UK investment and the return to equity: Q redux

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Abstract

The conventional wisdom is that Tobin's Q cannot help explain aggregate investment. Some recent papers have explored other information that it might provide. It is found that Q has strong predictive power for debt accumulation and returns, but also predicts UK business investment. On the latter variable it performs as well or better than a specification based on the user cost.

Keywords: investment, Q, forecasting

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1 Introduction

It has become a commonplace to observe that Tobin's Q is no practical use when we wish to explain aggregate business investment. Examples of this include Oliner *et al* 1998 for the US, where when Q is significant it is wrongly signed. Chirinko (1993: p 1891) concludes that the 'model's empirical performance has been generally unsatisfactory.' This is somewhat odd, as although a similar consensus held about the user cost in the 1980s,[1] the recent view is that the user cost is significant in the aggregate investment relation,[2] and Q is interpreted within the standard neoclassical framework.[3] Be that as it may, research into UK investment published over the past decade[4] has often searched for factors to augment Q and other models of investment, examining, for example, the roles of debt, profits, capacity utilisation and uncertainty.[5]

[1]Caballero (1995) and Chirinko (1993) survey the aggregate investment literature.

[2]There is, however, controversy about the size of the effect. Caballero (1994) for the US and Schaller (2003) for Canada emphasise the bias induced by adjustment costs, and find long-run estimates close to unity. Caballero *et al* (1995) use plant-level data and find a similar average elasticity, while Goolsbee (1998), who emphasises the short- to medium-run supply elasticity, obtains similar results. By contrast, a recent paper using a very large US panel by Chirinko *et al* (2002) intended to address all the issues concerning athe above authors find a precisely estimated user cost elasticity of approximately 0.40. In the UK, Price and Ellis (2003) find a well-determined value of around 0.45.

[3]Tobin (1969) did not provide a formal model when he introduced the concept. The link to the neoclassical model was made explicit by Mussa (1977), but the notion was a marginal one. Hayashi (1982) showed how marginal and average Q could be linked in specific cases, which encouraged the empirical exploitation of the concept, while Abel and Eberly (1994) extended the theory to encompass various realistic features, including irreversibility and fixed costs.

[4]For example, Bakhshi and Thompson (2002), Carruth, Dickerson and Henley (2000), Cuthbertson and Gasparro (1995) and Price (1995).

[5]Measurement may be an issue here. In recent work at the Bank on the user cost elasticity, Ellis and Price (2003) exploit a new measure of the capital stock. Although ONS publish a series for the stock of capital, it was suspended for a year in the 2002 National Accounts Blue Book. See Oulton (2001) and Oulton and Srinivasan (2003); the latter explains the methodology employed to create our series. This work has also involved the construction of a volume index of capital services (VICS), as an alternative to the conventional stock measure. Each measure has its own uses, as discussed in Oulton (2001) and Oulton and Srinivasan (2003), and VICS is especially useful in productivity and growth accounting. However, the appropriate measure of investment in the VICS approach is not the aggregate (National Accounts) measure, but one in which, like the

Partly as a reaction to the perceived lack of success in explaining investment with Q, and partly to address the interesting question of predictability of returns, one recent strand of research has investigated what else it can inform us about. Q is based on stock market valuations. In the modern finance literature, it is widely accepted that asset prices can have information about future developments. For example, there is some evidence that the dividend-price ratio may be a predictor of future returns over some horizons. Theoretically, this follows from a decomposition of the linearised asset price present-value condition. A similar decomposition of Q shows that it may predict a variety of series, including investment, but also financial variables. We are also able to work with a measure of average Q. The conditions for this to be valid in the neoclassical model based on first order conditions of the maximisation problem are unlikely to hold, but in the present-value model we employ this is not an issue. We do not require much more than that Q is mean-reverting. As theory predicts marginal Q mean-reverts, we then mainly need that marginal and average measures cointegrate.

Robertson and Wright (2003) find Q cannot predict US investment, despite having a very long time series; this is a puzzle. To anticipate our results, by contrast, we find Q is able to do so for UK data, and is also informative about some other variables, including returns.

In Section 2 we discuss the theoretical role of Q. In Section 3 we describe the data. Section 4 examines the empirical relationship between Q and investment, while Section 5 examines other information in the series. Section 6 concludes.

2 Q

Average Q is defined

$$Q_t = \frac{P_t + L_t}{K_t} \tag{1}$$

where P indicates the value of equity, L is total liabilities (debt) and K is the value of the capital stock. Normalising the number of shares issued at unity, we can think of P as the price of equity. In logs, indicated by lower

VICS, the amount of investment in each asset is weighted together by its rental price.

case, linearising around the mean value of $l - p$, $\widehat{l-p}$, we obtain

$$q_t \approx \xi + (1 - \zeta)p_t + \zeta l_t - k_t \tag{2}$$

where $\xi = \ln(1 + e^{\widehat{l-p}})$ and $\zeta = e^{\widehat{l-p}}/(1 + e^{\widehat{l-p}})$.

2.1 The neoclassical model with costs of adjustment

Hayashi (1982) showed that the neoclassical theory of investment in the presence of adjustment costs leads naturally to a definition of marginal q, which we will denote by q^M.[6] Using Hayashi's (obvious) notation but in discrete time, the firm faces the constraint

$$\Delta K_{t+1} = \psi(I_t, K_t) - \delta K_t \tag{3}$$

where the $\psi()$ function is the 'installation' or cost of adjustment function, telling us how a given quantity of investment is transformed into a change in the capital stock. Evidently, $\psi_I < 1$. Let λ be the Lagrange multiplier, or shadow price, associated with this constraint; this can be interpreted as the present discounted value of marginal profits following an extra unit of investment. Marginal Q is then defined as $Q_t^M = \lambda / P_{I,t}$ where P_I is the price of investment goods. Intuitively, in equilibrium marginal benefits of investment are equated to the cost, and Q^M is unity. The first order conditions can be solved to give an optimal investment rule of the form

$$I_t = \alpha(Q_t^M, K_t). \tag{4}$$

Q^M and K are sufficient to determine the optimal level of investment. But Q^M is unobservable. Hayashi shows that if firms are price takers and the production and installation functions are linearly homogenous, (4) reduces to

$$I_t/K_t = \beta(Q_t^M). \tag{5}$$

The assumption of constant returns to scale is usually considered to be acceptable, and homogeneity in the installation function (that is, any costs of

[6] The convention in the paper is to use lower case for logs. However, as q is a monotonic transformation of Q, to keep things tidy lower case is primarily used when referring to it in the text in the rest of the paper, except when it is explicitly the level being discussed.

