants with 50 or more workers. "Japan (II)" shows separation rates in plants with 30 workers or more.

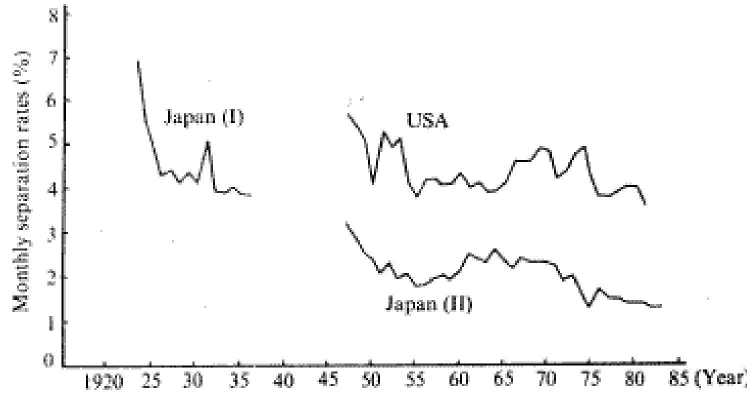


Figure 4: Labor turnover rates for Japan.

2.4 Management and the 'assembly' of the firm

The last century has seen a rise in the role of the manager (Nelson 1995), and the last 20 years, especially, have produced a rise in venture capitalism. The venture capitalist, especially, focuses on the formative stage of a business. The term "assembly" is supposed to represent the stage at which the firm has negative cash flows, a stage that every firm goes through at the outset. The rising importance of the process of assembly itself originates in our demand for a more rapid succession of new products.

A venture capitalist, together with the founder of a firm, assembles assets around an idea. The idea belongs to the firm, and the people and assets should be suited to the implementation of that idea. If the right team and right assets are assembled, the ratio of market to book value of the firm at IPO will be high.

An existing firm also must periodically move to new activities and new products. Banking, for example, is one place we see clear examples of how firm-specific capital, both physical and human, are assembled. Before buying a building, a retail bank wants to know if the likely customers will value its products. Management studies the demographics to see if the building is a good match for the bank's needs.

An investment bank will sometimes bid for an entire team of analysts from another bank. Before doing so, its management evaluates whether that team's human capital is a good match for the bank's own needs. For example, management will want to know if the team has expertise in those areas where its own sales force specializes.

If the market for used capital was liquid, evaluative expertise would not matter – buying the wrong building or hiring the wrong people could be reversed without cost. But informational and other frictions make it costly to trade used equipment and to move people around. Our model will assume that the only role of the manager is that of assembling the firm's assets.

3 Example

The following example of a single auction shows how specificity translates into a division of rents. The model in Section 4 will place this into an equilibrium setting, and Section 5 will present simulations of the model.

Consider a second-price auction for one asset, "capital," with two firms bidding for it. Each bidder independently draws a value of the object, z, from the following distribution:

$$z = \begin{cases} 1 & \text{with prob. } \frac{1}{2} \\ z_0 & \text{with prob. } \frac{1}{2}. \end{cases}$$

The winner of the auction pays what the loser has bid, and so it is optimal to bid one's own value. Therefore we have the following three types of outcomes.

1. Both bidders draw $z = 1$. All rents go to capital; the bidders get nothing.
2. Both firms draw $z = z_0$. Again, all rents go to capital.
3. One firm draws $z = 1$, the other draws $z = z_0$. Capital gets z_0, and the winning bidder gets $1 - z_0$.

Weighing the outcomes by their probabilities, the expected values are as follows:

Output	$\frac{(3+z_0)}{4}$
Share of capital	$\frac{1+3z_0}{3+z_0}$
Share of firm	$\frac{2(1-z_0)}{3+z_0}$.

We plot these three quantities as a function of z_0 in Figure 5.

Specificity of capital.—The specificity of capital can be measured as $1 - z_0$. As z_0 falls and as capital gets more specific, output falls, but the share of the firm rises

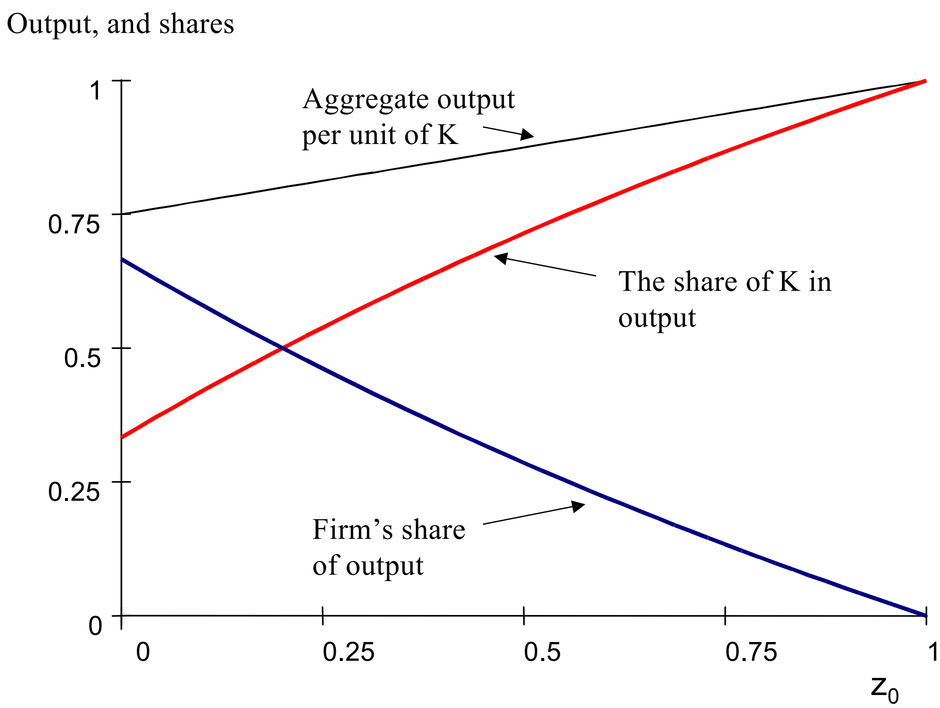


Figure 5: The expected shares of the bidders and the asset.

more than enough to offset this decline. Thus output falls but the value of firms rises. This explains why Q can rise in the midst of a productivity slowdown.

