The impact of regulation on market risk ♦

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Abstract

It is crucial to understand the impact of changes in regulation on market risk but there is no literature showing how risk responds to expected changes in regulation that are specifically designed to change risk. This paper fills this gap by providing a detailed study of one such case. Using a sample of privatized UK companies, and UK and US control samples, between 1993 and 2000 we show (both for the single factor market model and the three factor Fama-French model) that the changes in risk in the market are both significant and consistent with theory.

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1. Introduction

The direct and indirect regulation of quoted companies is a common and growing feature of 'stock market' economies. These regulations are usually intended to impact on the returns and/or risk of those holding claims on the underlying assets. For example, competition law, price controls, investor protection, market entry restrictions, etc., are all intended to transfer wealth between parties either as an end in its own right or to achieve specific objectives. There already exists a significant literature that documents the effect of regulation on valuation.[1] In contrast, there is no equivalent literature showing how risk responds to expected changes in regulation that have been specifically designed to change risk. The main reason for the lack of evidence, one suspects, is that, although regulatory changes will typically impact on risk, there is a lack of relatively 'clean' cases that isolate the risk effect. That is, although almost all regulatory changes will affect the risk of the parties involved, there are very few regulatory changes applying to quoted non-financial institutions that are designed primarily to transfer risk but not wealth between parties, and hence enable the risk effect to be isolated for investigation.

This paper addresses the gap in the literature. It provides a detailed study of a case where regulation was introduced specifically to transfer the risk between parties but not to create a wealth transfer. We inquire whether the market risk response is significant and, if so, whether it is consistent with theory. The paper analyzes the time-varying nature of risk and shows (using a single factor and three factor Fama-French model) that the impact was both significant and consistent with the theoretical predictions.

Understanding of responsiveness of market risk to regulatory changes that are designed to change risk is now more crucial in international markets than ever before due to the scale of activities involved. The proportion of an internationally diversified

[1] See, e.g., Bittlingmayer and Hazlett (2000), Eckel et al. (1997), Fields et al. (1990), Prager (1989) and Rose (1985). Kole and Lehn (1999) discuss the relationship between deregulation, market performance and corporate structure of the US airline industry. Binder (1985) discusses the problem of undertaking event studies of regulation changes (see Section 3 below). Using an international panel from the 1990s La Porta et al. (2002) show that valuation is higher where minority shareholders have stronger protection.

portfolio affected by changes in regulation is huge and growing. There has been a wave of privatization that has taken place around the world in the last twenty years. Estimates of May 2003 put the total value of assets transferred from the public to private sector at $3.24 trillion which is 18.2% of the global stock market value, and 38.6% of the non-US total value (Megginson (2005), chapter 7). Many of these companies (e.g., telecommunications, electricity, gas markets) have been accompanied by some form of specific regulatory control (see, for example, Dewenter and Malatesta (1997), Grout et al. (2004), Jones et al. (1999)). Even within well developed economies, regulated privatized companies now account for a significant fraction of the stock market (e.g., at least 13.1% in Germany, 11.7% in Australia and 7.7% in France (see Megginson and Netter (2001)) with many privatizations still to come.[2] In addition, where there has been little utility privatization (e.g., the US), existing regulation of utilities is unlikely, with the exception of telecommunications, to decline dramatically. Furthermore, the market provision of more traditional public services is growing in the US and elsewhere. For example, Lopes-de-Silanes et al. (1997) show that in the US newly provided services of this type are fifty percent more likely to be provided by private contractors rather than county government. Taken together this suggests that globally, direct economic regulation of privately owned companies appears set to continue on an upward trend.[3] Interestingly, Glaeser and Shleifer (2003) argue that there are strong reasons why regulation rather than enforcement through courts may be the dominant form of control. Bodies such as the OECD and World Bank also push the privatization agenda and quality regulation agenda (see for example, Scarpetta and Nicoletti (2003)).

The results of the paper are also important because financial markets, albeit not just stock markets, are the primary source of finance for quoted companies. It has been shown (see for example, Wurgler (2000) and Beck et al. 2000)) that financial markets (and less state ownership) improve the allocation of capital. Companies that face significant direct and indirect regulation fall between the state ownership and fully private models. How regulation affects the risk of these companies is therefore

[2] See Boutchkova and Megginson (2000) for study on the impact of share issue privatisations on the growth of stock markets.

