PRODUCTIVITY AND EQUITY RETURNS: A CENTURY OF EVIDENCE FOR 9 OECD COUNTRIES

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Abstract. The share market boom in the 1990s is often linked to the acceleration in labour productivity over the same period. This paper explores the suggestions that labour productivity may be an inaccurate measure of firm's cash flow which underlies equity valuations, and that innovations in productivity in the 1990s may have had only have temporary effects on capital productivity, the key element of the more correct measure of cash flow. Using a century of data for the OECD countries it is shown empirically that the link of productivity to share returns is indeed strongest for capital productivity, but generally the link is weaker that is sometimes maintained in the literature.

Keywords. Productivity, share returns, 'new economy'

JEL classification: G1, G3, O4

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Introduction

The worldwide increase in equity prices in recent years has often been linked to accelerating labour productivity, which has in turn been related to the information technology (IT) revolution (see the discussion in Campbell and Shiller, 2001, Greenwood and Jovanovic, 1999, Keon, 1998, Hall, 2001, IMF, 2000). It has been argued that the apparent acceleration[2] in labour productivity is an accurate indicator of increases in firms' current and expected real cash flow and thus dividends, and its acceleration has thereby contributed to an increase in the value of firms.

Despite the attention that has been drawn to effects of the 'new economy' on share prices, very little research has been undertaken to examine the relationship between productivity and firms' cash flow, and whether the recent acceleration in firms' cash flow is sustainable. Rather, it is often asserted that the IT revolution has sparked the recent acceleration in labour productivity, boosting future productivity, and that the higher growth in labour productivity is sustainable and boosts future cash-flow, thus justifying high equity valuations.

This paper queries both premises of the argument - that labour productivity proxies firms' cash flow and that a high productivity growth rate is sustainable. It is argued that the more relevant productivity measure for the remuneration of capital, and hence a key element for proxying firms' cash flow, is the marginal productivity of capital, which under certain assumptions is equivalent to capital productivity at a macro level. Other productivity proxies for firm's cash flow such as labour productivity, potential output and total factor productivity (TFP), may be misleading.

It is also argued that if one accepts the presupposition of diminishing returns to capital and an important role for capital productivity in determining earnings, then the IT revolution will have largely temporary effects on the growth in firms' cash flow. If the current high levels of share prices are not justified by such long run fundamentals, one is left with largely one-off or temporary factors to explain them. These include a decrease in the risk premium, higher international liquidity, baby boomers, the disinflation, irrational exuberance, a fall in the relative price of capital goods, a rise in the capital share of GDP and increased leverage (IMF, 2000, Shiller, 2000).

Using historical data over a century for 9 countries (G7, Australia and Denmark) the relationships between share prices and various measures of productivity are investigated empirically in the light

[2] We note that the data on labour productivity have themselves been subject to revision.

of the theoretical discussion. First, simple Granger causality tests are used to examine the bivariate relationship between real share returns and productivity growth. Second, the nexus between real share returns and productivity is investigated using a VAR framework where other variables than productivity are allowed to influence share returns. The overall conclusion is that capital productivity is indeed the measure which is most closely linked to share returns, although even for this measure, the close share price-productivity relationship asserted by some "new economy" advocates does not seem to be present over a long run of data.

2 Equity prices and the productivity debate

In the last few years, the popular controversy as to whether equity prices accurately reflect their fundamental values has, to a large extent, centred on the sustainability of the productivity advances in the 1990s. It was argued that unprecedented levels of share prices were justified by an acceleration in labour productivity related to the "new economy" and IT (see, e.g. Keon 1998). Despite recent falls in share prices and revisions to productivity data, the issue remains relevant at the time of writing given that valuation measures remain historically high, as well as to analyse the justification of the earlier boom. This section addresses two important issues in this context, namely the relevant productivity measure for share prices, and whether the productivity advances in the 1990s are sustainable.

2.1 Productivity and equity prices

2.1.1 The role of capital productivity

Addressing first the relevant productivity measure for equity prices, the fundamental value of shares has widely been derived from the well-known Gordon's growth model:

$$Q = \frac{(1+g)D}{r-g} \tag{1}$$

where Q is an index of the price of shares that is justified by fundamentals, D is an index of aggregate real dividends per share, r is the real required return to equity, and g is a constant expected growth rate in real dividends per share. We suggest that Gordon's model can usefully be rewritten as

$$Q = \frac{(1+g)fMP_K}{r-g} * \text{K/S} \qquad (2)$$

where MP_K is an index of the marginal productivity of capital, ❷ is the payout ratio, K is the capital stock, S is the number of shares.

MP_K equals earnings per unit of capital under the assumption of perfect competition in the goods market and that the capital stock K does not depreciate. Under imperfect competition in the goods markets the real return to capital is given by $MP_K(1-1/h)$, where $h < 0$ is the price elasticity of demand facing the firm.

In more detail, the marginal productivity of capital is the relevant measure of earnings to capital because it reflects the earnings associated with investing in one extra unit of capital. Consider the firm's profit maximizing problem:

$$\max_K p = P \cdot Y - W \cdot L - R \cdot K \qquad (3)$$

where p is nominal profits, P is the value-added price-deflator, Y is aggregate value-added output, K is capital services, W is the wage rate, R is the nominal cost of capital, and L is labour services. The first-order condition for profit maximization for the perfect competitive firm is given by $\partial Y / \partial K = R/P$. Hence, in the margin the real return to capital equals the marginal productivity of capital. For the imperfectly competitive firm the first order condition for profit maximization is given by

$$P\frac{\partial Y}{\partial K} + Y\frac{\partial P}{\partial K} = MP_K\left[1 + \frac{Y}{P}\frac{\partial P}{\partial Y}\right] = MP_K[1-1/h] = R/P \qquad (4)$$

which says that the return to capital exceed the marginal productivity of capital by the magnitude of $(1-1/h) \geq 1$.

Inclusion of the marginal productivity of capital hence relates to the first order condition of profit maximisation where investment takes place up to the point where the real interest rate (or cost of capital) $i = MP_K$. Depreciation changes the first order condition of optimum to $i + d = MP_K$, so that returns to capital have to cover real interests and depreciation costs. To simplify we assume that firms are perfectly competitive across the economy as a whole so that the real return to capital is given by MP_K

In equation (2) as set out above, total real dividends per share D = MP_K * K/S *ϕ; as the capital stock divided by the number of shares times the payout ratio scales the *rate* of marginal productivity up to a *volume* of dividends per share. There is an important question whether the terms other than MP_K can be omitted. It can be argued that if the Modigliani-Miller theorem holds then the form of financing of a firm should be irrelevant to its valuation and any rise in K/S owing, for example, to investment of retained earnings would be offset by a fall in ϕ. Hence only MP_K is relevant. However, if Modigliani-Miller does not hold, due in particular to external finance constraints and tax wedges, then the additional terms could be relevant, with investment of retentions boosting the value of the firm (see for example Bodie et al (1999), p538). We note that the growth rate of dividends shown in Table 6is actually higher than that of MP_K, which gives support to some role for terms other than MP_K.

Using the same logic the relevant measure of expected growth in dividends *g* is the growth in the marginal productivity of capital plus – depending on the view of Modigliani Miller set out above - a term related[3] to the growth in the real stock of capital divided by shares in issue times the retention rate.

For empirical implementation of this approach, there is a need for a proxy for MP_K at a macro level. For this purpose we employ the properties of the well-known Cobb-Douglas production function. Under the Cobb-Douglas technology assumption whereby the average product of capital equals the marginal product of capital Equation (2) can be written as:

$$Q = \frac{(1+g)f(Y/K)}{r-g} .* \text{K/S} \qquad (5)$$

where capital productivity Y/K and its growth (in the g term) enter the equation. To allow for the interaction between share prices and bond yields, the required return to equity is set equal to the real bond yield, r^B, and the equity risk premium, d , which inserted into Equation (5) and omitting terms in K/S, yields:

[3] Considerations of diminishing marginal returns to capital will also affect this term.

$$Q = \frac{(1+g)f(Y/K)}{r^B + d - g}. \qquad (6)$$

This equation forms the basis for the regression analysis in Section 4. The equation shows that equity returns are positively related to capital productivity and the growth therein, and negatively related to the real bond rate and the equity risk premium. The framework assumes fixed income shares as well as a fixed rate of distribution ⬢. The system could be extended to allow for varying income shares, payout rates and leverage, however, this is beyond the scope of this paper.