4 Equilibrium model

A firm's production function.—The firm's inputs are management and "broad capital" k. Its output, y, is

$$y = \sum_{i=1}^{k} z_i,$$

where the z_i are the qualities of the various units of k that a firm's manager has assembled. The managers 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. Each unit of capital, z_i, is purely firm-specific, so that capital has no hierarchical quality dimension. Moreover, a manager can see z_i before he bids for the i'th unit of k.

Second-price auctions.—Each unit of k sells in its own second-price auction unrelated to any other auction.[13] 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, λ. Then the total number of bidders in the economy is λM. Therefore, each unit of capital will have m firms bidding for it, where

$$m = \lambda \frac{M}{K}. \tag{1}$$

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 (i.e., the object goes to the highest bidder who pays the second-highest bid).

Idiosyncratic match quality.—Capital and firms are *ex ante* the same, but the quality of the match between assets and managers is random and unknown. Let $F(z)$ be the distribution of z. Firms value a given unit of capital differently, and this is what we mean by the "firm specificity" of capital. A manager learns the match quality z only after he commits to attending the auction for the asset in question.

4.1 Analysis of a single auction

Let the subscript $i \in \{1, ..., m\}$ 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

$$b_i \equiv z_i.$$

[13] Under certain conditions, a whole range of auctions (including the second-price auction) yield the same, maximal expected revenue to the auctioneer (Myerson 1981). The second-price auction is the simplest to analyze.

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

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

This is also "TFP." Conditional on a particular winning z, the C.D.F. of the price paid, q_i, is

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

so that the expected price paid is

$$E(q \mid z, m) = \frac{1}{F^{m-1}(z)} \int_0^z q dF^{m-1}(q).$$

Therefore, the expected payment to the capital purchased is

$$\alpha = \int_0^\infty E(q \mid z, m) \, dF^m(z).$$

The *ex-ante* expected profit on the deal, δ, going to the winning bidder is determined from the identity

$$\alpha + \delta = y.$$

Remark 1 *α is increasing in m, and δ is decreasing in m.*

Aggregation over auctions.—If every unit of capital has m managers bidding for it, then by the law of large numbers, aggregate TFP is $\frac{Y}{K} = y$. The share of K in output is α/y, and the share of firm owners is δ/y.

Tobin's Q.—If a firm had just a single asset, its Q would simply be the expected value of the firm's dividends divided by the purchase price of its capital: $\frac{z}{p_k}$. Aggregate Q does not depend on how assets are distributed over firms, but is just

$$Q = \frac{\alpha + \delta}{\alpha}. \tag{2}$$

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 2 was constructed.

4.2 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 economy-wide endowment ω of a single good that can be consumed immediately, or converted one-for-one into K, or converted into M at a cost of ϕ that the household takes as given.

Building K.—Competitive auction dealers in K will pay

$$p_K = \frac{\alpha}{1+r} \tag{3}$$

for a unit of K today and earn an expected sale of α in the second period for each unit of K that they now buy.

Firm formation and "IPO".—As in Diamond (1982), a person cannot use his own K in his production function – he must go to up to λ auctions and buy the capital there in the way that we have described. Each unit of M takes part in λ auctions. The probability of winning any single auction is $1/m$ and so a unit of M expects to win λ/m auctions altogether. 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. A unit of M delivers participation in λ auctions and δ in proceeds from every auction won. The probability of winning an auction is the same for all of the m bidders in that auction, and therefore

$$p_M = \frac{1}{1+r}\frac{\delta}{m}. \tag{4}$$

Lifetime budget constraint.—The numeraire in the lifetime budget constraint is current consumption. The agent's resources are his endowment, ω, and the proceeds from his two types of entrepreneurial activity, i.e., $p_K K + p_M M$. The constraint is thus

$$c_0 + \frac{1}{1+r} c_1 + K + \phi M = \omega + p_K K + p_M M. \tag{5}$$

The right-hand side of (5) are resources, and the left-hand side are expenditures.

First-order conditions.—The FOC with respect to K is,

$$\frac{1}{1+r} \alpha = 1; \tag{6}$$

with respect to M it is

$$\frac{1}{1+r} \frac{\delta}{m} = \phi, \tag{7}$$

and with respect to c_0 and c_1 (after eliminating the Lagrange multiplier) it is

$$\frac{1}{1+r} = \beta \frac{U'(c_1)}{U'(c_0)}. \tag{8}$$

Demand = Supply.—All agents consume the same, c_0 and c_1 which, therefore, also denote aggregate consumption in the two periods. In the second period the goods market clears and all output is consumed:

$$c_1 = yK.$$

The lifetime budget constraint (5) 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 (8) for c_0 and c_1. A further condition is the bidding proportions equation (1).

Congestion in the creation of M.—We assume an aggregate congestion cost in the creation of M. That is,

$$\phi = \phi(m),$$

where m is the economy-wide ratio M/K which each agent takes as given. We assume that $\phi' > 0$, which is a type of externality (pecuniary or non-pecuniary) in creating M, perhaps because it requires the presence of an unmodeled scarce input.

4.3 The effect of a rise in the specificity of capital

The dispersion of z measures the firm-specificity of assets. Consider the management premium, which we shall refer to as the "skill premium." From (3) and (4) this is[14]

$$\frac{p_M}{p_K} = \frac{\delta(m)}{m\alpha(m)}. \tag{9}$$

But using (6) and (7),

$$\frac{p_M}{p_K} = \phi(m).$$

Now consider the experiment that we performed when analyzing the example in Section 3: Raise σ_z by taking an inferior distribution of z with a longer left tail. Such a rise in σ_z raises $\delta(m)$ and lowers $\alpha(m)$. This also has the effect of raising Q in (2). Therefore the skill premium rises, creating the incentive to create more M and less K, so that m will rise to offset this effect partially. But $\phi' > 0$ means that the rise in m will not fully offset the initial stimulus, and therefore the effect will be a rise in both Q and the skill premium – see Figure 6. The figure plots both sides of the equation

$$\phi(m) = \frac{\delta(m)}{m\alpha(m)}. \tag{10}$$

When σ_z rises from σ_1 to σ_2, the right-hand side of (10) rises, whereas its left-hand side remains unchanged. And m must rise to restore equilibrium as illustrated in Figure 6. Indeed, our two simulations show that m is roughly proportional to σ/μ (see panels (e) of Figures 7 and 8).