adjustment depend on the ratio of investment to the capital stock) does not seem unreasonable. But perfect competition seems implausible.[7] It is easy to see that the effect of imperfect competition is that the marginal return to investment is declining, so average Q lies above the marginal: it should be greater than one. So it would be reasonable to presume that average q exceeds marginal q^M, the extent depending inversely on the elasticity of demand (the more market power, the higher average q), quite plausibly with a cyclical component.[8]

2.2 Present-value approach

Despite the caveat regarding the wedge between marginal and average q, it seems likely the average measure may be informative about investment; but that may not be all it can tell us. The question of what extra information it carries question has been addressed recently in two related papers which examine US data: Lettau and Ludvigson (2002) and Robertson and Wright (2003). They build on Campbell and Shiller (1988) and Cochrane (1991). Temporarily, to simplify the exposition we assume there is no debt, so (2) becomes

$$q_t = p_t - k_t. \tag{6}$$

The key to understanding the approach is in the standard decomposition of the equity price. The log stock return is defined by

$$r_{t+1} = \ln(R_{t+1}) = \ln\left(\frac{P_{t+1} + E_{t+1}}{P_t}\right) \tag{7}$$

[7] When Cooper and Haltiwanger (1999) estimate the (unrestricted) concavity of the profit function from micro data they find that the profit function is homogenous of degree 0.5.

[8] Robertson and Wright (2002) suggest other reasons why the mean value of average Q may differ from unity. These are a failure of market efficiency following from the market's and firm's information sets differing, and mis-measurement of capital. We return to the latter point below.

where E_t is dividends.[9] From Campbell and Shiller (1988), we can approximate this by

$$r_{t+1} \approx \theta + \Delta p_{t+1} + (1-\rho)(e_{t+1} - p_t) \tag{8}$$

where $\rho = \frac{1}{1+e^{\widehat{e-p}}} < 1$ and $\widehat{e-p}$ is the mean of the ratio $e-p$. If we rewrite (8) as an expression explaining p_t, we have a forward equation in the price. This can be solved forward (with a transversality condition) to express the current price as a weighted sum of future returns and dividends.[10] If the price is high, it must be that dividends are expected to grow rapidly and/or that future returns are expected to be low. The 'return' here should be thought of as the required rate of return - the rate which the market requires, given the risk of holding the asset. It is the rate at which future dividends are discounted. A useful interpretation of the relationship is in terms of the dividend-price ratio. If dividend growth is relatively constant, as is often thought to be the case, as the dividend-price ratio fluctuates it should forecast future returns, and it is often argued that the evidence supports this proposition.

This does require some discussion, as while the notion that returns are predictable at medium to long horizons has acquired stylised-fact status, there has been something of a counter-revolution recently. It has been argued that there are three potential problems with the standard tests of overlapping horizon returns.[11] First, persistence of the instruments predicting returns; second, the corrections employed to account for heteroscedasticity and the autocorrelation induced by the overlapping nature of the data; and third, endogeneity of the predictor. An influential paper was Nelson and Kim (1993).

[9] The return R_{t+1} can also be expressed as $\frac{EA_{t+1}}{EA_t}\frac{PE_{t+1}+PO_{t+1}}{PE_t}$ where EA_t is earnings, PE_t is the price-earnings ratio and PO_t is the dividend payout ratio, D_t/EA_t. Dividend growth can be decomposed into earnings growth and a payout ratio. Practically, it may be helpful in finite samples to work with earnings rather than dividends, as the latter may be smoothed or set to zero. For a finitely lived firm where the terminal value of the firm's assets are distributed, the present value of earnings (including the terminal value of the firm) is equal to the present value of dividends. In the empirical part of the paper we use aggregate earnings.

[10] This derivation assumes away bubbles. The consensus view in the finance literature (*e.g.*, Cochrane (2001) pp 399-402), is that bubbles are implausible. This is partly on theoretical grounds and partly empirical. If there are bubbles: stock returns would not be predictable, but they is some evidence they are; equity prices and price/dividend ratios would be non-stationary, but they are not. In this view, posssible counter-examples such as the great dot-com fiasco must have been sustained by mistaken expectations.

[11] We return to this issue below.

Thus Ang and Bekaert (2003) provocatively ask 'Stock return predictability: is it there?'. The answer appears to be, not as much as some people thought. This may be welcome: as Cochrane (2001, pp 406-7) observes the high estimates previously obtained were a puzzle. Wetherilt and Wells (2004) conclude that for the UK there is weak evidence that dividend yields predict long-horizon excess returns. The emerging new consensus remains that there is predictability; indeed, it may be that one of the other stylised facts (that long-run dividend growth is unpredictable) will be overturned (Lettau and Ludvigson (2003b)). Ang and Berkaert themselves conclude returns can be predicted, as do Campbell and Yogo (2002).

For this to work, there must be a reason why returns would vary. Standard models of intertemporal choice predict that assets should be priced according to their covariance with the stochastic discount factor or intertemporal marginal rate of substitution, the discounted ratio of marginal utility of consumption over the relevant horizons. As marginal utility varies, it is possible the price of risk (the required return on risky assets) may also vary.

The interesting corollary for our purposes is that there are implications for Q, and therefore investment. This was explored by Abel and Blanchard (1986), who were concerned partly to construct a measure of marginal q but who looked explicitly at the present-value condition. Using the same approach as in the literature examining the information in the dividend-price ratio, we may solve (8) forward and substitute into (6), using the transversality condition $\lim_{i\to\infty}\rho^i q_{t+1} = 0$, to obtain

$$q_t \approx \frac{\phi}{1-\rho} + \sum_{i=1}^{\infty} \rho^{i-1} f_{t+i} \tag{9}$$

where

$$f_t = \Delta k_t + (1-\rho)(e_t - k_t) - r_t. \tag{10}$$

If q is stationary, then the right hand side of (9) must also be stationary. Stationarity of q is not assured, but there are strong arguments to suggest that q^M is stationary, so if the divergence of marginal and average q is not non-stationary, q will be mean-reverting. Given (9), stationarity holds if each of Δk_t, $e_t - k_t$ and r_t are stationary. If not, then $(\Delta k_t, e_t - k_t, r_t)$ must be a cointegrating set. Moreover, as q_t is a weighted sum of future values, it follows immediately from (9) that q_t may be able to forecast some or all of these series; not in a causal, structural sense, but rather that q_t contains information that may help predict future outcomes, based as it is on agents' expectations. In the general case where firms issue debt, (2),

$$q_t \approx \sum_{i=1}^{\infty} \rho^{i-1} f_{t+i} \tag{11}$$

where f_t is redefined as

$$f_t = \Delta k_t + (1-\rho)[(1-\zeta)(e_t - k_t) + \zeta(l_t - k_t)] - \zeta \Delta l_t - (1-\zeta) r_t \tag{12}$$

where as above $\zeta = e^{\widehat{l-p}}/(1 + e^{\widehat{l-p}})$, the share of debt in total value. So q may have potential forecasting power for investment, the yield, gearing, the growth in debt and returns.