[3] Indeed, in some countries, the extreme example being New Zealand, the regulation of privatised companies is increasing rather than declining as the companies move further from privatisation.

important both for portfolio choice and for policy makers.[4] Of course, this emphasizes the positive aspect of regulation, e.g., regulations designed to improve efficiency and the efficient operation of markets. There is no guarantee, however, that most regulation exists for this purpose. The primary reason for its existence could be the benefit it bestows on politicians and bureaucrats (see for example, the 'grabbing hand' analogies in Djankov et al. (2002)). However, how the markets react is still just as valid a requirement, albeit without an 'efficiency' justification, in such a world.

The particular case study of the paper concerns the regulation of telecommunications, water, electricity and airports in the UK in the 1990's. In the late 1990s the UK government proposed a change in the regulation of prices of all regulated UK utilities from price-cap to a system of explicit profit-sharing between companies and customers.[5] After a period of 25 months (referred to as the 'profit-sharing period') the government abandoned the plan. In the paper we analyze the time-varying pattern of risk for each of the companies affected from 1993 to 2000 using a single factor and Fama–French three-factor model (referred to throughout as FF3F). The theoretical prediction for the impact on these companies is that the risk of the regulated companies should be lower in this twenty-five-month period relative a control sample. Applying Kalman filter techniques, OLS with White heteroskedasticity-consistent standard errors and covariance corrections (referred to as OLS WHC) and ML with GARCH(1,1) effects to a single factor market model and FF3F model we show that this effect is strongly confirmed in the data.

Using daily data with a market model the effect in the 'profit-sharing period' is very clear on time-varying betas for a portfolio of regulated companies. This is true whether we apply the Kalman filter technique to the full sample period or to three sub-samples (before, during and after the treatment). The effect is also clear when applying the Kalman filter to individual companies. Applying OLS WHC and ML with GARCH(1,1) specification we find the effect on the risk (as measured by beta) is

[4] Of course, the ability of regulators to intervene at any time, i.e., the incomplete nature of the contract, may affect investment in important ways other than changing the cost of capital (see for example, Grout (1984) and Hart (1995)) but this is not the concern of the paper.

[5] The shift to profit-sharing (whereby companies share increases and decreases in profits with customers) is an excellent example of a 'clean' case that isolates the risk effect. Although profit-sharing has been applied in a regulatory context, as far as we are aware this is the only example of a universal proposed change to profit-sharing from a different regulatory regime.

significant at a 1% level on a portfolio of regulated companies and on almost every company at the individual company level.

To show that the regulatory period changes in risk are UK specific we compare the US and the UK fluctuations in market risk for corresponding groups of companies. Choosing the US market as a comparator helps us to control for changes in demand and supply conditions (worldwide) that are unrelated to the regulation of ownership structure inside the UK. We show that there was no change in market risk for the US samples during the period of the regulatory debate in the UK. We also argue that changes in leverage cannot explain the observed decline in market risk. However, we find a significant decline in risk in both US portfolios in the period mid 1999 to end 2000. This decline is consistent with the pattern observed for the UK market for all studied portfolios. Although not central for the core result in the paper (since the test depends on the differences between samples) we conjecture on the cause of this decline (the e-commerce ‘bubble’) and provide evidence why we observe a significant effect.

We also investigate the effect of the impact of the change in regulation on risk using the FF3F model on monthly data. Here the effect is confirmed although the impact of the two additional factors is less clear than of the market factor. The Kalman filter approach on the monthly data only confirms the effect as significant through the market factor. However, we are using monthly data and the imposition of the assumption of constant beta (save for the profit-sharing period) easies the requirements on the data. Applying OLS WHC to the portfolios shows that the profit-sharing dummies are significant for all three factors. This is true but far weaker when we address individual company level data.

The study of the impact on systematic risk of the regulatory change is the primary question for investigation. The case study, however, also provides a tangential but intriguing contribution to the debate on the role of the FF3F. Typically studies that assess whether additional, i.e., non-CAPM, factors are significant address the extent to which they can explain returns over time across many companies. In contrast, here we are concerned with 'picking up' a predicted effect in an experiment. We are able to identify, from government publications and action, a specific proposed policy change to a specific set of companies for a specific period of time. We are able to predict from theory what effect this should have on systematic risk. Furthermore, taking the investigation as a whole there is very convincing evidence that the effect is strong and in the direction predicted. This then can be used as an informative experiment to throw light on the relevance of various factors. We find that all three FF factors are significant in 'picking up' the predicted effect, although the HML factor is only significant at 10%.