Q and the skill premium.—A simple relation holds between the two: Combining (2) and (10), we get

$$Q = 1 + m\frac{p_M}{p_K}.$$

Therefore Q will rise together with the skill premium. At first it may seem odd that Q can rise permanently. A value of Q permanently higher than unity is not generally an equilibrium outcome in an economy that is not growing and in which the cost of adjusting capital is convex. Even in our model, a Q different from unity would not arise if the supply of M were infinitely elastic. But the supply curve for M is, in fact,

[14] At this point the argument becomes clearer if we emphasize that α and δ both depend on m where $\alpha'(m) > 0$ and $\delta'(m) < 0$.

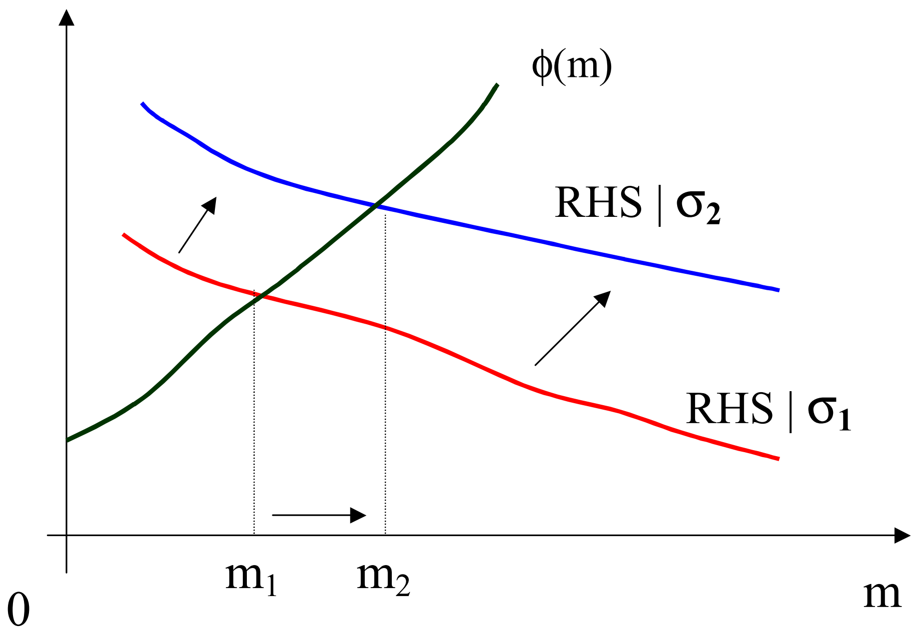


Figure 6: Comparative statics in (10): The effect on m of a rise in σ_z from σ_1 to σ_2.

probably positively sloped, even in the long run. In the model, M is homogeneous; what we believe really causes ϕ to rise with m is the heterogeneity of managerial talent and a non-degeneracy in comparative advantage in supplying M. In such a world, the most talented managers would find it profitable to manage even when the unit return to M is just slightly above that of the unit return to K. But as we move down the skill distribution or, rather, as we attract people whose comparative advantage in supplying M is not that high, we must raise the price. Thus the supply of M is positively sloped, even in the long run, or at least for as long as the distribution of managerial talents does not change.

5 Simulations

In this section we simulate the model's predicted profit rate, the skill premium, and Tobin's Q, and compare them to U.S. data from 1929 to 2001. For this purpose we shall use a simplified version of the model in which the technology parameter z is drawn from the binomial distribution:

$$z = \begin{cases} \mu + \frac{1}{2}\sigma & \text{with prob. } p, \quad \text{and} \\ \mu - \frac{1}{2}\sigma & \text{with prob. } 1-p. \end{cases} \tag{11}$$

so that $E(z) = \mu$. We assume that the parameters μ and σ_z grew at a constant rate from 1929 to 2001, and that TFP also grew at a constant rate.

In an auction with m bidders, each bidder may win (without a tie) with probability $p(1-p)^{m-1}$. The probability that *some* firm has a no-tie win is $mp(1-p)^{m-1}$. All other winning outcomes involve a tie and, hence, zero profits. The profit from the auction that the winning firm derives is now the binomially-distributed random variable

$$\tilde{\delta} = \begin{cases} \sigma & \text{with prob. } mp(1-p)^{m-1}, \\ 0 & \text{with prob. } 1 - mp(1-p)^{m-1}. \end{cases}$$

The unit of K receives an income of $\mu - \frac{1}{2}\sigma$ if there is a no-tie winner *or* if all m bidders draw a low value of z. Therefore the price that a unit of K fetches is

$$\tilde{\alpha} = \begin{cases} \mu + \frac{1}{2}\sigma & \text{with prob.} \quad 1 - mp(1-p)^{m-1} - (1-p)^m \\ \mu - \frac{1}{2}\sigma & \text{with prob.} \quad mp(1-p)^{m-1} + (1-p)^m \quad . \end{cases}$$

The expected earnings of the winning firm and the asset are

$$\delta = \sigma mp(1-p)^{m-1}, \quad \text{and} \quad \alpha = \mu + \sigma\left(\frac{1}{2} - mp(1-p)^{m-1} - (1-p)^m\right).$$

Expected output is

$$y = \mu + \sigma\left[\frac{1}{2} - (1-p)^m\right]. \tag{12}$$

This is also the economy-wide TFP, T.