In a recent paper Abel and Eberly (2002) use a similar conceptual framework. They examine a model without adjustment costs but where marginal and average q diverge due to monopoly power. Marginal Q is continually equal to one, but because profits vary with monopoly power average q can vary, and is informative about investment. Although the connection to the present-value approach to asset pricing is not is not explicitly made, it is nevertheless within this framework. For simplicity, they assume returns are constant, and focus on variations in profits. They observe that their model suggests the impact of q will be quantitatively small, which confounds the standard empirical criticism that implied adjustment costs are implausibly high. They also find cash flow has an effect on investment, a common empirical result.

In this alternative interpretation we need worry no longer about divergence between average and marginal measures, and it reinforces the belief q should help us forecast investment. The mystery remains that it has not been found to do so. Lettau and Ludvigson (2002) and Robertson and Wright (2003) do not resolve that puzzle, but instead explore what else q may tell us, and we pursue this below. But we also find q does predict investment. First, we examine the data.

3 Data

In the Bank we have constructed our own estimates of the capital stock, which we believe are superior to those that ONS used to produce. We would like a measure of Q for the business sector. We have two proxies available.[12] These are a measure for the Private Non-Financial Corporations (PNFCs) sector, and another for a broader PNFCs plus public corporations sector. Neither of these is perfect. The first will be distorted by privatisations. The impact of privatisations is that the underlying capital stock series will increasingly understate the 'true' PNFCs' net capital stock over time. We can interpret these baseline estimates as a lower bound to the 'true' in-house net capital stock series, and consequently the Q estimate derived from it can be viewed as an upper bound. The second gets round the privatisations problem by using a broader sector than PNFCs that includes public corporations. But our measure of the numerator of Q, as well as the inventories part of the denominator, is for PNFCs rather than PNFCs plus public corporations. Arguably, this series is to be preferred, as the impact of the data problems associated with this estimate are likely to be small in relation to the privatisation problem, and this is what we use in the subsequent analysis although, numerically, it must be too small.

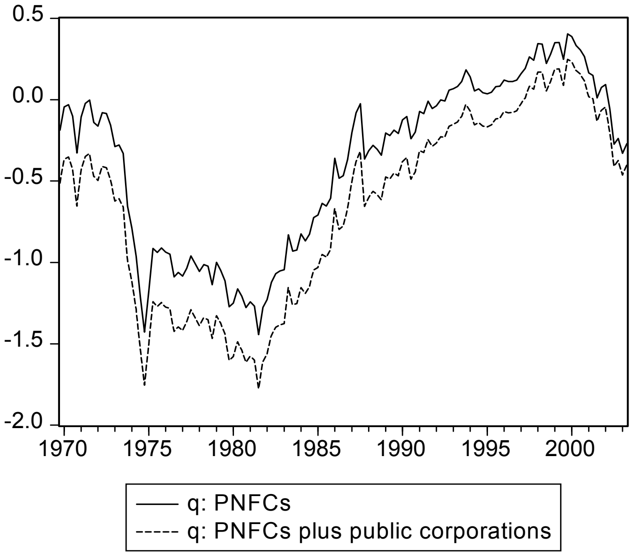
Figure 1 shows the two (log) measures. As expected, the narrower measure lies above the broader. But there are systematic variations in the discrepancy. Looking at the narrower measure, in natural levels the series ranges between 0.24 and 1.50: the sample mean is below unity, at 0.77. This is odd, as the arguments regarding why it might differ from one largely push the measured value up. Another such might be thought to be the stock of 'intangible investments' in software, firm specific human capital, and knowledge.[13] But one interpretation could be that the UK suffered from a lengthy period of 'negative intangibles'. Hall (2001b) acknowledges that these are a somewhat puzzling idea, but provides a number of possible explanations for the phenomenon.[14] First, Hall (2001a) refers to work by Greenwood and Jovanovic (1999). The falls in stock markets in the early 70s coincided with the implications of the information technology (IT) revolution becoming apparent. Although the overall effect on productivity was positive, existing firms with human and physical capital tied to existing practices were not able or willing to exploit the benefits of IT and therefore lost value. At the same time, new firms able to exploit the IT revolution had not been founded. This is supported by the observation that (in the US) on aggregate, the stock

[12] Fuller data descriptions and sources are given in the Appendix.

[13] For a discussion of the US context see Nakamura (2001) and Lev (2003).

[14] The discussion here is drawn from Eliades and Weeken (2003).

Figure 1: q: log Q, PNFCs and public corporations



market value of firms present in 1968 fell sharply over the next three years and never recovered, with the rise in the overall stock market capitalisation driven by firms which entered after 1968. A second related argument could be made with reference to the oil price shocks that hit the global economy in the 1970s. These may have made much of the existing capital stock obsolete. Third, Hall (2001b) points out that shareholders have the last claim on corporate revenue and may during the early 1970s have lost to other stakeholders such as suppliers, workers, managers or governments. All these factors could conceivably have been more important in the United Kingdom than in the United States, thereby explaining this period of 'negative intangibles' in the United Kingdom. Even so, its length and magnitude suggested by Figure 1 is somewhat puzzling. Nevertheless, we proceed to see what information the series does contain.

From the analysis above, we are interested in Δk_t, $e_t - k_t$, $l_t - k_t$, Δl_t and r_t. We also report the excess return, $r_t - r_t^f$. We examine data defined for PNFCs, shown in Figures 2 to 7. 'Dividends' are earnings net of interest payments and therefore include retained earnings. Figure 8 shows the business investment to capital stock ratio; business investment is defined to include all corporations. Of these series, a visual impression suggests that not all are unambiguously stationary. This is confirmed by the formal unit root tests in Table 1. Only the earnings ratio, the growth in debt, the business investment to capital ratio and returns are apparently stationary. From a theoretical perspective, the absence of mean-reversion is odd. For marginal q, the neoclassical theory sketched above is generally valid, and the steady-state value is invariant to most structural parameters. There are no compelling reasons to suppose the gap between average and marginal q should be non-stationary.[15] Empirically, (log) investment is an I(1) variable, as we would expect on theoretical grounds. In the long-run the capital stock accumulation identity ensures the capital stock has the same order of integration so long as the depreciation rate is stationary, which it is in our data set, so the growth in the capital stock should also be stationary. The debt to capital ratio can certainly not be bounded. However, stock accumulation processes can be long-lived. Thus it is possible that the series failing the tests are long-memory, but nevertheless stationary, against which the tests have low power. We therefore report a test for fractional integration below.