The plan of the paper is as follows. Section 2 provides a theoretical presentation of the predicted risk-regulation relationship for different regulatory regimes discussed in our study. Section 3 describes and discusses the data. We construct a sample of 15 privatized regulated companies and a control sample of 18 unregulated companies that will be the core of our analysis. Section 4 tests our theoretical predictions using a single factor market model and gives the estimation results using the Kalman filter approach with GARCH(1,1) specification, OLS WHC and ML with GARCH(1,1) specification for the portfolios constructed in Section 3. Section 5 gives the comparison of the Kalman filter estimates obtained for the UK and the US markets based on portfolios created from DataStream sector indexes that contain companies selected in Section 3. The section closes with the discussion of leverage effects. Section 6 applies the Kalman filter and OLS and ML to a FF3F model. Section 7 closes with conclusions.

2. Regulation and risk

2.1 Risk and regulation

Historically rate-of-return regulation was the most common form of direct price control regulation for companies. The central feature of a rate-of-return regime is that prices are adjusted to ensure that the rate of return on the company's assets does not exceed some specified level. As a result the company does not benefit from achieving lower costs and the consequences of inefficiency are more easily passed on to consumers. These incentives are in stark contrast to those that arise in a competitive market where gains that a company is able to make, e.g., from implementing a new, cheaper way of doing things, will lead to higher profit for a period of time. Of course, the benefit will be eroded over time as competitors catch up. When they do so the competitive process will push prices down, passing the benefits on to the market place, and will culminate in a position where the innovator again earns no greater reward than others in the industry. The failure of rate-of-return regulation to replicate the risk and rewards inherent in competition have led to the well documented disadvantage that it provides poor incentives for efficiency improvements, leading to higher costs and over investment.[6]

In contrast, price-cap regulation sets a pre-determined ceiling on prices for a number of years. During this time the ceiling is only allowed to increase by the rate of inflation less some predetermined adjustment factor.[7] The adjustment factor is set at the start of the five year period at a level that will enable the regulated entity to earn an expected fair rate of return on its assets, provided it is run efficiently. If, through greater effort, the regulated company is able to reduce costs at a greater rate than expected, or if business conditions are better than expected, prices still follow the pre-specified rule and the company will earn a higher return for the life of the price-cap. Similarly if the company is less efficient or faces unexpected adverse business conditions then the company earns a lower return than expected. The effect is that the regulated entity is able to retain the rewards of greater effort for a few years but these are passed onto the consumer at the next price review. Overall, price-cap regulation aims to mimic the benefits of the competitive process and brings to the regulated firm the risks and the rewards that would arise in a competitive industry. [8]

Profit-sharing is a compromise form of regulation between rate-of-return and price-cap regulation. Under profit-sharing the regulated firm's profits and losses are explicitly shared with consumers according to some pre-specified rule. Each of these

[6] See Armstrong et al. (1994) for a thorough discussion of models of regulation.

[7] For example in UK telecommunications, the first UK utility to be privatised, the adjustment factor is called X and for this reason price-cap regulation is frequently referred to as RPI-X regulation

[8] This view that the beta is affected by the form of regulation is somewhat confirmed in the cross section empirical evidence of Alexander et al. (1996). They aim to test the conjecture that, with all else being equal, a regulated firm's beta is higher under a price-cap than rate-of-return regime. They divide companies into high-powered (price-cap and revenue-cap), low-powered (rate-of-return) and intermediate-powered (discretionary systems) regulatory regimes. Data is taken from different firms (from countries and regimes) with the aim that indicative values for the three groups may be established by averaging the betas of the companies within each of the regulatory regimes. They find that the average asset betas are 0.71 for high-powered regulatory regimes, 0.6 for intermediate and 0.32 for low- powered regulatory regimes

models of regulation implies different risks for a regulated company. This is considered in the next sub-section.