The profit rate.—The profit rate is

$$\pi \equiv \frac{\delta}{y} = \frac{\sigma mp(1-p)^{m-1}}{\mu + \sigma\left[\frac{1}{2} - (1-p)^m\right]}. \tag{13}$$

The skill premium.—Combining the above information with (9), the skill premium is

$$\frac{p_M}{p_K} = \frac{\delta}{m\alpha} = \frac{\sigma p(1-p)^{m-1}}{\mu + \sigma\left(\frac{1}{2} - mp(1-p)^{m-1} - (1-p)^m\right)}. \tag{14}$$

Tobin's Q.—Using (2),

$$Q = 1 + \frac{\sigma m p (1-p)^{m-1}}{\mu + \sigma \left(\frac{1}{2} - mp(1-p)^{m-1} - (1-p)^m\right)}. \tag{15}$$

Special case of $p = 1/2$. In this case, (12), (13), (14) and (15), which summarize the model's predictions for the four observable series, after letting $\theta = \sigma/\mu$, are

$$\tau \equiv \frac{T}{\mu} = 1 + \theta \left(\frac{1}{2} - \frac{1}{2^m}\right), \qquad \text{(TFP)} \tag{16}$$

$$\pi = \frac{\theta m \frac{1}{2^m}}{1 + \theta\left(\frac{1}{2} - \frac{1}{2^m}\right)}, \qquad \text{(profit rate)} \tag{17}$$

$$\frac{p_M}{p_K} = \frac{\theta \frac{1}{2^m}}{1 + \theta\left(\frac{1}{2} - [m+1]\frac{1}{2^m}\right)}, \qquad \text{(skill premium)} \tag{18}$$

and

$$Q = 1 + \frac{\theta m \frac{1}{2^m}}{1 + \theta\left(\frac{1}{2} - [m+1]\frac{1}{2^m}\right)} \qquad \text{(Tobin's } Q\text{)}. \tag{19}$$

Simulation details.—We shall simulate the model by putting in two forcing variables – τ_t and θ_t – that grow at constant and possibly different rates. Those growth rates, g_τ and g_θ, and the initial levels, τ_0 and θ_0, are the four parameters we shall choose in order to get a better fit. Substituting $\tau_t = \tau_0 e^{g_\tau t}$ and $\theta_t = \theta_0 e^{g_\theta t}$, we compute the time path of m by solving (16):

$$m = -\frac{1}{\ln 2} \ln\left(\frac{1}{2} + \frac{1}{\theta}[1-\tau]\right).$$

We then use $(\tau_0, \tau_t, \theta_0, \theta_t, m_t)$ in (16), (17), (18), and (19) to predict the observables.

Further notes on data used.—For the left-hand side of (16) we let $T_t \equiv TFP_t = \exp\left\{\sum_{s=1}^{t} g_s\right\}$, where

$$g_t = (\ln y_t - \ln y_{t-1}) - 0.25(\ln K_t - \ln K_{t-1}) - 0.75(\ln L_t - \ln L_{t-1}).$$

Here y_t is GDP, K_t is the aggregate stock of physical capital, and L_t is quality-adjusted labor hours.[15] For (17), the model assumes that firm owners compensate

[15] We construct the net capital stock using the private fixed asset tables published by the BEA (2003). Labor input for 1948-2001 is the number of man-hours worked in the private domestic economy from NIPA tables 6.9b and 6.9c. For 1929-47, we divide GDP by the Kendrick-NBER

managers fully and earn zero profits ex-post, and so the empirical counterpart of π_t is the *adjusted* profit series – i.e., the steeper of the two profit series plotted in Figure 1. For the left-hand sides of (18) and (19), we use the same variables plotted in Figure 2 and described in Section 2.2.

Simulation results.—Figure 7 shows simulation results for a parameterization obtained using a weighted least squares fitting criterion across all four of the observables. The weights were given by the inverse of the variances of the underlying de-trended series. The observables are given by the dashed lines and the model's predictions by the solid lines. This criterion fits TFP (panel a), the profit rate (panel b), and the skill premium (panel c) well, but under-predicts Tobin's Q (panel d). This is because m (panel e) does not rise quickly enough under this parameterization to fit Q while maintaining direct proportionality with the skill premium, which does not vary as widely as Q. The ratio σ/μ rises as the model predicts.

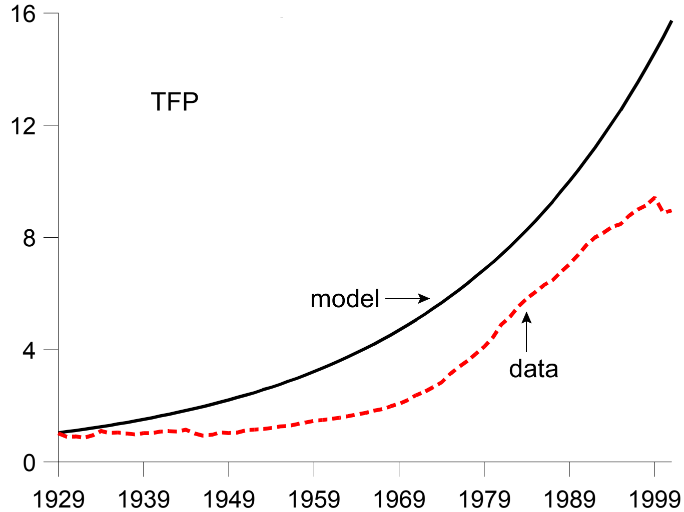
Figure 8 uses a parameterization that fits the slope of Q more closely, though it now over-predicts its level, and continues to fit the skill premium well. This is because m now rises quickly enough. The model also gets the slope of the profit rate correct but over-predicts its level. Note that while σ and μ both rise, the coefficient of variation

$$\frac{\mu}{\sigma} = \frac{1}{2} - \frac{1}{2^m}\left(m - \frac{p_K}{p_M}\right)$$