2.1.2 Alternative measures of dividend growth

It has been argued above that the relevant measure of productivity for remuneration of capital and hence for determining equity prices is the marginal productivity of capital, which is best proxied by capital productivity and not labour productivity, total factor productivity (TFP) or potential output. The marginal productivity of labour is relevant for the remuneration of labour and TFP is relevant for the remuneration of labour and capital jointly. However, despite the logic that the marginal productivity of capital is the main component of the relevant measure of firm's earnings potential, the literature has consistently focussed on other productivity measures, especially labour productivity and potential output. In IMF (2000), for example, it is argued that the growth in potential output can be used as a proxy for expected dividend growth (pp 106-109), and thus may be used in empirical implementations of Gordon's growth model.[4] Kennedy *et al* (1998) of the OECD employ the same method. The argument is that if income shares remain constant, then the growth in earnings will be reflected in output growth.

Elsewhere in IMF (2000), the case is presented that growth in labour productivity can also be the relevant measure of earnings growth (Box 3.1 p 140). Labour productivity growth has also been stressed as the relevant measure for share prices in a series of articles by the *Economist*, for instance Economist (2001). Similarly Campbell and Shiller (2001) note – without endorsing - the argument

[4] Since potential output varies over time, the following version of the Gordon growth model, which is suggested by Barsky and De Long (1993), is used:

$$Q_t = \frac{(1+g_t)D_t}{r - g_t}$$

where dividend growth is allowed to vary over time. Note, however, that this equation is invalid since the Gordon model is derived under the assumption of *constant* growth in dividends.

that the high stock market value is often justified by expectations of a continuation of the high labour productivity growth in the 1990s, with an underlying premise that labour productivity is the relevant productivity measure of earnings. Finding that price-smoothed-earnings ratio cannot predict future labour productivity for the US, they conclude that the high share prices today cannot be due to a rational forecast of productivity growth.

To assess the differences between productivity measures in a given technical and economic framework, we return to the Cobb-Douglas production function as follows:

$$Y = AL^{a} K^{1-a} \; . \qquad (7)$$

Assuming competitive product and factor markets, a is the share of labour in GDP, (1-a) the share of capital, and *A* represents TFP. Growth in TFP captures changes in organisational efficiency and economies of scale as well as technical progress as more normally measured and is often referred to as "Hicks neutral" technical progress. Meanwhile average labour productivity is *Y*/*L*, and its growth is defined as the change in output per person hour worked. Similarly, average capital productivity is Y/*K* and its growth is defined as the percentage change in output divided by the non-residential capital stock (in terms of both machinery and buildings). Total differentiating Equation (7) yields:

$$D \ln Y = (1 - a) D \ln K + a D \ln L + D \ln A \qquad (8)$$

which shows that the growth of output is the sum of the share-weighted growth of inputs and growth in TFP.

From Equation (8) it follows that the growth in labour productivity is given by:

$$D \ln(Y / L) = (1 - a) D \ln(K / L) + D \ln A \qquad (9)$$

The first right-hand-side term shows capital deepening, whereby an increase in capital per worker leads to an increase in workers' productivity and raises labour productivity in proportion to the share of capital. The other term is TFP, which raises labour productivity on a pro rata basis.

The growth in capital productivity is given by:

$$D \ln(Y / K) = a D \ln(L / K) + D \ln A \qquad (10)$$

From this equation it follows that capital deepening lowers capital productivity while TFP adds to it.

Comparing Equations (9) and (10) it is transparent that TFP growth enhances both capital and labour productivity. Capital deepening, however, increases labour productivity (equivalent in the Cobb Douglas framework to the marginal productivity of labour) but lowers capital productivity (marginal productivity of capital) and therefore explains why the real interest rate tends towards a constant mean in the long run while real wages show a continuous rise in the long run. Indeed, subtracting equation (10) from equation (9) gives ☛ln*K*/*L*. From this it follows that changes in labour productivity are only equivalent to changes in capital productivity to the extent that changes in TFP dominate changes in capital deepening. Historically, growth in capital deepening has dominated total factor productivity growth. Our calculations suggest that the *K*/*L* ratio has increased by 3.7% per annum in the OECD countries since 1960, whereas TFP has increased by only 1.8%**.** Over the period from 1990 to 1999 labour productivity increased by 18%, whereas capital productivity has remained almost unaltered in the countries considered in this study.

In this context, for the US Oliner and Sichel (2000) have found that capital deepening accounts for 40% of the rise in labour productivity in the late 1990s and TFP for 60%. They also concluded that two thirds of the acceleration in productivity in the US is accounted for by either the use or the production of IT equipment. Hence, they suggest that the future rates of productivity growth are dependent on continuing IT investment. The overall contribution of computer hardware to economic growth was seen as 0.6 percentage points, and the wider concept of information processing capital 1.1 percentage points.

The difference between the growth in potential output and capital productivity can be calculated by subtracting Equation (10) from Equation (8):

$$D\ln Y - D\ln(Y/K) = (1-a)D\ln K + aD\ln L + D\ln(K/L) \tag{11}$$

ignoring for simplicity cyclical fluctuation in income so that growth in income equals growth in potential output. The difference – equal to the growth of the real capital stock - is unambiguously positive since all variables on the right-hand-side of Equation (7) are positive. The difference was 34% over the period from 1980 to 1992 and 18% from 1993 to 1999 for the countries used in this study.

In the light of the above arguments we would contend that it is by no means obvious that the measures typically used to proxy g in the Gordon formula are the best available. It has been suggested that the correct measure is related to the growth in the marginal productivity of capital, which under the Cobb Douglas assumptions equals the growth of capital productivity. We have shown that growth in potential output exceeds this aggregate, and for most countries this is also true for labour productivity. TFP has occasionally been mentioned as a potential measure of the growth in earnings. Using equation (10), if TFP is used to proxy g instead of the measure based on capital productivity, then the growth in earnings is measured by capital productivity plus workers' income share times the change in the inverse of the capital labour ratio: ɞ☛ln(L/K). This may again be an inaccurate measure of g.

The impact of any bias on estimations of the fundamental value of shares can be seen from the partial differential of Equation (1):

$$\frac{\partial Q/Q}{\partial g} \approx \frac{1}{r-g} \qquad (12)$$

Suppose that r is 8%, as found below, and that g is 2%. Then the fundamental value of shares is biased upward by 25% for each percentage upward bias in g. This suggests that valuation models are highly sensitive to the choice of productivity measure.

We acknowledge that the Cobb-Douglas and Modigliani-Miller assumptions required for an exact correspondence between growth in capital productivity and dividend growth are unlikely to hold precisely. For this reason, it is essential for empirical analysis to be carried out on the relationship of the various productivity measures. Do the actual data support the theoretical arguments presented above? Do they give any guidance on the best proxy for g? We return to this issue in Section 4.

2.2 Are the recent productivity advances sustainable?

2.2.1 The recent debate on productivity

The main outcome of this paper is to provide empirical analysis using a long run of data addressing the arguments above about the appropriate productivity measure to relate to equity returns. However, before turning to the empirical analysis we consider it helpful to also address the sustainability of productivity growth in the light of a technical innovation such as IT, also seen in the light of Section 2.1. This is, as noted, the second leg of support for the argument that high levels of equity prices may be justified by fundamentals.

Indeed, the recent productivity debate has focussed on the sustainability of the recent acceleration in TFP and labour productivity in the US. Growth in capital productivity has not entered the debate. The acceleration in the US productivity growth in the 1990s has also spurred interest in the link between productivity and the IT revolution. Almost all analysts agree that the continuous decline in quality-adjusted prices of IT has spurred productivity growth. The benefits of the use of IT are more controversial. Sceptics argue that the surge in economy-wide labour productivity is unrelated to the use of IT (Gordon, 1999, 2000, and Kiley, 1999, 2000). Others have found that the use of IT has enhanced labour productivity (Basu *et al*, 2001, BLS, 2000, CEA, 2000, Jorgenson, 2001, Oliner and Sichel, 2000).

Gordon (2000) notes that whereas there were undeniable increases in productivity in the durable manufacturing sector, they in his view did not touch the remaining 88% of the economy, where TFP has decelerated, despite the boom in IT investment. The increase in computer power is seen as limited in its contribution to TFP because of the tension with the fixed endowment of human time. Meanwhile, use of the Internet in these non-durable sectors is seen as solely for market-share protection, recreation of old activities rather than new ones, duplicative activity and consumption on the job. In this there is a major contrast with the "golden age" from 1913-72 when there was a sizeable impact on productivity of inventions related to electricity, the internal combustion engine, chemical processes and communications/entertainment. The data in Section 3 suggests this was reflected in rising capital productivity throughout this period.