2.2 Risk and profit-sharing

This sub-section provides a simple theoretical illustration of the impact that the change in regulation should have on the company's risk. If the firm faces profit-sharing regulation then its profits, $\hat{\pi}$, can be represented as a restricted deviation around a target profit level, π^*. More formally,

$$\hat{\pi} = \pi^* + \gamma(\tilde{\pi} - \pi^*),$$

where $\gamma < 1$ is the proportion the firm is allowed to keep if its profit exceeds the target profit π^*, and $\tilde{\pi}$ is the profit the company would earn under price-cap regulation.

The above formula can be rewritten as a weighted average of the outcome under rate-of-return regulation, i.e., guaranteed profit of π^*, and the outcome under price-cap regulation:

$$\hat{\pi} = (1-\gamma)\pi^* + \gamma\tilde{\pi}. \tag{1}$$

The target profit π^* is guaranteed; therefore, equation (1) says that the profit-sharing profit can be expressed as a linear combination of the risk free target profit and the risky price-cap profit.

For the purpose of the paper, equation (1) is the central relationship required for our empirical analysis. The equation implies that regardless of the factors that determine return, the company's exposure to each factor with profit-sharing should be γ of the exposure in the absence of profit-sharing. However, to provide further insight it might be useful to explore an explicit example of how this relationship could theoretically arise in the single factor case. The mechanism in this example is straightforward. An increase in the market index leads to an increase in wealth and permanent income which itself causes an increase in consumption and hence profitability for the regulated company.[9] Hence there is a positive correlation between the company's value and the market index that will depend on the form of price control regulation that a company faces. We assume that the aggregate demand for the company's output depends on aggregate wealth.[10] If firm i faces price-cap regulation, its profit, $\tilde{\pi}$, is given by:

$$\tilde{\pi} = p_i x(\underline{p}, W) - c(w, x(\underline{p}, W)),$$

where x is aggregate demand for product i and c is the firms cost function, p_i is its output price, $\underline{p}$ is the vector of prices in the economy, w is all other input prices and W is aggregate wealth. The Gorman polar form implies aggregate demand of the form:

$$x(\underline{p}, W) = a(\underline{p}) + b(\underline{p})W,$$

where a and b are functions of the vector of prices in the economy. If total costs take the form of a fixed cost, F, and marginal cost, c, then,

$$\tilde{\pi} = (p_i - c)(a(\underline{p}) + b(\underline{p})W) - F.$$

The systematic risk of the regulated company within the CAPM framework can be expressed as:

$$\beta_i = \frac{\text{cov}(\tilde{\pi}, W)}{\sigma_W{}^2} = \frac{\sigma_{\tilde{\pi}}}{\sigma_W} = (p_i - c)b(\underline{p}).$$

Then, since $\text{cov}(\pi^*, W) = 0$, the beta of a firm under the profit-sharing regulation, $\hat{\beta}$, is:

$$\hat{\beta}_i = \frac{\text{cov}(\hat{\pi}, W)}{\sigma_W{}^2} = \gamma(p_i - c)b(\underline{p}) = \gamma\beta_i. \qquad (2)$$

In other words, the profit-sharing beta is a fraction, γ, of the price-cap beta. The more profit-sharing, i.e., the lower value of γ, the bigger the difference in beta between profit-sharing and price-cap regulation. Therefore, this example predicts that, other

[9] Note, Ostergaad et al. (2002) show that deviations from permanent income hypothesis consumption are small once one moves to state level data and Attanasio et al. (2002) show that for shareholders consumption is particularly sensitive to wealth.

[10] This is equivalent to assuming that the consumers' utility functions satisfy 'Gorman's polar form'.

things being equal, a shift to profit-sharing should reduce the risk of the regulated company to a fraction γ (< 1) of the risk in the absence of the shift to profit-sharing.[11]

3. Data

3.1 Background

As mentioned in the introduction, event studies of significant regulatory changes face particular problems. Binder (1985) identifies three common problems. One, that major regulatory events usually involve no single unique announcement date, two, that regulation changes often favor some firms but harm others (e.g., protects small firms at the expense of large) and, finally, that regulation usually affects firms in the same industry at the same calendar time and so are difficult to separate from industry-specific shocks. In this study we are concerned with a proposed change to profit-sharing for all regulated companies in the UK (covering airports, electricity, gas, telecommunications and water) so the study is not exposed to the last problem at the industry level, although we do have to construct a control sample to fully interpret the results. With regard to the second problem, the proposed change was not to be selectively applied. For this reason, all regulated companies in our sample are affected by the change and, more importantly, the direction of the theoretical prediction on risk is the same for all companies. The scale of the impact may differ between companies and, as well as looking at the overall effect on a regulated sample, we adopt a company-by-company investigation to allow for differential effects.