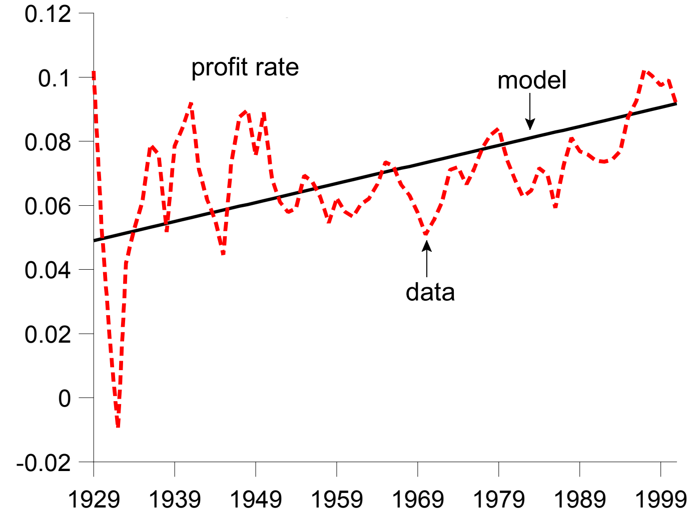
turns out to be decreasing in m. This means that the coefficient of variation of z has been increasing so that the specialization of assets rises not just absolutely (i.e., a rising σ), but also relative to the average productivity of the assets, μ.[16]

index of employee output from *Historical Statistics* (Bureau of the Census, 1975, series D-683, p. 162), and join the result to the NIPA series. To adjust for labor quality, we begin with the index constructed by Ho and Jorgensen (2001), and extend it backwards for 1929-47 using the growth rate of secondary school enrollment from Goldin (1994) as a proxy. Quality-adjusted hours are then the product of aggregate hours and the quality index.

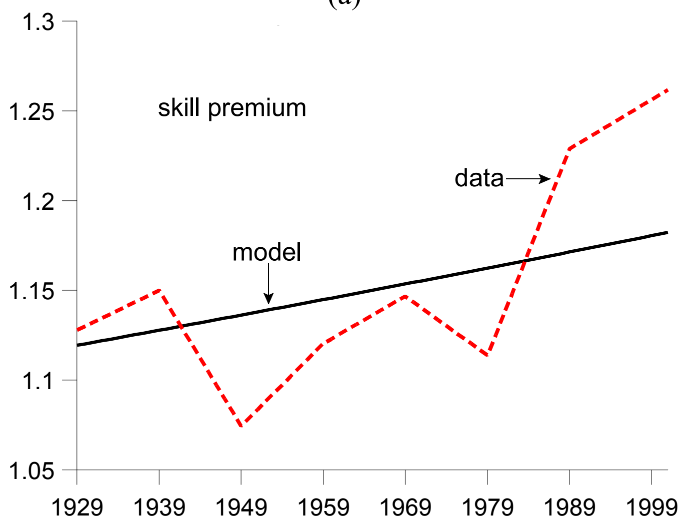
[16]We cannot simulate labor turnover because we do not have turnover in our model. In fact, in presenting Figure 3 as evidence for rising specificity, we have implicitly assumed that K is what Lippman and McCall (1981) call an "inspection good" which means that the manager has a perfect signal of the quality of the match, z, before he makes the bid. There is no further information about the quality of the match to be revealed that would call for an ex-post reassignment of K among M. In the face of other shocks, then, a dispersed z means that the match will survive a greater range of outside shocks. As σ rises over time, we would expect labor turnover to fall.



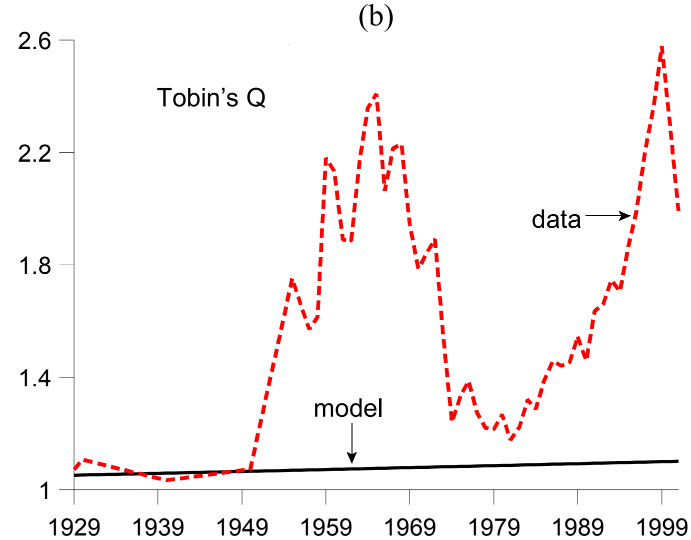
(a)



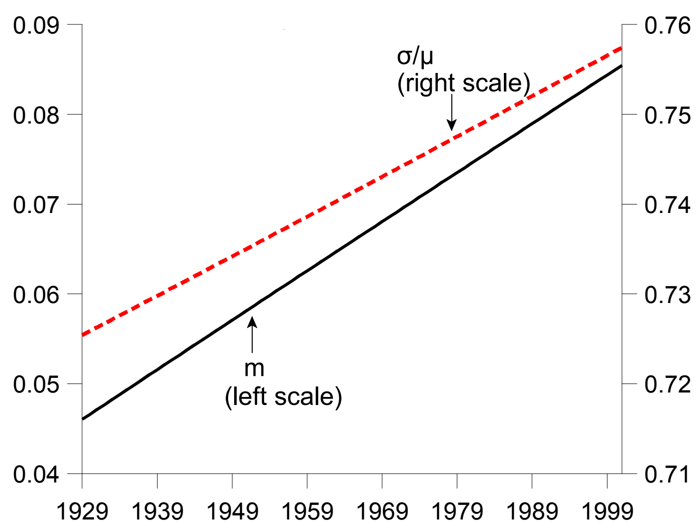
(b)



(c)



(d)



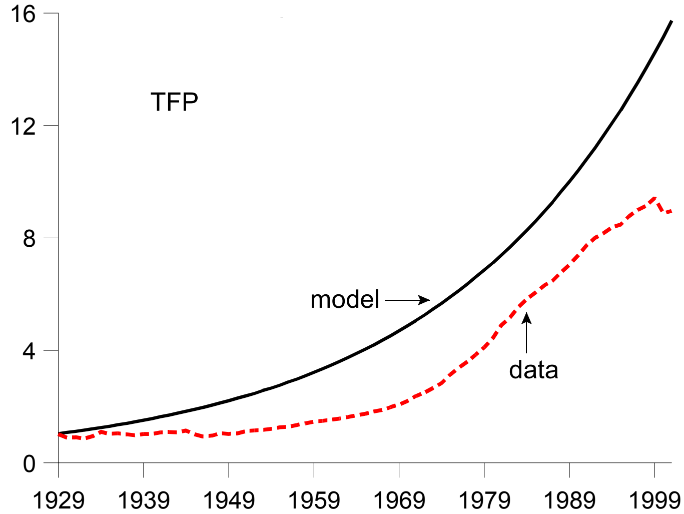
(e)