Counter to this argument, David (1990) notes that the dynamo was an invention whose impact on the productivity data at a macro level was very slow to come through – with factories often overlaying electric equipment on old capital rather than replacing it, leading to capital deepening rather than TFP growth, before wholesale adoption in Gordon's 'golden age'. The same could be true of IT. Measurement problems may also limit contributions to productivity in official data. This line of reasoning suggests that the returns from the IT investment in the 1990s have yet to come.

Analysing potential factors that are responsible for the recent boom in share prices Hall (2001) concludes that the high share prices can be justified by the recent growth in cash flow, thus implicitly accepting the thesis that the earning advances are sustainable. Hall, however, does not substantiate his prediction. Greenwood and Jovanovic (1999) suggest that the rise in the stock market from the 1980s onwards was linked to the rise of IT based firms, arguing that "if the stock market provides a forecast of future events then the recent dramatic upswing represents a rosy estimate about growth in future profits, and this translates into a forecast of higher output and productivity growth, holding other things equal (such as capital's share of income)" (p116). Intriguingly, Gordon (2000) notes that for capital markets the relationship between equity valuation and growth prospects requires much further study. Campbell and Shiller (2001) reach similar conclusions.

We would suggest that the large amount of research on the recent productivity advances are of little comfort for the earnings prospects of firms and the risk that share holders are (still) too optimistic about future earnings potential of firms. First, research has focussed entirely on the effects of the IT revolution on TFP and labour productivity rather than capital productivity. Second, no study has rigorously investigated the effects of IT investment on future earnings. Furthermore, as we show below, equilibrating factors in the economy suggest that advances in capital productivity and earnings may only be temporary.

2.2.2 Tobin's valuation ratio and the sustainability of productivity advances

The debate of whether equity prices are at their fundamental value centres to a large degree on the expected permanent growth rate in real cash flow and hence on the term g in the Gordon model. We have argued in Section 2.1.1 that the best proxy for cash flow is capital productivity. In this section we argue that under certain assumptions capital productivity growth is zero at a macro level, which may implying a low level of g. This follows the predictions of Tobin's valuation ratio model (which suggests that the market valuation of firms will in the long run be equal to the replacement cost of the capital stock).

To see this consider a technology innovation that increases the productivity of capital. The higher marginal productivity of capital drives the valuation ratio in excess of one because future profits per unit of capital is temporarily increased and this triggers investment. The increase in the capital stock will lower the returns to capital due to diminishing returns to capital. The lower cash flow per unit of capital will lower the valuation ratio. Equilibrium – which may take a protracted period - is reached when the valuation ratio is driven back to one. Hence, a one off productivity shock should have only temporary effects on the marginal productivity of capital and hence equity returns unless there are constant returns to capital, as assumed in the early literature on endogenous growth (Romer, 1986). However, no empirical studies have given support to the assumption of constant returns to capital, and later models of endogenous growth have relaxed this extreme assumption.

Note the parallel to the neoclassical growth model where changes in the investment ratio (savings rate) have only temporary effects on growth. In these models an increase in savings increases net investment and brings the capital stock up to a higher steady state level. Growth in output is only temporarily higher on the transitional path from the initial equilibrium capital stock to the new equilibrium capital stock.

There are several caveats. Tobin's valuation ratio is only one under the assumption of perfect competition in the goods market and the absence of adjustment costs and uncertainty. Moreover, if productivity growth is continuous rather than discrete, the capital stock may never reach the point where the rise in marginal productivity is wholly eliminated. Both of these effects may have been in operation in the "golden age" referred to by Gordon (2000). We have noted that earnings growth may exceed capital productivity growth owing to factors such as taxes and capital market imperfections, as well as under differing technology than Cobb-Douglas. Nevertheless, the calculation suggests a need for caution in projecting productivity gains. Gordon (2000) indeed argues that IT investments are particularly vulnerable to diminishing returns.

3 Data analysis

Before turning to more formal econometric analysis, this section presents growth rates in various measures of productivity, share returns, real bond returns and other relevant variables in various periods across 9 OECD countries; the US, Germany, Canada, the UK, France, Italy, Japan, Denmark and Australia. Particular attention is given to the 1920s and 1990s in which share returns and productivity growth rates were extraordinary high.

The typical dataset available is illustrated for the US in Chart 1. The high volatility of stock returns is apparent, as well as a close correlation between TFP growth and economic growth. Reflecting rises in factor inputs, the growth in TFP is generally lower than overall economic growth. It is also apparent that the 1990s are by no means historically outstanding ether in terms of growth in output or productivity.

Some long-term characteristics of the data are illustrated in the attached tables. Table 1 shows the long-term arithmetic average growth rates for various measures of productivity and real returns over the period since 1920. TFP growth is estimated as $100(\Delta \ln Y - a\Delta \ln L - (1-a)\Delta \ln K)$, where a is set to 2/3, which is approximately labour's income share. Concerning productivity growth, an immediate stylised fact is that capital productivity growth falls far short of that of labour productivity. The capital stock has in effect risen much more than labour hours, with the latter "capturing" the benefits of productivity in terms of its marginal productivity – reflected in turn in growth in real labour earnings. Total factor productivity growth, reflecting both factor inputs, lies between the two.

Over the 80-year period considered, capital productivity growth was negative in the UK and Japan, and less than 1% per annum elsewhere. Following the analysis in Section 2, there has been marked capital deepening, with capital/labour ratios rising strongly and TFP growth unable to compensate. Labour productivity growth was 1-2% in the US and Australia, 2-3% in the UK, Canada, Italy and Denmark, and 3-4% elsewhere. These results suggest that in historical perspective, labour productivity has been substantially higher than capital productivity due to capital deepening.

Real equity returns are remarkably consistent at 7-9% annually everywhere except Germany and Japan, where large outliers affect the latter during hyperinflation and war periods[5]. Real bond yields are correspondingly also negative in those countries, although real yields are also negative on average in France and Italy. Elsewhere they are in the range of 2-3%. Hence, the equity premium is 5-7% on average, being the highest in the US. In terms of GNP growth, the UK is the weakest performer, with average performance being below 3%, and Japan the highest at 4.6%, while elsewhere it lies between 3-4%. In terms of "growth accounting", it can be seen that total factor productivity accounts for a half to two-thirds of this total, with factor inputs accounting for the remainder. Finally, average inflation has been around 3% in the US and Canada, 4% in the UK, Australia and Denmark and well in excess of that figure elsewhere.

Table 2 excludes the earlier years of hyperinflation, depression and war, instead focusing on the 50-year period from 1950 to 1999. Patterns of productivity are little changed, although capital productivity growth is on average negative now for all countries expect France, Italy and Australia, reflecting capital deepening. Real equity returns are in most cases higher, and considerably so for Germany and Japan, reflecting post-war recovery and reconstruction. Bond yields are consistently positive, while equity premia rise to 8-10% in the US, UK, Germany and Japan. Economic growth is again highest in Japan, but is also over 4% in Canada, Germany and Australia. The final line shows the well-known higher inflation in most countries in the post-war period, although exclusion of earlier hyperinflation makes it much lower in Germany.

Table 3 displays the long-term data back to 1870, where it is available. In Table 4 we show the annual correlation of real equity returns with productivity, bond yields, growth and inflation, to assess in a preliminary way what contemporaneous features returns link to. Of course, since equity returns depend on actual and expected future dividends and there are strong cyclical elements to both variables, this will in no way give the "whole story". Nevertheless, it is interesting to note that the relation to capital productivity growth is everywhere positive, while a number of countries show negative correlations with labour productivity and TFP. These results are consistent with the analysis in Section 2, which suggested that capital productivity is the correct productivity measure to use in projections of cash flow. Real equity returns are positively related to GDP growth and real bond yields and negatively related to inflation, all except in the UK and (for growth) Canada. As shown in Table 5, some of these results fail to hold if the earlier years are excluded.

Table 6 shows an estimate of annual real dividend growth since 1920 and 1950, derived from data on the dividend yield, share prices and the CPI. The calculations should be viewed as approximate, given they neglect factors such as the fact that aggregate share index and dividends only cover surviving firms. If a firm goes bankrupt, then it drops out of the aggregate index. This implies that real share returns (capital gain + dividends) as well as dividends themselves may be overestimated.. It can be seen that for most countries, dividend growth has on average been rather slow, with only Germany and Denmark significantly exceeding 3% (we consider the Danish figure to be distorted by the high volatility of dividends in that country). US real dividend growth since 1920 is 2.7%, and only 1.7% since 1950. The growth rates of dividends fall far short of the real total returns on equity and economic growth (which is broadly equivalent to growth in potential output) .In some cases they are also below labour productivity and as expected they somewhat exceed the growth rate of capital productivity reflecting factors such as taxation, financial constraints and non Cobb-Douglas technology.