The first problem, however, is a real concern for all major regulatory changes. In some cases it is possible using daily data to identify some effects of individual regulatory announcements and publications but for a major regulatory change there will be many such dates, and it is usually the net effect of the regulation that is sought, not changes in expectations along the way. The announcement problem is less of an issue though for a study (such as this) that seeks to address the impact on risk than for studies that seek to identify the transfers of wealth that arise from a major regulatory

[11] Following Rubinstein (1973) a similar process extends to other co-moments between R_i and R_m. This is a special case of the general point made earlier that given equation (1) and the fact that π^* is a fixed target, implies that under profit-sharing the company's exposure to any risk factor is γ of what it would be under price-cap regulation.

change. This is because the former is not concerned with specific share price changes on particular dates. Instead we are concerned whether the time-varying risk for the relevant companies was lower for a significant period of time coinciding with the time that the regulatory change was expected. In the case of this study we use daily and monthly data, and deal with a period of 'expectation' that is about 25 months within a full sample period of over six years. For this reason our results are less sensitive to the choice of precise dates. However, we need to define the period of expectation and now turn to this problem.

3.2 The relevant dates

Price-cap regulation has been used in the UK as the basis of regulation for all the utilities and, save for minor changes, the price-cap regime remained similar in each regulated sector to that introduced at privatization. Prior to their election, it was widely expected that the New Labour Party would implement an overall utilities review and indeed after coming to power in 1997 this occurred. The formal opening consultation for the review was published on June 30, 1997. It required the sector specific regulators to submit their views on potential changes to the current regulatory structure and specifically whether profit-sharing should be adopted. Therefore, we believe that from mid 1997 onwards it is reasonable to assume that profit-sharing was expected by the market to be a real possibility. Specifically, we take July 1, 1997, as the opening period for the expected change.

The regulators were negative about a shift to profit-sharing but it was clear that the government were not going to lay profit-sharing to one side. The formal Green Paper (Department of Trade and Industry, 1998a) in March 1998 explicitly favored the use of error correction mechanisms as 'an in-built means of sharing unearned benefits promptly between consumers and shareholders'. As always with statements of this type there are prior discussions between interested parties and the government as the ideas become concrete. Therefore, it is difficult to pin-point the exact date that the information showing that the government were fully committed to profit sharing entered the market. By January 1998 this was being reported widely in the newspapers, e.g., the Financial Times published an article 'Utilities brace for wind of change' indicating that discussions between the parties were not going as well for the companies as they would have liked.[12] Therefore, the strength of the government's intentions would be known many months before this. By February 1998 much of the debate focused on the practical details. For example, the Independent pointed out that 'it is not clear how much detail the Green Paper will contain on what constitutes 'excess' profit, how it would be taxed and what shareholders might be allowed to retain'.[13] On March 1st the Financial Times confirmed the view that profit-sharing would be introduced.[14] In late March 1998, referring to the proposed error correction mechanism, the Independent newspaper expressed concern that 'given the increased degree of political control over regulation which is evident elsewhere in the Green Paper, regulators may be tempted to reach for the mechanism too often'.[15]

The regulated companies were against profit sharing and lobbied to get the proposals overturned. Apparently the issue became a battle within the government, some of whom wished to pull back from the proposals because of the 'poor' signal it gave to the business community of the intentions of the government. The front page of the Financial Times in July 1998 claimed that the Prime Minister himself might intervene to prevent the government minister in charge of the Department of Trade and Industry from implementing the proposals. The article claimed that Tony Blair was 'set to veto proposals to force utilities to share windfall profits with consumers through changing the system of price regulation' and if correct 'the decision to scrap the long-standing Labour plan will be welcomed by the city'.[16] Later that month the Financial Times, referring to utility regulation, still claimed that 'the most controversial issue has been the long-standing Labour proposal to add some form of profit sharing to the existing inflation-minus-X price regulation formula'.[17]

Despite the pressure from the Prime Minister, when the proposals were brought forward again (Green Paper (Department of Trade and Industry 1998b)) the government still would not drop the idea of profit sharing. It did, however, dilute it to

[12] January 23, 1998.