Model parameters:

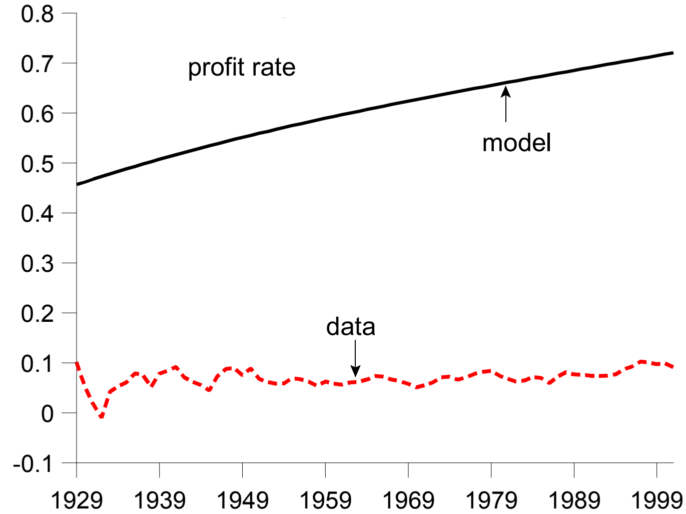
$\tau_0 = 0.660,\ g_\tau = 0.0001,$

$\theta_0 = 0.725,\ g_\theta = 0.0006$

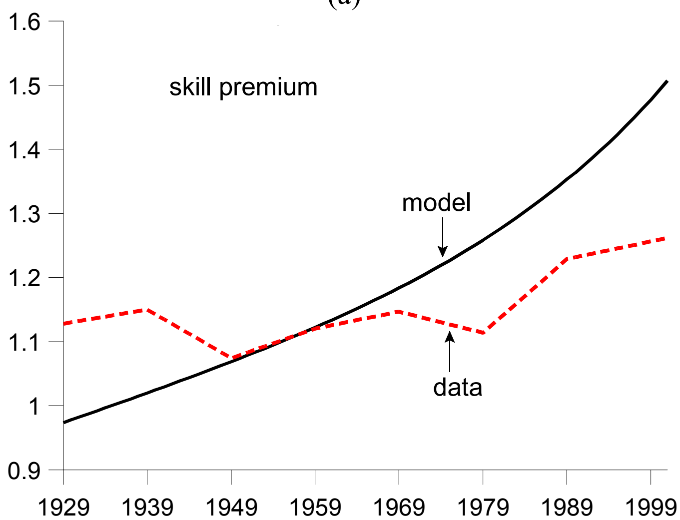
Figure 7



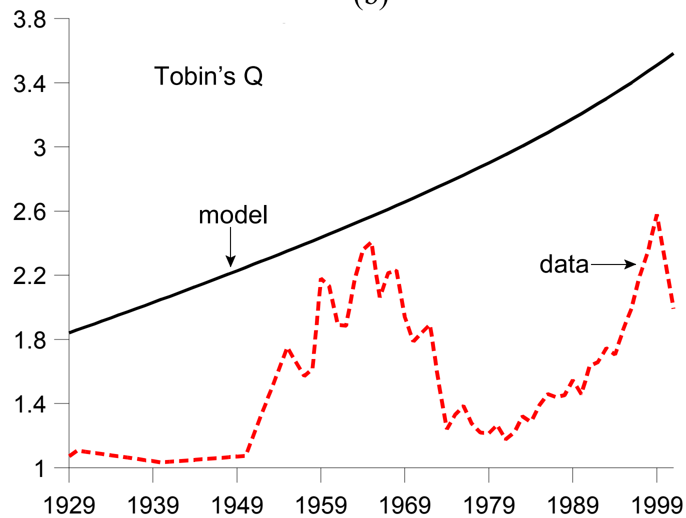
(a)



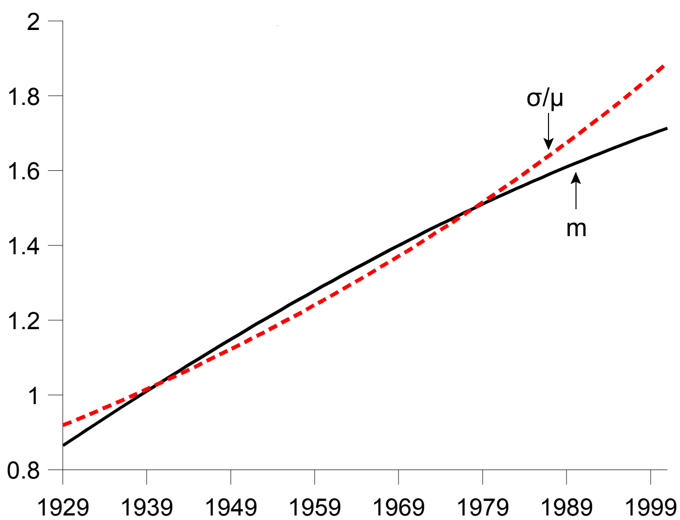
(b)



(c)



(d)



(e)

Model parameters:

$\tau_0 = 0.950$, $g_\tau = 0.005$,

$\theta_0 = 0.910$, $g_\theta = 0.010$

Figure 8

6 Regressions

In this section we report a few regressions that test our argument further, and briefly mention a small portion of the interesting work that relates to the questions at hand.

6.0.1 Unmeasured capital

Brynjolfsson and Yang (2000), Hall (2000), Atkeson and Kehoe (2000), and Laitner and Stolyarov (2002) emphasize the role of unmeasured capital in generating high stock prices. But productivity growth is not accelerating and it therefore seems that we need a different explanation. We can compare their arguments with ours in a regression that predicts Q and profits. Since missing capital should be correlated with patents, our statistical horse race will represent the "intangibles" hypothesis with the number of patents per thousand business concerns.