[5] The data in war periods were difficult to obtain and sources conflict. This is particularly true for the Japanese

Complementing the tables, we show trends on a decade-by-decade basis for the UK, US, Japan and Germany in Charts 2-5 (using arithmetic means) to wash out cyclical influences and noise. The US saw positive labour productivity and TFP growth in all decades since 1870, but negative capital productivity growth since the 1960s (and growth close to zero in the late 19th century) consistent with the Gordon (2000) discussion of a "golden age" up to the 1960s. Average real equity returns (including dividends) were only negative in the 1910s; even in the 1930s and 1940s they were around 7%. The exceptional decades were clearly the 1920s and 1990s, with real average returns on equity of 17-18% – we examine these in more detail below. Data for the UK (Chart 3) show that productivity has indeed been much more sluggish than in the US, with capital productivity negative throughout. Labour and TFP growth peaked in the 1920s and 1960s. Finally in Germany and Japan a pattern of strong growth in measures of productivity is apparent after a fall in the war decade of the 1940s. This reached a peak in the 1950s before tailing off thereafter. This decade also witnessed sharp rises in share prices. In Japan TFP growth fell continuously to near zero in the 1990s, while in Germany the average in the 1990s still exceeded that in the US. Capital productivity has been negative since the 1960s in both countries.

Finally in Charts 6-13 we focus on productivity and equity returns in specific decades – the 1920s and 1990s for the four countries noted above. These decades both saw high real equity returns and rapid rises in productivity. Looking first at the US and the UK, the charts show that in the 1920s, TFP, labour and capital productivity growth rates were generally stronger than in the 1990s, while equity returns were comparable in the two periods. There is a particular contrast in growth rates for capital productivity, which it is argued is most relevant for equity returns.

As noted, the contrast between strong equity returns and falling capital productivity in the 1990s, while partly reflecting fundamentals such as tax effects and external finance constraints, may also be partly resolved by temporary or one-off factors such as the rise in capital's share of GNP over the period, as well as rising borrowing of firms, share buybacks, takeovers, a decrease in the risk premium, higher international liquidity, changes in leverage, equity buybacks, the influence of baby boomers, the disinflation and "irrational exuberance" (IMF, 2000, Shiller, 2000).

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consumer prices in the mid 1940s.

4 Empirical estimates

In Section 2 it was shown that equity prices reflect the discounted value of expected cash flow, which in turn should depend largely on the expected marginal productivity of capital. Since the pronounced increase in equity prices in the 1990s has been partly justified by expectations of increasing productivity in the future, we would expect equity prices in an efficient market to be able to predict the marginal productivity of capital.

In this section we test the causal relationship between equity prices and productivity to shed light on whether equity markets correctly base share valuations on the marginal productivity of capital and not other productivity measures; and whether capital productivities are predicted by equity prices. We also include some assessment of reverse causality from productivity to equity prices, while noting that this would imply market inefficiency. Granger causality tests are undertaken in the first subsection and VAR models are estimated in the second subsection. A third issue – not investigated in this paper - is whether there is a cointegration relation between productivity and share prices[6]. The long and eventful data period covered lends additional weight to estimation results.

4.1 Granger causality tests

A straightforward way to address the direct relation between productivity growth and the level of real share returns is to undertake Granger causality tests[7]. Productivity is measured as growth in labour productivity, capital productivity and TFP in the tests. The Granger causality test assesses whether there is a consistent pattern of shifts in one variable preceding the other. Such tests do not give any proof on causality, but nevertheless where causal mechanisms based e.g. on expectations can be suggested, as outlined in Section 1, then a positive result gives grounds for further investigation.

Granger causality can only be a starting point in empirical investigation for at least two reasons. First, there are a number of additional influences on equity prices, as outlined above, so a multivariate regression approach needs to be adopted before reaching any conclusions. Also the absence of a short-term relationship may not preclude a long run link in a cointegrating framework.

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[6] Preliminary investigation using the Johansen trace test suggests that there are a range of countries where cointegration relations between productivity and share prices may exist. Work on cointegration will feature in a future paper.

To run the Granger causality test, the following equations are estimated for each country:

$$X_t = a_0 + a_1 X_{t-1} + a_2 X_{t-2} + b_1 Y_{t-1} + b_2 Y_{t-2} + e_t \qquad (10)$$

where X is either productivity growth or real equity returns and Y is the other variable in question, and e is a disturbance term. If there is Granger causality from Y to X, then some of the *ß* coefficients should be non-zero; on the other hand, if not then all of the *ß* coefficients should be zero. Testing whether the coefficients on the lagged indicator variables are zero can be readily performed using standard *F*- or *t*-tests.

The results of the Granger causality analysis are shown in Tables 7-9, based on using two lags of each variable. We show whether there is significant autocorrelation in productivity growth and real equity returns in columns 1 and 3, before showing whether the addition of two lags in the *X*-variable can help in prediction. The signs indicate the direction of effect of the significant lags. Data are for 1920-1999; figures in square brackets show the outturns for the period 1950-1999.

The autoregressive equations presented in columns 1 and 3 show that capital productivity growth is frequently positively correlated, while labour productivity growth and, to a lesser extent, TFP growth show negative autocorrelation in some countries. Equity returns show the well-known negative autocorrelation (consistent with mean reversion) in the US, Canada and the UK.

The tests for Granger causality between share returns and productivity growth tend to suggest that share returns are often a leading indicator of productivity growth, but that productivity growth is very rarely a predictor of share prices. This is of course consistent with the forward-looking nature of equity returns. There are strong contrasts between the types of productivity, with real equity returns frequently predicting capital productivity, and to a lesser extent TFP, but very rarely predicting labour productivity – an interesting contrast to the focus of US analysts on labour productivity[8].

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[7] As confirmed in Section 4.2, productivity tends to be integrated of order 1, while real equity returns are stationary. Hence we need to difference productivity to obtain consistent results.

[8] Similar tests – not reported in detail - were run using the dividend yield, following the intuition that this may be a more forward looking measure of equity market sentiment than the total return (as argued inter alia by Campbell and Shiller 2001). The outcome shows a more tenuous link from dividend yields to productivity growth than was the case

4.2 VAR systems

As noted, a key problem associated with the estimation of predictive links between variables, is that they are almost always conditioned on the other variables incorporated in the related equation (Davis and Fagan, 1997). A criticism of Granger causality tests is naturally that only two variables and their interrelations are assessed, while as shown in equation (9) these should only be a subset of the set of variables which combine to determine returns on equity. Accordingly, we proceeded to wider estimation using multiple variables. We estimate a standard VAR system, which is the reduced form of a linear dynamic simultaneous equation model in which all variables are treated as endogenous. Each variable is regressed on lagged values of itself and on lagged values of all other variables in the information set. In the light of the discussion of equity price determination in Section 3 summarised in equation (9), we sought to assess the relation between equity returns, productivity, the long real bond rate, and real equity price volatility (the standard deviation of monthly share price changes, deflated by the CPI). These proxy the variables entering the valuation formula. We added to these variables the growth in GDP to allow for the influence of cyclical fluctuations.

A preliminary to such estimation is testing for unit roots, since variables entering a VAR should normally be stationary. The results of Dickey-Fuller tests are shown in Table 10. They indicate that productivity growth as well as economic growth are difference stationary, as are real share prices and real dividends. Share market volatility and equity returns are stationary in levels. There are mixed results for the real long-term interest rate and the dividend yield – we prefer on balance to treat these variables as also stationary in levels.

We estimated VARs separately for TFP, labour productivity and capital productivity. Two lags were chosen, as this tends to minimise the Schwarz Bayesian Information Criterion. The aim is to provide some quantitative estimates of the relationship between productivity, equity returns and related variables. To do this we need to orthogonalise the estimated VAR model - which is in reduced form - to identify the effect of shocks to the innovations of the variables in the VAR. The problems of identifying impulse responses in VAR models now arise. We have treated this by adopting a standard approach, using a Choleski decomposition. Identification then uses the Sims's triangular ordering.