[13] 'Utilities braced as Government plans new tax on excess profits', Independent, February 23, 1998.

[14] 'Beckett to propose profit cap in utilities shake-up', March 1, 1998.

[15] 'A mechanism for future errors: Outlook on proposals to regulate utilities', Independent March 26, 1998.

[16] 'Blair set to veto proposals on utilities' windfall profits', Financial Times, July 10, 1998.

[17] 'Utility chiefs face pay and service level link', Financial Times, July 27, 1998.

some extent. Specifically, the second Green Paper stated that regulators will be urged to consider the circumstances when companies made profit by good fortune, and hence when it might be appropriate to refine the price formula, and 'in such cases regulators would be expected to pass on to customers company profits made thanks to specific factors outside their control'.[18] After this second Green Paper the minister in charge of the Department of Trade and Industry was replaced with one more favorable to business and over time the debate on profit-sharing gradually dropped away. Formally, the relevant Utilities Bill entered Parliament for discussion at the start of 2000. The Utilities Bill received "Royal Assent" in July 2000 and contained no profit-sharing regulations. One could take this as the closing date of our 'treatment' period but this would be misleading. It was clear from the parliamentary debate before the Bill received "Royal Assent" that there would be no profit-sharing of any type. However, we would argue that it was obvious even before early 2000 that profit-sharing was no longer a genuine possibility.

We suggest that a critical date is August 12, 1999. On this date the detailed draft proposals for all the Regional Electricity Companies were simultaneously published (for final consultation). These proposals had no profit-sharing element in them at all and it has always been the case that, although the specific proposed prices may change from final proposal to implementation, the structure of regulation does not. That is, all the evidence on that date pointed to there being no profit-sharing for any of the electricity companies. Therefore, we believe, it is very difficult to argue that profit-sharing was still a likely outcome in the UK after this. For this reason we close the period of policy uncertainty with this date. Indeed, as we will see, the opening and closing dates for the profit-sharing period of July, 1 1997 and August, 12 1999 are confirmed by our results obtained using the Kalman filter approach.

The profit-sharing period is part of a longer period taken for the investigation. Specifically, we employ daily and monthly data on the companies from May, 1 1993 to December, 29 2000.[19] This gives 1938 log-returns at daily frequency for most companies. The starting and closing dates are chosen to balance off the desire to

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[18] Financial Times, July 28, 1998.

[19] All the time series are collected from DataStream and are dividend adjusted. In the case of monthly observations we use end-of-month log-returns.

include a long period of price-cap regulation (i.e., either side of the profit-sharing period) against the constraint of analyzing as many regulated companies as possible (mergers and breakups reduce the number of companies the longer the sample period adopted) while avoiding having a large number of companies in the sample that are in their immediate post privatization position. The construction of our samples is described in detail in the sub-sections 3.3 and 3.4.

3.3 The sample of regulated companies

The privatization program initiated by the Conservative government introduced over 30 public utility companies to the London Stock Exchange in the 1980s and early 1990s. However, many of these utilities have either been taken-over or merged since privatization.[20] As a result, only 22 companies are listed on the London Stock Exchange between May 1993 and December 2000.[21] Unfortunately, out of this group seven companies had to be removed from our analysis due to poor quality data. Six of these, all water companies, have been excluded due to insufficient data (these are extremely small companies suffering from thin trading making the data unsuitable for any statistical and time series analysis). The other is British Gas where there was a fundamental restructuring and separation.

The remaining 15 companies are controlled by price-cap regulation with the exception of PowerGen (PWG) and National Power (NPR). These two are regulated but do not face direct price controls. We have kept them in the sample as it could have been expected that the profit-sharing regime may to be applied to them directly if the Utility Review had increased the scope of regulation and then it would not be unreasonable to think that their potential profitability could be similarly affected, albeit indirectly, by these changes. Note, that all companies in the sample, save British Telecommunications (BT) and to a lesser extent the National Grid Company

[20] For example, of the original twelve regional electricity companies (RECs), none remain listed on the stock exchange in 2000.