For our hypothesis we need a measure of σ/μ. Consider again the example in (11). For a firm – say firm i – with a single asset, we would have

$$Q_i = 1 + \frac{\tilde{\delta}_i}{\tilde{\alpha}_i} = \begin{cases} 1 + \frac{1}{\frac{\mu}{\sigma} - \frac{1}{2}} \text{ with prob. } mp\left(1-p\right)^{m-1}, \text{ and} \\ 1 \text{ with prob. } 1 - mp\left(1-p\right)^{m-1}. \end{cases} \tag{20}$$

The mean and variance of Q are both increasing functions of the ratio σ/μ. We would then argue that if the cross-firm standard deviation of Q is positively related to the cross-section mean of Q, this constitutes independent evidence that σ/μ has risen. Thus, we shall use the standard deviation of Q, denoted by $std\left(Q_t\right)$, in our benchmark regression, which we report in the first column of Table 1. We limit the regression to the 1955-2000 period, since these are the years for which we have annual observations on Q from Compustat. In this specification, the cross-sectional variance of Q has the expected positive sign, though it is significant at only the 12 percent level, while the coefficient on patents per thousand business concerns is negative and not statistically significant. This is broadly consistent with the proposition that a rise in σ_z raises Q, and does not support an "intangibles" explanation.

Regressing Q on its standard deviation probably biases things in our favor because any multiplicative shock to all firms' Q's would raise both its mean and its standard deviation in the same proportion. This bias can be avoided by using the standard deviation of the log of Q instead, which tracks not the variance of Q but its coefficient of variation. For the parameter values used in our simulations, the coefficient of variation of Q_i rises when the ratio σ/μ rises.[17] The results, reported in the second column of Table 1, show a positive coefficient on $std\,(\ln Q_t)$, but with a t-statistic that is just above unity. The coefficient on patents remains negative and not statistically significant.

Table 1. Regressions, 1955-2000

	Dependent Variable					
	Tobin's Q		Earnings		Adj. Profits	
patent$_t$	-0.002	-0.001	0.003	0.004	-0.015	-0.013
	(-0.16)	(-0.05)	(0.05)	(0.08)	(-0.40)	(-0.36)
std(Q$_t$)	0.039		0.842		0.466	
	(1.57)		(6.18)		(5.00)	
std(ln(Q$_t$))		0.234		8.275		4.425
		(1.03)		(7.39)		(5.44)
constant	1.789	1.735	17.603	15.132	6.301	4.997
	(8.00)	(7.12)	(14.29)	(12.56)	(7.48)	(5.71)
R^2	0.055	0.050	0.479	0.566	0.370	0.410
no. obs.	46	46	46	46	46	46

Note: T-statistics in parentheses.

The remaining columns of Table 1 report alternative formulations of our horse

[17]When $p = 1/2$, $mp\,(1-p)^{m-1} = m2^{-m}$. This is because the coefficient of variation of a binomially distributed variable

$$\begin{cases} \frac{1}{\frac{\mu}{\sigma}-\frac{1}{2}} \text{ with prob. } m2^{-m}, \text{ and} \\ 0 \text{ with prob. } 1-m2^{-m} \end{cases}$$

is invariant to changes in the value of $\frac{1}{\frac{\mu}{\sigma}-\frac{1}{2}}$ as long as m is held fixed. Adding unity to this random variable implies that the mean varies proportionally less than its standard deviation. Now m is endogenous and rises with the ratio σ/μ. Indeed, while both of our simulations show that m is roughly proportional to σ/μ (see panels (e) of Figures 7 and 8), the function $m2^{-m}$ is relatively flat in the relevant range of the simulation in Figure 8. As a result, the coefficient of variation of Q_i rises from 0.23 to 0.31 in the simulation summarized in Figure 7, and from 0.75 to 16 in the simulation in Figure 8.

race. We do this by replacing Q as the dependent variable with NIPA earnings and after-tax profits (as shown in Figure 1). In all cases, these regressions show a positive coefficient on $std\,(Q_t)$ or $std\,(\ln Q_t)$ that is significant at the 1 percent level, while patents per concern are never statistically significant. These results favor our argument that the trends are explained by a rise in σ/μ and offer no support to the view that missing capital is behind these trends.

6.0.2 Taxes

Taxes cannot explain the profits series in Figure 1 (from the NIPA data) because they are after-tax profits. If anything, however, corporate taxes have risen since 1925. Taxes may explain the behavior of Tobin's Q since, say, 1960, as McGrattan and Prescott (2000) have argued. The fact remains, however, that taxes were at their lowest early on in the century – certainly lower than today – so here, too, they cannot explain the century-long upward trend in Q. Taxes were identically zero at the start of the century, yet this is when Q was lowest: Some sparse data on Q that we have collected for that epoch show values of Q averaging less than one.

7 Conclusion

Our economic world has become more Schumpeterian. Product lifetimes are now shorter and firms must constantly refocus. Forming a team that can promote a particular idea or product matters more now to a firm's survival. Together with this, the proliferation of different technologies has raised the inter-worker dispersion of comparative advantage. In other words, team-specific capital and firm-specific capital are now more important than before, and this may have raised firms' profits relative to factor earnings. This rise shows up in earnings, adjusted profits, and in Tobin's Q. Indirectly, it also shows up in the skill premium.

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8 Appendix

8.1 Correcting profits for pre-IPO debt.

To adjust earnings and profits to add in interest payments on debt incurred prior to IPO, as shown in Figure 1, we use a steady state formula for the fraction of debt that originated as IPO debt. The assumptions are as follows: total debt, B, is divided into B^{IPO}, the sum total of outstanding debt that originally came from financing IPOs, and B^{OLD}, which is the debt incurred by incumbent firms:

$$B_t = B_t^{OLD} + B_t^{IPO}. \tag{21}$$

We also assume that

$$B_{t+1}^{OLD} = gB_t \quad \text{and} \quad B_{t+1}^{IPO} = \rho B_t - \delta B_t^{IPO}. \tag{22}$$

That is, g is the net expansion of debt by all incumbents, ρ is the birth rate of debt through IPO, and δ is the retirement rate of debt. These are rough approximations and, since we only want trends, they should suffice. The steady state ratio of IPO debt is

$$b^{IPO} = \frac{\rho}{\rho + g(1+\delta)}. \tag{23}$$

When we average b^{IPO} from 1968 to 2001 using debt among all firms in Compustat and assuming a value of 0.1 for δ, we get 0.272.[18]. We can then add 27.2 percent of interest payments back into earnings after interest and into after-tax profits, with the latter adjusted for the taxes that would be paid on the saved interest (i.e., multiplied by $1 - tax$).[19]