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for equity returns. There are very few cases where dividend yields help to predict productivity growth, and virtually

A well-known problem with the Sims triangular ordering is that it is arbitrary, and requires a justification for the ordering chosen. The presence of common shocks and co-movements among the variables makes the decision on ordering a crucial one. We decided, in line with Canova and De Nicolo (1995) and Nasseh and Straus (2000) to assume that exogenous shocks are largely technology driven and hence affect productivity and output. Stock returns, in line with the present value model, respond according to the effect of these shocks on future cash flow. Stock returns may also respond to changes in inflation, long term real rates (discount factor) and volatility (risk premium), which may all also be affected by technological factors. Hence, we order the variables with productivity first, followed by output growth, inflation, long rates and real equity price volatility before equity returns themselves. Equity returns are thus constrained to only feed back on the other variables with a lag.

With a model of this sort there is a large amount of output generated by this exercise: six equations, subject to six different shocks gives 36 solutions. So we have selected a few representative and key results for presentation. Given the focus of the work on equity returns and productivity, we report only the variance decomposition of equity returns to shocks in the innovations to variables in the VAR, and of productivity to equity returns, together with selected impulse responses.

The results for variance decompositions in the VARs are shown in Tables 11-13. These show the degree to which the variance of the "independent variables" explain the forecast variance of the "target" variable in the VAR system, in the light of which one may interpret the response of the system to shocks. There are some interesting cross-country contrasts. In the United States, equity returns have a strong element of autocorrelation, with errors in equity returns helping to explain forecast errors in the same variable. This is arguably consistent with an efficient market and random walk process. The strongest effect otherwise is from price inflation, and to a lesser extent the real long rate. Lagged productivity has little effect on equity prices, in line with market efficiency; TFP is shown to be a better "indicator" of equity returns than capital or labour productivity. There is a strong feedback effect of equity returns on capital productivity, amounting to 15% of the forecast variance after 4 years, suggesting forward looking behaviour by equity holders, which is absent for TFP and labour productivity. Australia and Canada closely resemble the

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none where productivity helps to predict the yield.

US results in virtually all respects, except capital productivity is the best indicator of equity returns in Canada, and equity price volatility is more influential in both countries than the US.

A polar opposite result is in Japan and Germany, where the own-effect on forecast variance of stock returns is much lower, and a substantial part of the forecast variance of equity returns is explained by lagged capital productivity and (to a lesser extent) TFP and labour productivity. This may of course relate to the lesser development of equity markets (only responding in the wake of actual real developments, rather than in line with expectations), as well as the strong post war growth in productivity highlighted in Section 4. Equity price volatility also plays a role in both countries, while inflation is important in Japan (this may reflect relatively high inflation during the high-growth period up to 1973). In neither of these countries is there strong feedback from equity returns to productivity, again suggesting that there are limited forward looking signals from financial asset prices to real activity. Italy and to a lesser extent France also have a substantial impact of productivity on equity returns – the main difference with Germany and Japan is in a more substantial feedback effect in Italy and effect of GDP in France.

Of the remaining countries, the forecast variance of equity returns in the UK is strongly influenced by the real long rate and equity price volatility – real economy variables have much less impact. The same comment applies to the real long rate in Denmark. In neither country do shocks to productivity or equity prices show a significant interrelation.

Table 14 shows the impulse responses to certain shocks, which are highlighted by the variance decomposition analysis. First there are effects of shocks in capital productivity on equity returns in Germany, Japan, Italy and France. They in each case generate a rise in equity returns, which is sizeable in the case of Japan and more modest in the other countries. The overall effect after 6 years is positive except in France. On the other hand, a rise in equity returns tends in the medium term to depress capital productivity in the US and Canada, as well as initially in Italy. This is consistent with either cyclical patterns or a valuation ratio effect whereby high equity returns prompt increased investment, which given diminishing marginal productivity of capital leads to lower capital productivity.

6. Conclusions

The share market boom in the 1990s is often linked to the accelerating labour productivity over the same period. We have suggested that labour productivity may be a misleading measure of firm's cash flow and that innovations in productivity in the 1990s only have temporary effects on capital productivity, the key component of a more correct measure of cash flow. Among the empirical findings are that the overall performance of the major OECD countries since the 1920s is broadly similar both in terms of productivity and equity returns. The 1990s have featured relatively low productivity growth compared to the 1920s, with a great deal of reliance on capital deepening, suggesting a weak background for equity price increases in the 1990s. Of the three measures of productivity, equity returns seem to be most strongly related to capital productivity. VARs suggest that there may be effects of equity returns on productivity in the US, Australia and Canada, which may link to the effects of higher returns on investment. There is less evidence that shocks to productivity consistently help to predict equity returns in these countries. For Germany, Japan and Italy there is evidence of an opposite effect, with productivity shocks helping explain the forecast variance of equity returns. This may link to the period of post-war recovery in these countries, when investment and productivity growth were strong, but equity markets were rather underdeveloped.

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Chart 1: US growth, stock returns and productivity (TFP)