[21] Among these 22 companies three were listed for a slightly shorter period of time (Viridian listed since June 18, 1993, National Grid Company listed since December 8, 1995 and Hyder delisted in October 2000) but were included to maintain sample size. Extending the overall sample period beyond December 2000 would further reduce the sample size.

(NGC), can be described as 'old economy'. BT is a clear outlier and we give a special attention to it and NGC when analyzing our findings.[22]

Table 1 shows the 15 regulated companies included in the sample, along with the code by which they will be referred to in the further analysis.

Table 1
Sampled Regulated Companies

Company	**Code**	**Main Business Area**
Anglian Water	AW	Water and Sewerage Company
BAA	BAA	Airport Services
BT	BT	Telecommunications
Hyder	HYR	Water and Sewerage Company
Kelda	KEL	Water and Sewerage Company
National Grid Company	NGC	Electricity Transmission and Telecommunications
National Power	NPR	Electricity Generation & Supply
Pennon	PNN	Water and Sewerage Company
PowerGen	PWG	Electricity Generation & Supply
Scottish Power	SPW	Electricity Generation & Supply
Scottish & Southern Energy	SSE	Electricity Generation & Supply
Severn Trent	SVT	Water and Sewerage Company
Thames Water	TW	Water and Sewerage Company
United Utilities	UU	Water and Sewerage Company
Viridian	VRD	Electricity Generation & Supply

3.4 The control sample

There is a potential problem in isolating the specific effects of the regulatory events since there may be other changes that could have affected the performance of regulated companies relative to the market. A particular concern in this regard is that the composition of the market changed towards the end of our sample period because e-business and related stocks became extremely significant. A particular feature of these stocks was that there was considerable uncertainty as to their long run position.

[22] NGC had placed a small telecommunications network around its electricity network and created a telecommunications company called Energis (within the quoted NGC business). In this sense NGC is on the border of 'old' and 'new' economy, given the relative size of the two components it tends to be closer to the former.

That is, they were more like options on underlying assets than is the case for conventional shares. This helped push up the returns on the stock market portfolio but also could have increased the risk of holding that portfolio. This may have manifested itself for many non high-tech companies as a fall in their beta. Since most regulated companies are traditional utilities they are likely to be 'old economy' type stocks and prone to any such effect. For this reason it is useful to create a control sample to attempt to eliminate any such effect.

A standard approach to create a control is to match individual firms with similar firms within the same sector. Clearly this option is not available here, since we are attempting to isolate effects that are specific to regulated sectors, so the control sample has to drawn across other sectors. There are various properties that we desire in the construction of the control sample. The control sample should not contain any regulated companies but should otherwise attempt to be representative of the general market save for the elimination of companies that may strongly benefit from any 'e-business' effect. However, in addition to being representative of the market, it would also be useful to make the control sample similar to the regulated sample in terms of number of firms, size of firms and leverage ratios. Inevitably there has to be some compromise between these demands.

In the UK there was, until 2003, a 30-company index (called FT30 index) that consisted of 30 companies which were chosen to be representative, as a group, of the UK economy. There is clearly an element of judgment required in identifying such a small number of companies as representative of the market. The FT30 was chosen by a committee and was sometimes criticized as an index because it consists of the view of the committee as to what they feel is representative rather than being objective, say, in the sense of the FTSE100 which is basically the largest one hundred companies on the market. However, this representative albeit subjective feature is exactly what we require in the index. We therefore use as our starting point for construction of the control sample the 30 FT30 companies at the end of our sample period.

We remove from this list all regulated companies and those that are likely to be directly affected by the new economy (namely companies in financial, electronic, information, communications and media sectors). Appendix 1 gives the list of companies and those that were eliminated. This leaves 18 companies in the control sample (compared to 15 in the regulated sample). The average capitalization at the start of our sample period was £4005m for the regulated sample and £5507m for the control sample. The regulated sample contains one company (BT) that is far larger than the others in the regulated sample. The control sample has two outliers (British Petroleum and Glaxo Wellcome are larger than others in the control sample). The average leverage for the first full year of the sample period was 0.10 for the regulated sample and 0.11 for the control sample. Section 4.2 closes with a discussion of the robustness of our results to the choice of the control companies and Section 5 shows that the properties of the control sample carry over to an equivalent US sample.