Before doing so, given our strong prior of mean-reversion it may be appropriate to use a test where the null is stationarity, such as the KPSS test.[16] But the results shown for the variables where there is a question to be resolved (Table 2) are qualitatively the same. Finally, we note that an alternative, joint, test for stationarity is offered by the Johansen method. From the forward expansion, we know that the relevant set of variables is q_t, Δk_t, $e_t - k_t$, $l_t - k_t$, r_t and Δl_t. Either they are all stationary or some form cointegrating relationships. r_t is unambiguously stationary, so there are five variables in question. Table 3 reports the results of performing a Johansen test on these. The VAR length selected by the SIC is two, but this leaves residual autocorrelation.[17] To remove this the lag length needs to be eight, which is probably excessively high. This number of lags implies that the VAR is almost certainly overparameterised, which reduces the power of the tests. Thus we should err on the side of caution when determining the number of cointe-

[15] See Robertson and Wright (2003) for an extended discussion.

[16] Kwiatowski, Phillips, Schmidt and Shin (1992). We report results using a lag of 8, which KPSS suggest is appropriate, However, results are not sensitive to lag length.

[17] Dummies for the 1974:1 oil shock and a change in tax incentives affecting 1985:1 and 1985:2 are also included.

grating vectors (use higher critical values). But the consequences of using too low a lag length are usually thought to be more severe.[18] On diagnostic failures in a cointegrating context, Hendry and Juselius (2000) conclude that '[s]imulation studies have demonstrated that statistical inference is sensitive to the validity of some of the assumptions, such as, parameter non-constancy, serially correlated residuals and residual skewness, while moderately robust to others, such as excess kurtosis (fat-tailed distributions) and residual heteroscedasticity.' On normality, each equation in the VAR comfortably passed tests for skewness, but there was evidence for excess kurtosis at the 1% level in Δk_t, q_t and $l_t - k_t$ and at the 5% rate for Δl_t. As observed above, it is quite possible that these data have memories too long to enable us to satisfactorily test for stationarity with the thirty years of data available: Robertson and Wright use a century of data. We must be cautious, given the lag length and kurtosis, but the interesting conclusion is that we can reject the hypothesis that the cointegration rank is 4 against the alternative it is 5. As the VECM is full rank, this must imply all the series are stationary.

Table 1: Augmented Dickey-Fuller statistics; no trend

	q	q^{PP}	Δk_t	$e_t - k_t$	$l_t - k_t$	Δl_t	$i_t^b - k_t^b$	r_t	$r_t - r_t^f$
level	-1.31	-1.17	-2.58	-3.11	-0.96	-5.25	-2.90	-5.84	-6.56
change	-4.66	-4.59	-4.22	n/a	-4.90	n/a	n/a	n/a	n/a

Lag length 4; 5% critical value -2.88

Table 2: KPSS stationarity tests

	q^{PP}	Δk_t	$e_t - k_t$	$l_t - k_t$	Δl_t
no trend	0.99	0.62	0.21	0.76	0.26
trend	0.23	0.09	0.11	0.25	0.10

Lag 8; 5% critical values: no trend 0.46, trend 0.15

[18] There are many Monte Carlo studies of finite sample properties of the Johansen and other tests for cointegration, examining deviations from the maintained assumptions. Much of this literature is summarised in Maddala and Kim (1998).

Figure 2: Capital stock (PNFCs) growth

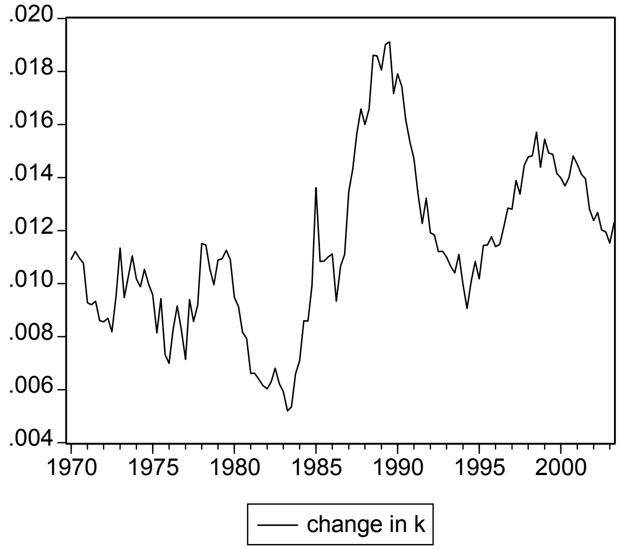


Figure 3: Net earnings to capital stock ratio (PNFCs)

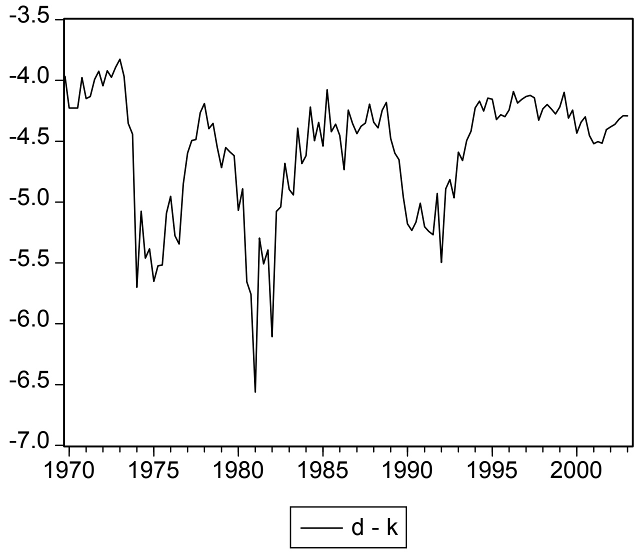


Figure 4: Debt to capital stock ratio (PNFCs)