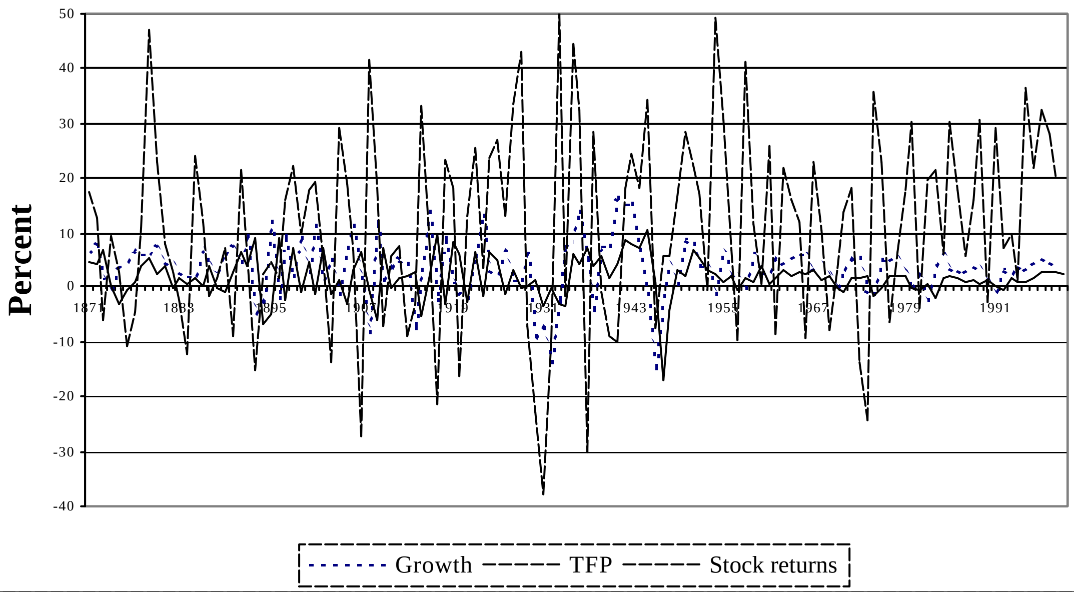


Chart 2: US productivity and real equity returns by decades

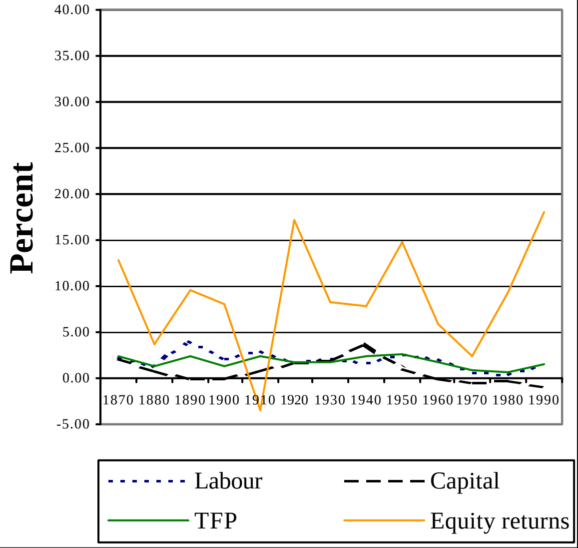


Chart 3: UK productivity and real equity returns by decades

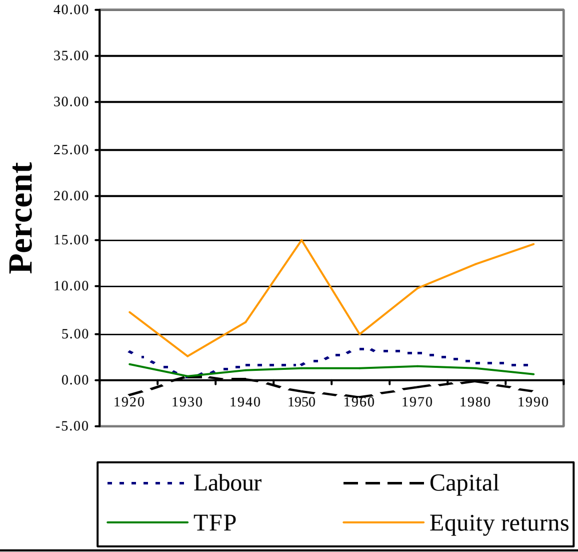


Chart 4: Japanese productivity and real equity returns by decades

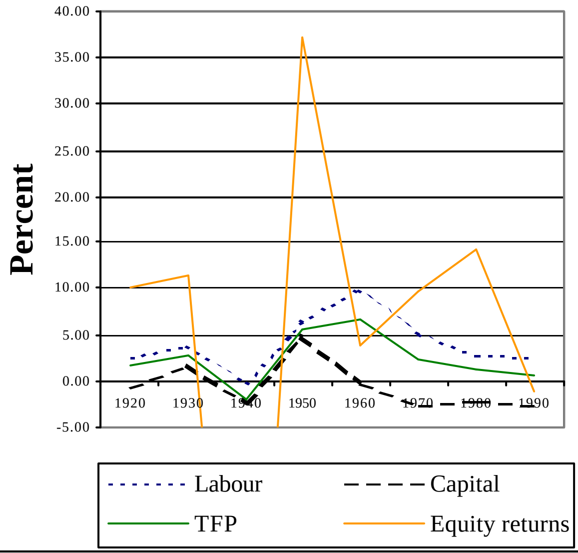


Chart 5: German productivity and real equity returns by decades

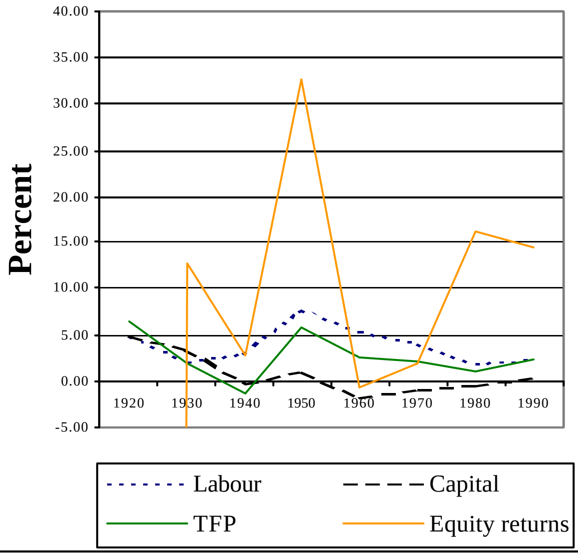


Chart 6: US productivity and real equity returns in 1920s

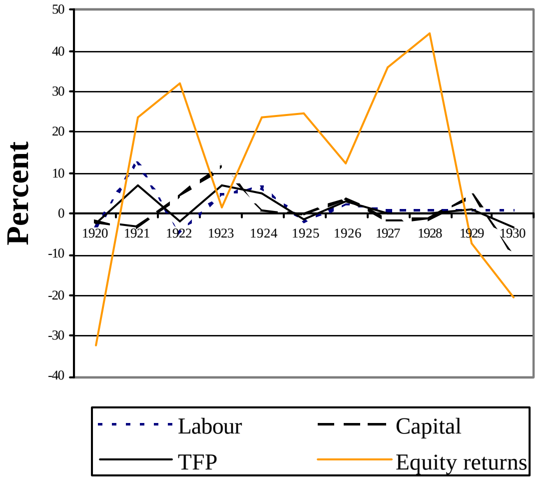


Chart 7: US productivity and real equity returns in 1990s

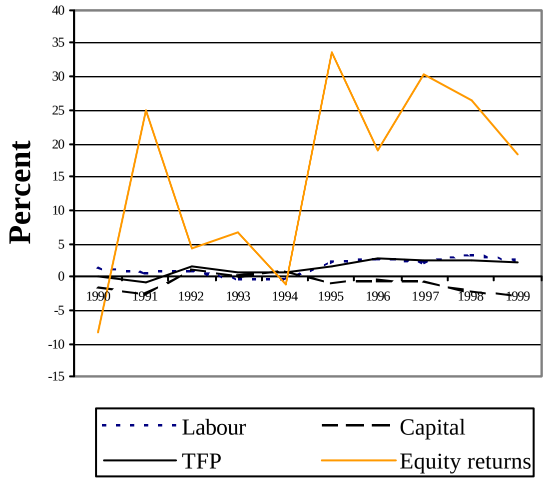


Chart 8: UK productivity and real equity returns in 1920s

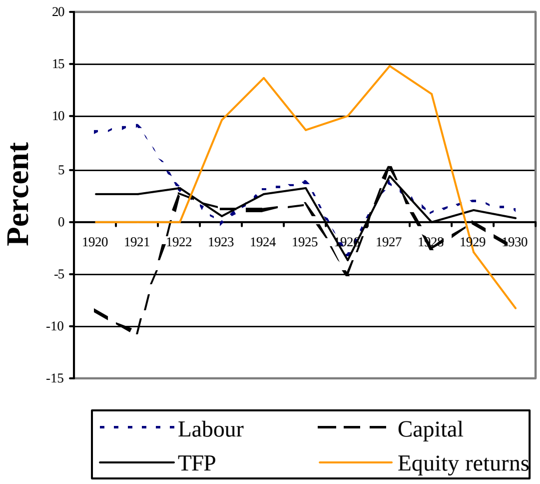
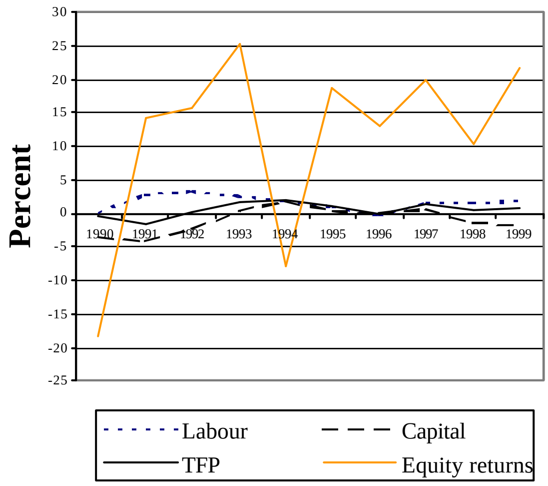


Chart 9: UK productivity and real equity returns in 1990s



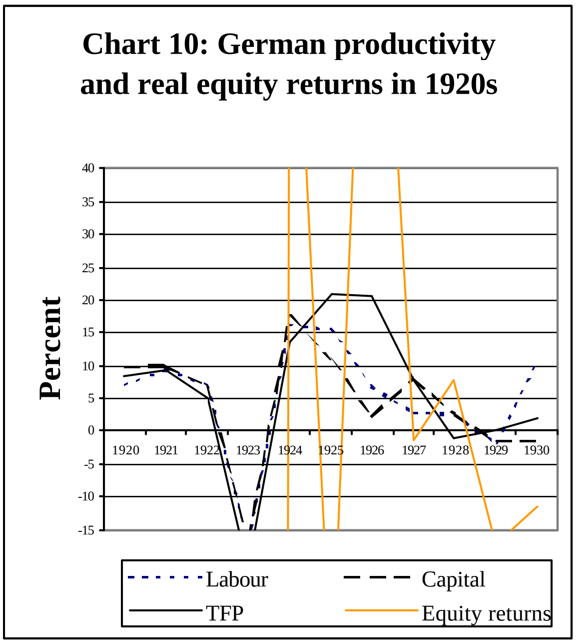


Chart 10: German productivity and real equity returns in 1920s
Percent
40
35
30
25
20
15
10
5
0
-5
-10
-15
1920
1921
1922
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1926
1927
1928
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1930
Labour
Capital
TFP
Equity returns