If the ratios are to converge to positive numbers, the two components of debt must, in the limit, grow at the same rate as total debt. Let γ be the common limiting growth factor of these variables, and let b^{IPO} be the ratio of IPO debt to total debt. (21) implies

$$\frac{B_{t+1}^{OLD}}{B_t} = \frac{B_{t+1}^{OLD}}{B_t^{OLD}} \frac{B_t^{OLD}}{B_t} \to \gamma \lim \left(\frac{B_t^{OLD}}{B_t} \right) = \gamma \left(1 - b^{IPO}\right),$$

[18] Debt is computed from Compustat as the sum of long-term debt (data item 9) and current debt (data item 34).

[19] We compute the effective corporate income tax rate using various issues of the *Economic Report of the President* as the ratio of taxes actually paid to taxable earnings.

and similarly

$$\frac{B_{t+1}^{IPO}}{B_t} \to \gamma \lim \left(\frac{B_t^{IPO}}{B_t} \right) = \gamma b^{IPO}.$$

From (22) we have

$$\frac{B_t^{OLD}}{B_t} = g\frac{B_{t-1}}{B_t} = \frac{g}{\gamma} \Longrightarrow 1 - b^{IPO} = \frac{g}{\gamma} \Longrightarrow b^{IPO} = \frac{\gamma - g}{\gamma}, \tag{24}$$

and

$$\frac{B_t^{IPO}}{B_t} = \rho\frac{B_{t-1}}{B_t} - \delta b^{IPO} \to b^{IPO} \Longrightarrow \frac{\rho}{\gamma} - \delta b^{IPO} = b^{IPO}. \tag{25}$$

These are 2 equations in 2 unknowns, γ and b^{IPO}. Solving (24),

$$\gamma b = \gamma - g, \quad \text{i.e.,}\ \gamma = \frac{g}{1-b}$$

Substituting for γ into (25),

$$\frac{\rho}{g}(1-b) = b(1+\delta) \Longrightarrow \frac{\rho}{g} = b\left(1 + \delta + \frac{\rho}{g}\right),$$

i.e.,

$$b = \frac{\rho}{g}\left(\frac{1}{1+\delta+\frac{\rho}{g}}\right) = \frac{\rho}{\rho + g(1+\delta)}.$$

8.2 Inflation corrections for the Q's

Let P_t be the consumption deflator. This is the deflator that governs the numerator (because dividends are consumed), therefore we need to deflate the denominator by this index. Let $p_{k,t}$ be the price of the capital (equipment and structures) relative to the basket of goods in GDP.

Let b_j be the nominal book value added to the firms equity at time t (i.e., b_j is the dollar value of the capital stock purchased at date j). Then

$$B_t = \sum_{j=1886}^{t} b_j.$$

The period-t value of the same purchase today would be

$$b_{j,t}^* = \frac{P_t p_{k,t}}{P_j p_{k,j}} b_j.$$

Therefore, if we had the entire history of b_t, we would have the replacement cost of the capital market (distinguishing true from nominal with an asterisk)[20]:

$$B_t^* = \sum_{j=1886}^{t} \frac{P_t p_{k,t}}{P_j p_{k,j}} b_j + \frac{P_t p_{k,t}}{P_{1885} p_{1885,t}} B_{1985}. \tag{26}$$

We have equipment prices, and Gort, Greenwood and Rupert (1999) have prices of structures falling at 1 percent relative to consumption. This simply means subtracting about 3.5 percent (halfway between 1.5 percent and 5 percent) from inflation after World War II, and less before World War II – a reasonable number is 0.5 percent. Thus if $j > 1945$,

$$\frac{P_t p_{k,t}}{P_j p_{k,j}} = \frac{P_t}{P_j} \frac{1}{(1.035)^{t-j}},$$

and if $j < 1945$

$$\frac{P_t p_{k,t}}{P_j p_{j,t}} = \frac{P_t}{P_j} \frac{1}{(1.035)^{t-1945}} \frac{1}{(1.005)^{1945-j}}.$$

8.2.1 Estimating the b before 1960

The Compustat data tell us the b's after 1960. The earlier ones must be imputed.

CASE 1: The simple case is adjusting the value of Qs in years $t < 1960$. Then we set

$$b_j = \theta_t \left(\frac{M_j}{Y_j} \right) I_j \text{ for } j = 1886, 1887, ..., t$$

and

$$B_{1885} = \theta_t \left(\frac{M_{1885}}{Y_{1885}} \right) K_{1885}.$$

Then the constant, θ_t is defined by

$$\theta_t = \frac{B_t}{\left(\frac{M_{1885}}{Y_{1885}} \right) K_{1885} + \sum_{j=1886}^{t} \left(\frac{M_j}{Y_j} \right) I_j},$$

and we can just substitute into (26) to get B_t^*.

CASE 2: Suppose we have a Q in a year $t \geq 1960$. Now we know some of the bs from Compustat. That is, we know $b_{1960}, b_{1961}, ...$ Therefore the unaccounted portion

[20] In the end we are able to estimate B using the ratio of stock market capitalization to GDP, for which we have annual observations from 1885 (see Jovanovic and Rousseau 2002).

of B — call it B_t^U, is

$$B_t^U = B_t - \sum_{j=1960}^{t} b_j.$$

Once again, we set

$$b_j = \theta_t \left(\frac{M_j}{Y_j} \right) I_j \text{ for } j = 1886, ..., 1959$$

and

$$B_{1885} = \theta_t \left(\frac{M_{1885}}{Y_{1885}} \right) K_{1885}.$$

Then the constant, θ_t is defined by

$$\theta_t = \frac{B_t^U}{\left(\frac{M_{1885}}{Y_{1885}} \right) K_{1885} + \sum_{j=1886}^{1959} \left(\frac{M_j}{Y_j} \right) I_j},$$

and we can substitute into (26) to get B_t^*.