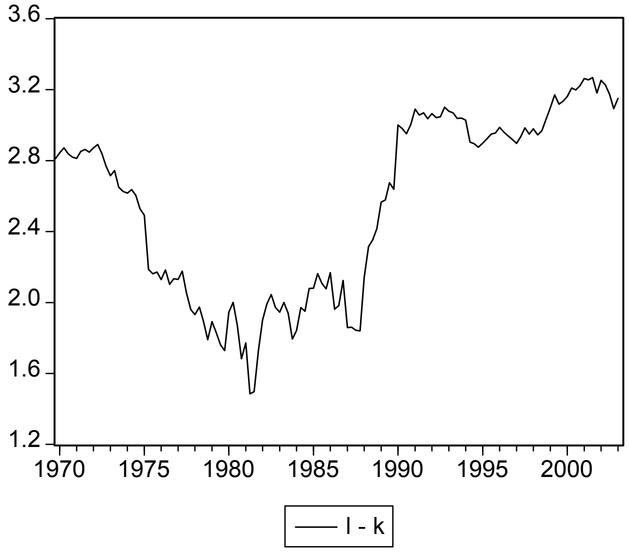


Figure 5: Debt (PNFCs) growth

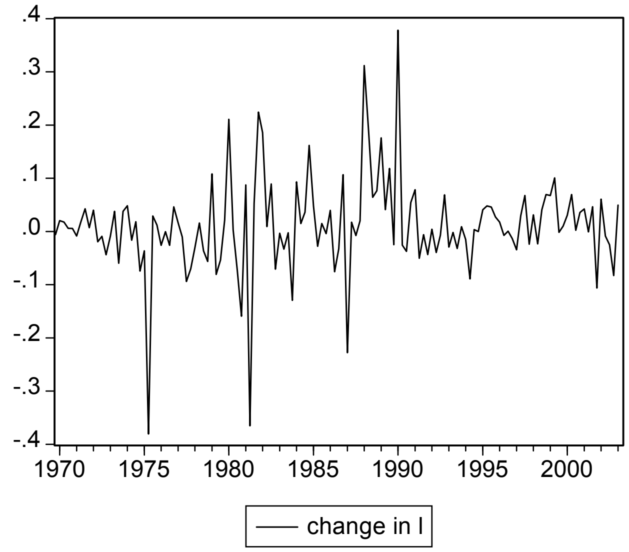


Figure 6: FTSE all-share real return

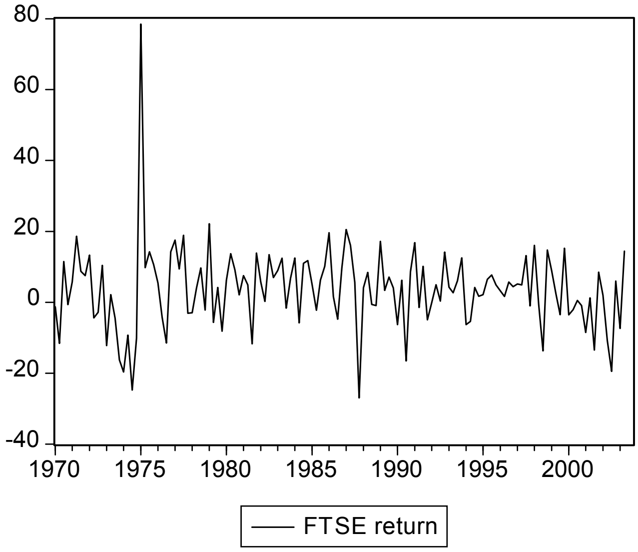


Figure 7: FTSE all-share excess return

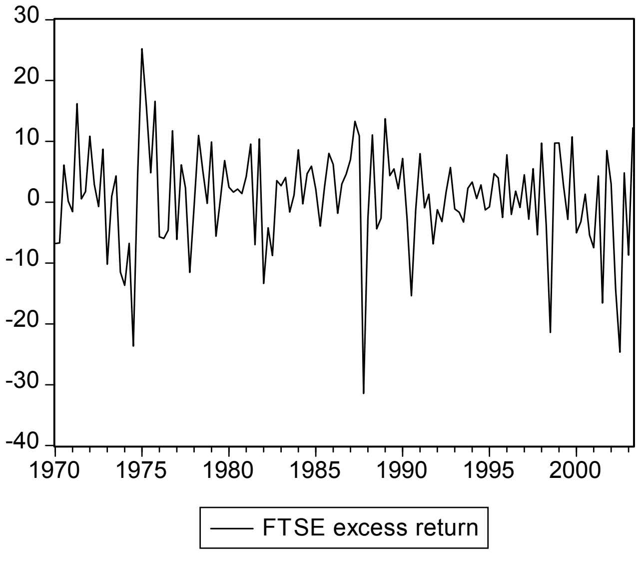
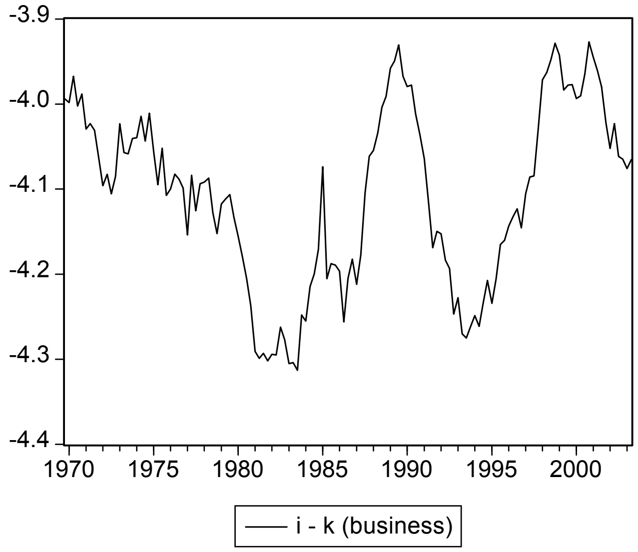


Figure 8: Investment to capital stock ratio (business)



Turning to the long-memory issue, a generalisation of the $I(0)$ and $I(1)$ dichotomy allows fractional integration, $I(d)$, which nests the two classical cases. The autoregressive fractionally integrated moving average process (ARFIMA (p, d, q)) may be written

$$\Phi(L)(1-L)^d(y_t-\mu) = \Theta(L)\varepsilon_t \tag{13}$$

where ε_t is i.i.d., L is the backward-shift (lag) operator, $\Phi(L)$ and $\Theta(L)$ are lag polynomials and $0 < d < 1$. When $d = 0$ we have stationarity and when $d = 1$ there is a unit root. For other cases, $(1-L)^d$ can be expanded to generate an expression with a rich lag structure. When $0 < d < 0.5$, y_t is stationary. When $0.5 \leq d < 1$, y_t mean-reverts but is non-stationary as the error variance tends to infinity with the sample size. The important point for our purposes is that if d is close to 0.5, the series will be mean-reverting and stationary but with very persistent dynamics. Table 4 reports a test introduced by Robinson (1995). All the estimates of d lie below 0.5, but for q_t and $l_t - k_t$ the estimates are nevertheless very close to and insignificantly different from 0.5. Were $0.5 \leq d$, the series would mean-revert so long as $d \leq 1$, but the exploding variance would make forecasting problematic.