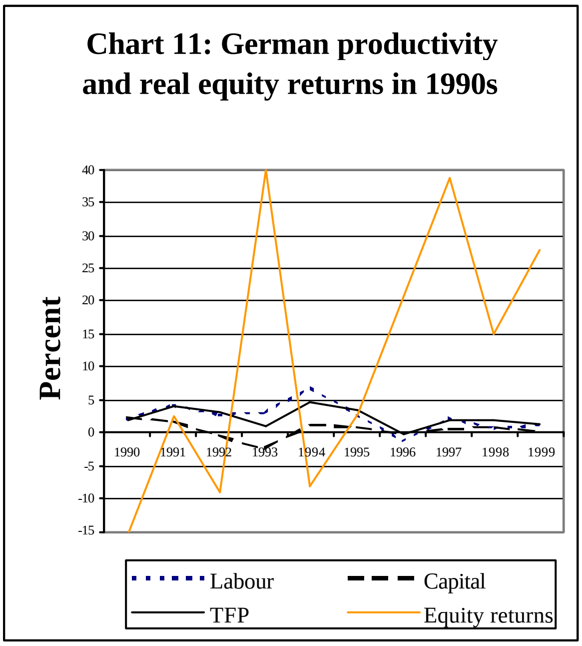
Chart 11: German productivity and real equity returns in 1990s
Percent
40
35
30
25
20
15
10
5
0
-5
-10
-15
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
Labour
Capital
TFP
Equity returns

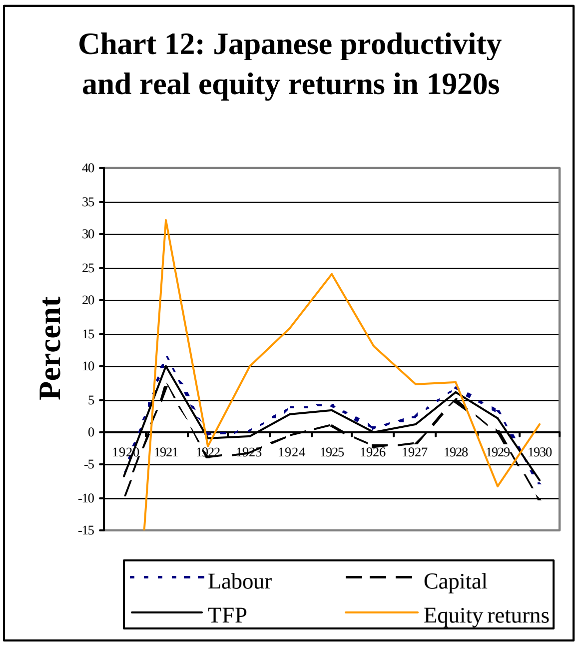
Chart 12: Japanese productivity and real equity returns in 1920s
Percent
40
35
30
25
20
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10
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-10
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1920
1921
1922
1923
1924
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1930
Labour
Capital
TFP
Equity returns

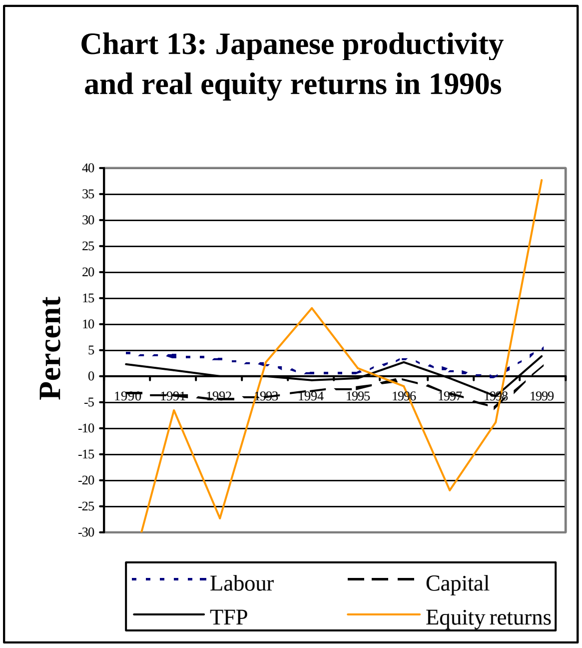
Chart 13: Japanese productivity and real equity returns in 1990s
Percent
40
35
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25
20
15
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-10
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-20
-25
-30
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
Labour
Capital
TFP
Equity returns

Table 1: Long term averages for annual productivity growth and real equity returns (1920-99)

Percent per annum	US	UK	Canada	Germany	France	Italy	Japan	Australia	Denmark
Labour productivity	1.65	2.10	2.16	3.91	3.25	2.51	4.06	1.79	2.22
Capital productivity	0.83	-0.70	0.10	0.81	0.94	0.27	-0.60	0.37	0.18
Total factor productivity	1.61	1.09	1.55	2.54	2.34	1.79	2.37	1.32	1.55
Real equity returns	9.79	9.06	7.50	-129.01	6.90	7.15	2.57	7.58	7.85
Memo: Real bond yields	2.24	2.66	3.22	-140.70	-2.83	-2.87	-6.98	2.3	3.48
Memo: Growth	3.16	2.15	3.82	3.80	3.32	3.03	4.62	3.49	2.99
Memo: Inflation	3.00	4.01	2.96	147.03	9.31	10.24	12.94	4.42	4.01

Table 2: Post-war averages for annual productivity growth and equity returns (1950-99)*)*

Percent per annum	US	UK	Canada	Germany	France	Italy	Japan	Australia	Denmark
Labour productivity	1.50	2.31	2.06	4.26	3.38	3.50	5.29	2.07	2.62
Capital productivity	-0.09	-0.93	-0.39	-0.34	0.54	0.56	-0.63	0.28	-0.29
Total factor productivity	1.41	1.15	1.45	2.70	2.51	2.45	3.29	1.59	1.73
Real equity returns	10.25	11.23	7.84	12.85	8.50	8.37	12.94	6.09	9.47
Memo: Real bond yields	2.45	2.64	3.30	4.29	2.15	2.40	2.11	2.09	3.75
Memo: Growth	3.26	2.51	4.11	4.10	3.70	3.83	6.12	4.04	3.09
Memo: Inflation	3.42	4.92	3.44	2.45	9.25	12.51	15.21	4.75	4.79

Table 3: Secular averages (1870-1999)

Percent per annum	US	UK	Canada	Germany	France	Italy	Japan	Australia	Denmark
Labour productivity	2.01	1.53	2.21		NA	2.21	3.52	1.42	2.27
Capital productivity	0.78	-0.71	-0.37	0.10	0.17	0.40	NA	-0.53	0.29
Total factor productivity	1.71	0.71	1.26	1.61	NA	1.60	NA	0.66	1.60
Real equity returns	8.69			-79.79					
Memo: Real bond yields	2.38	2.20	2.19	-87.24		-2.76		2.55	3.09
Memo: Growth	3.50	1.99	3.80	3.07	2.42	2.47	4.00	3.31	2.80
Memo: Inflation	2.15	3.11	2.32	92.68		7.65		3.15	3.08

Table 4: Annual correlation of real equity returns (1920-1999)

Percent per annum	US	UK	Canada	Germany	France	Italy	Japan	Australia	Denmark
Labour productivity	0.09	-0.05	0.07	0.22	0.03	0.31	-0.32	0.03	0.12
Capital productivity	0.10	0.03	0.03	0.23	0.07	0.43	0.01	0.09	0.15
Total factor productivity	0.17	0.04	0.00	0.23	-0.03	0.39	-0.02	0.21	0.13
Memo: Real bond yields	0.30	-0.07	0.15	0.99	0.10	0.48	0.9	0.2	0.17
Memo: Growth	0.09	-0.04	-0.10	0.26	0.04	0.40	0.11	0.05	0.08
Memo: Inflation	-0.33	0.09	-0.28	-1.00	-0.12	-0.50	-0.90	-0.30	-0.10

Table 5: Annual correlation of real equity returns (1950-1999)

	US	UK	Canada	Ger-many	France	Italy	Japan	Aust-ralia	Den-mark
Labour productivity	0.12	-0.14	0.03	0.04	-0.04	-0.05	0.26	0.06	0.11
Capital productivity	-0.07	-0.03	0.16	0.15	0.26	0.28	0.56	0.19	0.15
Total factor productivity	0.15	0.04	-0.01	0.16	0.09	0.07	0.41	0.39	0.10
Memo: Real bond yields	0.27	-0.19	0.07	-0.05.	0.05	0.21	0.18	0.12	0.16
Memo: Growth	-0.08	-0.12	0.01	0.11	0.07	0.05	0.37	0.13	-0.01
Memo: Inflation	-0.39	0.07	-0.24	-0.16	-0.12	-0.22	-0.18	-0.25	-0.12

Table 6: Growth rate of real dividends

Percent per annum	US	UK	Canada	Ger-many	France	Italy	Japan	Aust-ralia	Den-mark
1920-1999	2.6	1.2	0.5	4.9	2.6	2.7	-0.3	1.7	11.2
1950-1999	1.7	1.7	0.2	6.7	3.2	1.2	2.2	1.1	16.4
Memo: growth rate of real capital stock 1920-1999	2.35	2.89	3.75	2.96	2.38	2.73	5.30	3.13	2.82
1950-1999	3.36	3.49	4.52	4.46	3.14	3.26	6.84	3.75	3.41