Table 3: Johansen tests; linear deterministic trend

Variables: q_t, Δk_t, $e_t - k_t$, $l_t - k_t$, Δl_t Sample 1971:3 to 2003:1, 8 lags				
Trace test				
H0: r	Eigenvalue	Trace Statistic	5% Critical Value	1% Critical Value
0 **	0.200	85.00	68.52	76.07
At most 1 **	0.18	57.31	47.21	54.46
At most 2 *	0.12	33.40	29.68	35.65
At most 3 *	0.10	17.30	15.41	20.04
At most 4 *	0.038	4.84	3.76	6.65

* (**) denotes rejection of the hypothesis at the 5% (1%) level

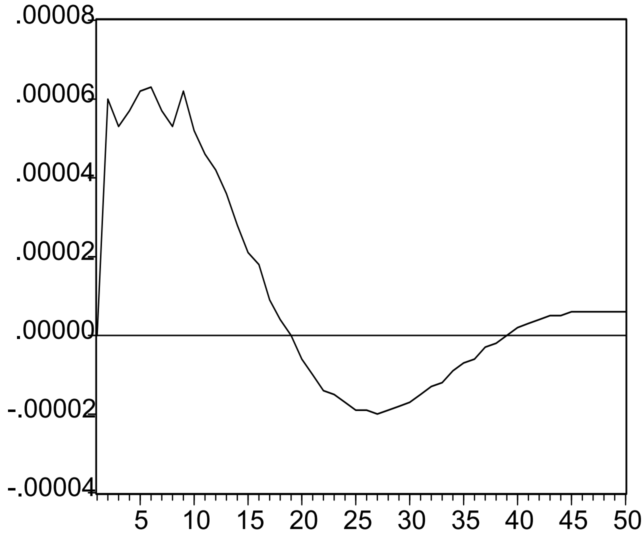
Table 4: Test for fractional integration

	q_t	Δk_t	$e_t - k_t$	$l_t - k_t$	Δl_t
$\hat{e}$	0.48	0.25	0.10	0.47	0.09
se	0.02	1.98	0.57	0.03	0.58
$t \ (d = 0)$	25.4	0.12	0.17	15.2	0.15

4 Q and investment

We begin by examining whether q can explain investment. We do so by estimating an error correction equation to explain the business investment to capital ratio where the only explanatory variables are own dynamics, lagged q, where q is defined in our preferred way as PNFCs plus public corporations, and a dummy for changes in tax incentives in 1985:1 and 1985:2. When two series are cointegrated, the ECM has a particularly useful interpretation. But an ECM is simply a linear reparametrisation of an ARDL, so there is no necessary implication that these series cointegrate, as they may be stationary. However, if they are non-stationarity then the error correction parameter serves as a test of the hypothesis of cointegration: see Banerjee, Dolado, Hendry and Smith (1986) and Banerjee, Dolado and Mestre (1998). Table

Figure 9: Investment to capital ratio response to one-period 1% shock to Q.



5 reports the results. As with the VECM, long lags are required to remove serial correlation, but we are able to do this: the F version of the LM(12) statistic has a p-value of 0.65. There is a very significant error correction term implying 37% of adjustment to the long-run occurs within one year, and a small but well determined parameter on lagged q. The dynamic response to a temporary one-period shock to q is shown in Figure 9. Despite the rapid error correction, the other dynamics create a moderate degree of persistence to the initial shock. Fixing the dummy effect, the equation is stable (it passes Chow breakpoint tests at 1990:1, 1995:1 and 200:1; p-values 0.40, 0.96 and 0.51 respectively). This equation has reasonable explanatory power. Fixing out the constant and dummy, the R^2 is still 0.25; in levels, 0.94. The equation is comparable in terms of goodness of fit to single equations conditioned on output and the user cost reported in Ellis and Price (2003). Re-estimated over the sample 1972:1 2003:2 using current data, the relevant R^2 is 0.357, while that from the specification in Table 5 over the same period, and written with Δi as the dependent variable to make comparisions of R^2 sensible, is 0.405.

Another test is to see whether q can predict growth in investment over different horizons, which we can do with a simple regression of the $(i_{t+i} - k_{t+i})$ on q_t. To account for autocorrelation induced by overlapping horizons a Newey-West correction is employed, together with a Hansen-Hodrick correction for the cumulative capital growth regressions.[19] Table 6 shows that q has predictive power for investment at short to medium horizons for PNFCs, with the impact fairly flat for three or four years, with peak power at a three-quarter horizon. For Business, the profile is flatter and smaller, but with forecasting power remaining at six years. The table also reports the results of using the change in the Business capital stock (cumulative net investment) at the same horizons, and there is a significant effect here as well. So it appears that a measure of q has explanatory power for investment, contrary to the conventional wisdom.

Table 5: Business investment and q

Dependent Variable: $\Delta(i-k)$ (business)				
Sample: 1971:4 2003:2				
$\Delta(i_t - k_t) = a_0 + a_1\Delta(i_{t-2} - k_{t-2})$ $+a_2\Delta(i_{t-3} - k_{t-3}) + a_3\Delta(i_{t-4} - k_{t-4})$ $+a_4\Delta(i_{t-7} - k_{t-7}) - \lambda(i_{t-1} - k_{t-1} - b\,q_{t-1})$				
	Coefficient	Standard-Error	t-Statistic	Probability
a_0	-0.45	0.11	-4.26	0.00
a_1	0.15	0.07	2.03	0.04
a_2	0.21	0.07	2.94	0.00
a_3	0.16	0.07	2.09	0.04
a_4	0.26	0.07	3.43	0.00
λ	0.11	0.03	4.27	0.00
b	0.087	0.04	2.37	0.02

$R^2 = 0.39$
Coefficient on dummys for 1985:1 and 1985:2 not reported

[19] See Section 5 for more discussion of these corrections.

Table 6: Regression of future log investment to capital ratio and growth in capital on q_{t-1}

Independent variable q_{t-1}									
forecast horizon	1	2	3	4	8	12	16	20	24
Dependent variable $i_{t+i} - k_{t+i}$ (PNFCs)									
coefficient	0.19	0.18	0.19	0.18	0.17	0.14	0.11	0.08	0.06
t-statistic NW(4)	6.50	6.52	6.54	6.38	5.20	3.49	2.25	1.43	0.92
Dependent variable $i_{t+i} - k_{t+i}$ (Business)									
coefficient	0.08	0.08	0.09	0.09	0.10	0.10	0.10	0.09	0.09
t-statistic NW(4)	2.66	2.89	3.09	3.31	3.96	4.07	3.90	3.31	2.57
Dependent variable $k_{t+i} - k_t$ (Business)									
coefficient	0.001	0.003	0.004	0.006	0.012	0.019	0.025	0.031	0.034
t-statistic NW(4)	2.69	3.05	3.16	3.08	3.70	3.99	4.20	4.42	4.66
t-statistic NW(k)	4.09	3.56	3.26	3.08	2.78	2.75	2.83	3.13	3.57
t-statistic HH(k)	3.37	2.79	2.51	2.36	2.17	2.28	2.67	3.79	5.81

Newey West with 4 lags: NW(4)
Newey West with k lags equal to horizon: NW(k)
Hansen-Hodrick with k lags equal to horizon: NW(k)

5 Other information in Q

We have established that q can inform us about investment: but there may be other information in it. One way to disentangle this is to estimate a VAR using the variables in (12), and examine block exogeneity of the variables, using pairwise Granger causality tests. These tests are valid under either stationarity or the existence of cointegrating relationships. Table 7 reports the results. q is able to predict the liability rate and growth in liabilities. Despite the well determined effect reported in Table 5, it cannot predict investment: the p-value is 11%. However, when we use the change in the capital stock (Table 8) it does have predictive power; predictability of the liability ratio is now only marginally significant, at 10%. But in both cases, contrary to the results in Robertson and Wright (2002), it cannot predict returns or earnings.

It remains possible that q contains information, but does not bring additional news beyond that contained in the other conditioning variables. Returns are usually thought to be predictable at medium term horizons. The standard predictive variables is the price-earnings ratio, but other variables may also have predictive power. Economic theory suggests the deviation from the long-run relationship between consumption, income and wealth should be one such, and in both Lettau and Ludvigson (2003a) for US data and Fernandez-Corugedo *et al* (2003) for U.K data, returns are predictable from this series. Similarly, there is evidence from the papers cited above that q has this property for the US.[20]

So it is of interest to see if this result holds for our data, despite the failure to find Granger causation. Recall what theory predicts. When q is large (the value of equity relative to the price of capital is high), one explanation is that future returns are expected to be low (future profit streams are discounted at a lower rate). Thus the larger q, the smaller future returns. Is this the case? The remarkable answer is that it is. Tables 9 and 10 reveal strong evidence of correctly signed predictive power at medium to long horizons. Figures 10 and 11 give examples of the fitted relationship. It is easy to see from the charts why the econometric results are so strong.

Nevertheless, we may wish to be cautious in interpreting these results. We apply Newey-West correction (using both the standard Newey-West recommendation and a lag equal to the horizon). Ang and Bekaert (2001) argue that Newey-West standard errors are downwardly biased in small samples, and that the bias can be substantial. The Hansen and Hodrick (1980) correction is also biased, although less so. They advocate using the Hodrick (1992) correction. Wetherilt and Wells (2004) find that the for UK excess returns, the Newey-West, Hansen-Hodrick and Hodrick t-statistics are respectively 3.16, 2.70 and 2.02 for the coefficient on the dividend yield in a one-year horizon regression. Unfortunately, in our data set estimation of the Hodrick tests were infeasible, as the weighting matrix was numerically non-positive definite in all cases.[21] However, the t-statistics, which are substantially below

[20] This is consistent with the results from Abel and Blanchard (1986), who find that for their measure of marginal q the majority of the variation is driven by returns, as opposed to marginal profits.

[21] This was also true for Hansen-Hodrick 24 and 28 period horizons with excess returns. An alternative would be to bootstrap the sample to generate corrections: we leave this for a further paper.

the uncorrected OLS values, are large enough at medium to long horizons to suggest the results would be preserved after such corrections.

Table 7: Pairwise Granger Causality Wald Tests: $i-k$ (VAR(8))

Excluded	Dependent variable					
	$i-k$	q	$e-k$	$l-k$	Δl	$r-r^f$
$i-k$	-	0.470	0.951	0.527	0.367	0.737
q	0.113	-	0.368	0.022	0.005	0.949
$e-k$	0.476	0.220	-	0.031	0.053	0.417
$l-k$	0.123	0.590	0.707	-	0.012	0.897
Δl	0.505	0.875	0.117	0.101	-	0.938
r	0.067	0.760	0.816	0.389	0.099	-
all	0.039	0.078	0.525	0.000	0.000	0.587

Sample: 1971:4 2003:1

6 Conclusions

The perceived failure of average q to predict investment, despite the success of recent attempts to explain investment with the neoclassical model using the user cost of capital, has led to a reappraisal of the information contained within it. Studies on long series of US data confirm that it has little predictive power for investment, but may help forecast returns and earnings. Examining these issues for the UK on a shorter span of data, by contrast we find that q does forecast investment. It also forecasts debt and returns. Indeed, q can predict returns remarkably well over medium to long horizons. It therefore appears that q is far from a theoretically interesting but practically useless variable: on the contrary, it is a rich source of information about real and financial quantities.

Figure 10: Actual and fitted excess returns: horizon 32 quarters

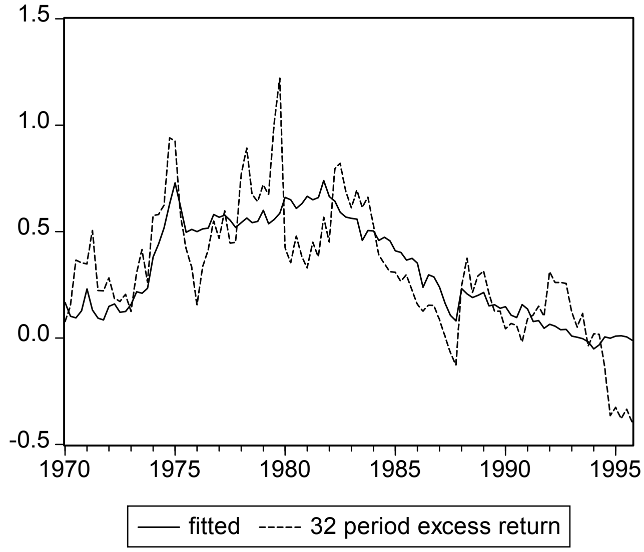


Figure 11: Actual and fitted returns: horizon 32 quarters

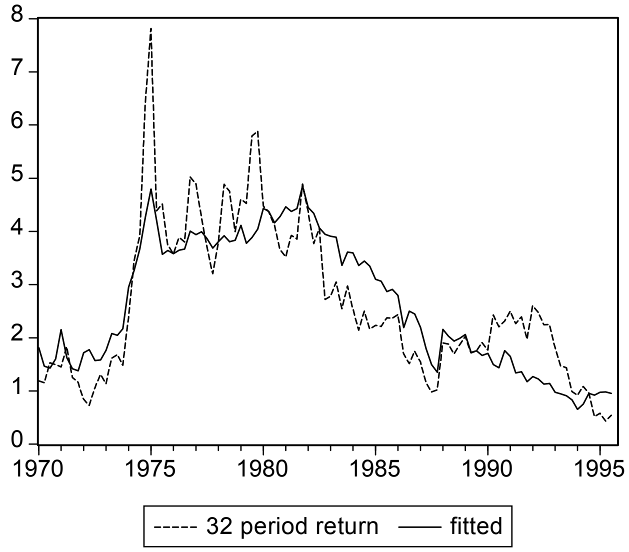


Table 8: Pairwise Granger Causality Wald Tests: Δk_t (VAR(8))