Table 7: Granger causality tests for real equity returns and capital productivity

Country	Capital productivity	Real equity returns on capital productivity	Real equity returns	Capital productivity on real equity returns
US	+ [0]	+ [+]	- [0}	0 [0]
Germany	+ [+]	- [+]	0 [0]	0 [0]
Canada	0 [0]	- [+]	- [-]	0 [0]
UK	+ [+]	0 [+]	- [-]	0 [0]
France	+ [+]	0 [0]	0 [0]	0 [0]
Italy	+ [0]	- [0]	0 [0]	0 [0]
Japan	0 [+]	0 [-]	0 [0]	+ [0]
Denmark	0 [0]	0 [0]	0 [0]	0 [0]
Australia	= [0]	0 [0]	0 [0]	- [-]

Table 8: Granger causality tests for real equity returns and labour productivity

Country	Labour productivity	Real equity returns on labour productivity	Real equity returns	Labour productivity on real equity returns
US	- [-]	0 [0]	- [0}	0 [0]
Germany	- [+]	0 [0]	0 [0]	0 [0]
Canada	0 [0]	0 [0]	- [-]	0 [0]
UK	0 [0]	0 [0]	- [-]	0 [0]
France	+ [+]	- [0]	0 [0]	0 [0]
Italy	0 [+]	- [0]	0 [0]	0 [0]
Japan	0 [+]	0 [0]	0 [0]	+ [0]
Denmark	0 [0]	0 [0]	0 [0]	0 [0]
Australia	- [-]	0 [0]	0 [0]	- [-]

Table 9: Granger causality tests for real equity returns and total factor productivity

Country	Total factor productivity	Real equity returns on total factor productivity	Real equity returns	Total factor productivity on real equity returns
US	0 [+]	+ [+]	- [0}	0 [0]
Germany	+ [+]	- [+]	0 [0]	0 [0]
Canada	0 [0]	0 [0]	- [-]	0 [0]
UK	0 [0]	0 [0]	- [-]	0 [0]
France	0 [+]	0 [0]	0 [0]	0 [0]
Italy	+ [0]	- [0]	0 [0]	0 [0]
Japan	0 [+]	- [0]	0 [0]	+ [0]
Denmark	- [-]	0 [0]	0 [0]	0 [0]
Australia	- [0]	0 [0]	0 [0]	- [-]

Table 10: Unit root (DF) tests (* indicates stationarity at the 95% level)

	US	DE	CA	UK	FR	IT	JP	DK	AU
RLR	-2.1	-4.0*	-2.7	-3.0	-2.9	-2.9	-4.1*	-3.5*	-2.6
DRLR	-5.3*	-5.7*	-5.1*	-3.7*	-4.8*	-4.8*	-5.3*	-6.3*	-5.8*
EQR	-4.9*	-6.0*	-4.3*	-4.9*	-3.7*	-4.5*	-4.6*	-5.4*	-2.3
DY	-3.2	-2.8	-2.5	-3.7*	-2.1	-3.6*	-2.4	-2.5	-2.7
SP	-2.0	-3.0	-2.4	-2.1	-2.0	-2.2	-2.2	-0.9	-3.0
DSP	-4.7*	-6.4*	-4.3*	-6.1*	-5.3*	-4.4*	-4.4*	-5.5*	-5.2*
RDIV	-3.2	-2.9	-1.9	-3.4	-2.3	-2.4	-2.4	-3.9*	-2.8
DRDIV	-5.7*	-4.0*	-4.4*	-4.7*	-3.4	-4.3*	-4.3*	-3.7*	-3.8*
CPI	-3.1	-4.0*	-2.3	-2.3	-2.2	-2.8	-1.7	-1.7	-2.4
DCPI	-2.0	-4.3*	-1.8	-2.4	-2.9	-2.9	-4.2*	-2.6	-2.7
VOL	-3.6*	-3.2	-3.9*	-3.9*	-3.2	-4.1*	-3.9*	-4.3*	-4.3*
DLP	-4.2*	-4.5*	-4.3*	-4.9*	-4.0*	-1.9	-3.6*	-3.8*	-4.4*
DTFP	-3.8*	-3.9*	-5.0*	-5.0*	-4.1*	-2.1	-4.7*	-4.8*	-5.0*
DKP	-3.6*	-5.4*	-5.1*	-4.6*	-4.3*	-4.3*	-4.7*	-4.6*	-3.1
GDP	-2.0	-3.0	-2.0	-3.5*	-2.6	-2.3	-2.0	-1.6	-1.8
DGDP	-3.7*	-4.7*	-4.4*	-5.2*	-3.9*	-3.9*	-4.4*	-4.9*	-3.2

Key: RLR=real long rate, EQR, real total return on equity, DY dividend yield, SP share price index, RDIV real dividend index, CPI consumer price index, VOL share price volatility, TFP total factor productivity, KP capital productivity, LP labour productivity, a "D" before the variable name indicates first difference.

Table 11: Variance decompositions for stock returns, using TFP

Variable	Years	US	DE	CA	UK	FR	IT	JP	DK	AU
DTFP	1	4	1	0	2	0	14	0	5	7
	4	5	8	0	2	7	13	58	7	8
DGDP	1	0	2	2	1	3	4	0	1	2
	4	2	10	6	3	5	5	11	2	4
DCPI	1	7	2	1	1	0	0	29	3	1
	4	7	2	6	1	2	7	9	3	2
RLR	1	4	0	7	40	10	0	9	30	5
	4	5	4	6	37	10	1	8	36	4
VOL	1	1	2	4	5	0	0	10	4	2
	4	3	12	8	19	0	6	3	5	5
EQR	1	84	93	86	52	86	83	52	59	84
	4	77	65	73	38	76	68	11	48	76
Memo:										
EQR on DTFP	1	0	0	0	0	0	0	0	0	0
	4	1	0	2	0	3	15	1	4	3

Table 12: Variance decompositions for stock returns, using capital productivity

Variable	Years	US	DE	CA	UK	FR	IT	JP	DK	AU
DKP	1	1	3	4	0	4	22	1	4	1
	4	2	21	5	2	12	20	67	6	2
DGDP	1	1	2	0	1	9	0	15	10	3
	4	1	3	2	3	13	3	6	10	5
DCPI	1	13	4	0	6	3	2	18	0	2
	4	12	3	4	5	3	10	6	2	3
RLR	1	3	0	9	33	1	1	6	27	6
	4	4	3	7	32	2	1	5	33	6
VOL	1	1	3	6	5	1	4	8	3	2
	4	3	10	8	20	1	8	5	3	4
EQR	1	81	88	81	55	81	72	51	55	87
	4	77	60	73	40	69	58	10	46	80
Memo:										
EQR on DKP	1	0	0	0	0	0	0	0	0	0
	4	15	1	10	1	1	13	3	3	5

Table 13: Variance decompositions for stock returns, using labour productivity

Variable	Years	US	DE	CA	UK	FR	IT	JP	DK	AU
DKP	1	1	1	1	0	0	7	0	5	2
	4	4	12	1	1	5	7	38	11	6
DGDP	1	2	3	5	0	0	13	0	0	1
	4	3	6	7	4	6	14	34	3	3
DCPI	1	7	2	0	3	0	0	24	1	4
	4	7	2	5	2	2	7	7	2	4
RLR	1	4	0	6	35	7	0	7	29	4
	4	5	4	5	33	7	1	3	35	5
VOL	1	1	1	3	5	0	0	5	4	1
	4	2	13	6	19	0	5	4	5	3
EQR	1	85	94	84	54	92	79	63	59	87
	4	78	63	75	39	79	64	14	45	78
Memo:										
EQR on DKP	1	0	0	0	0	0	0	0	0	0
	4	0	1	1	0	9	11	13	3	1

Table 14: Impulse response functions for selected variables (responses to 1% shocks in other variables)

Year	1	2	3	4	5	6
DKP on EQR						
JP	-2	55	11	4	5	-6
DE	4	-5	12	0	-1	-5
IT	16	1	5	4	-1	1
FR	8	-10	-6	-1	-1	0
EQR on DKP						
US	0	1.4	-1	-1.5	-0.6	-0.3
CA	0	0	-1	-0.8	0	-0.2
IT	0	-1.2	-0.2	1.7	0.4	0