Excluded	Dependent variable					
	Δk	q	$e-k$	$l-k$	Δl	r
Δk	-	0.824	0.748	0.386	0.289	0.999
q	0.013	-	0.432	0.100	0.020	0.932
$e-k$	0.580	0.401	-	0.029	0.049	0.580
$l-k$	0.011	0.849	0.955	-	0.016	0.799
Δl	0.227	0.987	0.308	0.048	-	0.925
r	0.779	0.564	0.956	0.619	0.189	-
all	0.005	0.232	0.409	0.000	0.000	0.787

Sample: 1971:4 2003:1

Appendix

Four-letter identifiers are Office for National Statistics (ONS) codes.

Investment and the capital stock

Business investment is available from the (ONS) National Accounts data, with quarterly backruns to 1965 and 1955 respectively. The capital stock and associated depreciation series are constructed in-house following Oulton and Srinivasan (2003). In particular, a four-asset wealth measure of the non-housing capital stock (NHK) is employed, assuming that the asset split of business investment is the same as whole-economy investment (excluding dwellings), which is available from National Accounts data. ONS temporarily suspended their estimates of the capital stock in the 2002 Blue Book: see National Statistics (2002).

Differences between the Business sector and PNFCs

PNFCs are comprised of United Kingdom Shelf Companies (oil companies), manufacturing, non-financial service sector, and 'others' (including *e.g.* agriculture, construction, energy and mining). Only nominal quarterly investment data are published by the ONS for this sector (Quarterly national Accounts (QNA) Table K2) The business sector is comprised of PNFCs + financial corporations + public corporations. The quarterly ONS business investment release gives separate series (nominal and real) for: private man-

Table 9: Regression of i-period excess returns R_i^x on q

Dependent variable $R_i^x = \prod_0^i (1 + r_{t+i} - r_{f,t+i}) - 1$									
Independent variable q_{t-1}									
forecast horizon	1	4	8	12	16	20	24	28	32
coefficient	-0.02	-0.09	-0.15	-0.20	-0.26	-0.36	-0.39	-0.44	-0.45
t-statistic NW(4)	-1.79	-2.10	-2.66	-3.22	-3.98	-4.84	-5.21	-5.00	-6.60
t-statistic NW(k)	-1.62	-2.10	-2.42	-2.82	-3.39	-4.19	-5.53	-7.66	-10.92
t-statistic HH(k)	-1.62	-1.99	-2.23	-2.92	-3.87	-6.62	N/A	N/A	-44.57

Newey West with 4 lags: NW(4)
Newey West with k lags equal to horizon: NW(k)
Hansen-Hodrick with k lags equal to horizon: NW(k)

ufacturing; construction; distribution services; other services; other production (including *e.g.* agriculture, oil and gas, energy and mining); and public corporations (split into manufacturing and non-manufacturing). Adding public corporations to PNFCs means that the only difference between the two sectors is financial services companies. The shares in nominal business investment in 2002 were: PNFCs (88%); financial corporations (7%); and public corporations (4%).

Alternative measures of Q constructed for PNFCs

The measures of Q can be defined as

(Net financial value of the corporate sector)/(Current value of capital stock and inventories).

The numerator is an ONS series (NYOT) which can be defined as the sum of the current market values of PNFCs net debt (definition below) and equity. The denominator has two versions: one that includes public corporations (PCs), and another that excludes them. To calculate measures of PNFCs real capital stock, consistent with the Bank measure of whole economy capital stock (KNH), three pieces of information are required for each variant: an investment series; a starting value for the capital stock; and a depreciation rate.

Investment: as observed above, the ONS only publish a nominal PNFCs

Table 10: Regression of i-period real returns R_i^r on q

Dependent variable $R_i^r = \prod_0^i (1 + r_{t+i}) - 1$									
Independent variable q_{t-1}									
forecast horizon	1	4	8	12	16	20	24	28	32
coefficient	-0.04	-0.17	-0.32	-0.55	-0.79	-1.07	-1.45	-1.85	-2.40
t-statistic NW(4)	-2.22	-3.18	-4.54	-4.91	-5.83	-6.61	-7.22	-8.22	-8.27
t-statistic NW(k)	-1.87	-3.18	-3.88	-3.97	-4.37	-5.00	-5.59	-6.24	-5.88
t-statistic HH(k)	-1.96	-3.24	-3.18	-3.45	-3.97	-5.04	-5.75	-5.94	-5.69

Newey West with 4 lags: NW(4)
Newey West with k lags equal to horizon: NW(k)
Hansen-Hodrick with k lags equal to horizon:NW(k)

investment series (ROAW). To obtain real investment, ROAW is deflated by the implied ONS total business investment deflator (NPEK/NPEL). The measure that includes public corporations' investment is calculated by adding nominal PCs investment to ROAW and deflating in a similar fashion.

Starting value: the starting value of the non-housing capital stock (KNH) is scaled by taking the proportion of the constructed PNFCs (or PNFCs + PCs) real investment in real whole-economy minus dwellings investment in 1969 Q4.

Depreciation rate: this is the implied depreciation rate from the KNH calculations.

The real investment series, together with the starting values and (implied) real depreciation rate for KNH allows calculation of two variants PNFCs real capital stock by employing the Perpetual Inventory Method (PIM). In order to obtain the current values of these measures including inventories, the real measures are divided by by the KNH deflator and PNFCs stock of inventories added to each. PNFCs stock of inventories is based on ONS data for inventory flows and holding gains.

Net earnings and net debt

Net earnings are defined as PNFCs gross operating surplus less taxes on income, interest payments and depreciation. Apart from depreciation, all series in this calculation are published by the ONS in QNA Tables K1 and K2. Depreciation is the nominal level of depreciation of PNFCs capital stock implied by the above calculations.

Net debt is calculated solely from ONS data, and is defined as:

Domestic bank debt + foreign bank debt +total bonds - liquid assets

where the relevant ONS codes are NLBE (domestic bank debt), NLBI (foreign bank debt), NKZA (total bonds), and NKJZ (liquid assets).

FTSE returns

Returns are the quarterly return of FTSE All-Share (price appreciation plus dividends) or equivalent. For excess returns, the risk-free rate is a 20-year government bond (coupon plus price appreciation).

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