4. Empirical analysis: market model

4.1 Model selection and specification

Although addressed in many research papers, the best way of modeling an asset's exposure to risk remains in dispute. Historically, following the contributions of Sharpe (1964) and Lintner (1965), the CAPM approach was dominant for many years, with extensions developed in response to disparities between the theoretical CAPM predictions and corresponding empirical tests (e.g., Consumption CAPM (Breeden (1979)), the Intertemporal CAPM (Merton (1973)) and Arbitrage Pricing Theory (Ross (1976))). More recently a three-factor model has been considered by Fama and French (FF3F) (Fama and French, 1992, 1993). Fama and French (2003) provide an excellent survey of the CAPM and FF3F models. In this section we analyze the time-varying beta in a single factor market model and in Section 6 we consider the extent to which the FF3F model provides further insight.

The time-varying nature of CAPM betas has been reported[23] for more than 30 years but it is only last 15 years that there has been significant progress in the development of econometric techniques that enable the estimation of the time pattern of market

[23] For earlier studies see for example Blume (1975, 1979).

risk.[24] A particular issue is that the violation of NII assumptions in stock market returns focuses attention on the most suitable estimation technique and appropriate specification of the error generating process (in particular, the pattern of changes in volatility). In this paper we address the question of non-normal distribution of stock market returns and the changing character of beta coefficients by enriching the CAPM model with a GARCH(1,1) specification of the variance term and employing the Kalman filter technique to estimate the GARCH effects and the time paths of CAPM coefficients.[25]

For the purposes of this paper the use of the Kalman filter is more suitable than the switching-regression model. A primary reason is that, if we use the Kalman filter, we are not obliged to define the exact point of the switch. Instead, whether and when there is a change in the pattern of beta can be assessed after the regression results are revealed. This is particularly important when, as in our case, the timing of the change is well understood but is not unambiguously defined. A second benefit is that switching models are at best numerically demanding and in the case of short data periods are impossible to implement.[26]

We use the market model specification, i.e., we assume that, at any time t, the return on asset i, $R_{i,t}$, can be explained by the return on the market portfolio $R_{M,t}$:

$$R_{i,t} = \alpha_{i,t} + \beta_{i,t} R_{M,t} + \varepsilon_{i,t} \ , \tag{3}$$

where the error generating process $\varepsilon_{i,t} \sim N(0, \sigma_{i,t}^2)$ has a variance described as:

$$\sigma_{i,t}^2 = \theta_{i,0} + \theta_{i,1}\sigma_{i,t-1}^2 + \theta_{i,2}\varepsilon_{i,t-1}^2. \tag{4}$$

[24] There are now many such papers, e.g., Ball and Kothari (1989), Black et al (1992), Bollerslev et al (1988), Braun et al. (1995), Ng (1991), Schwert and Seguin (1990) among others. Studies on the time-varying nature of the factor loadings in the FF3F model can be found, for example, in Bollerslev and Zhang (2003), and Lettau and Ludvigson (2001).

[25] We also tested for a stochastic time trend but do not report it in the paper since it was not detected. The results can be obtained from the authors on request.

[26] This is particular problem for the FF3F analysis in Section 6 since the last two sub-periods, i.e., the profit-sharing period and post profit-sharing period, count for 25 and 17 monthly observations respectively. Bearing in mind that a Markov switching model even with just a mean and a variance would require the definition of four states, and a transition matrix containing 12 independent elements, the Kalman filter appears the best solution.

The time-varying coefficients, $\alpha_{i,t}$ and $\beta_{i,t}$ constitute a state vector in the state-space representation of the Kalman filter. Denoting the value of the state vector at time *t* by $a_{i,t}$ (i.e., $a_{i,t} = [\alpha_{i,t}, \beta_{i,t}]'$), we complete the state-space model by defining the state equation as

$$a_{i,t} = a_{i,t-1} + \eta_{i,t}, \tag{5}$$

where $\eta_{i,t}$ is a 2x1 vector of serially uncorrelated disturbances with zero mean and covariance matrix *Q*.[27] The random walk specification implies a filter on the data in which parameters evolve smoothly and are mostly determined by the observations around time *t*. How much data around time *t* is used for estimation of the coefficients, (i.e., α_t and β_t) depends on the variance of η_i and is estimated from the data. The specification is therefore well suited for depicting the likely evolution of market risk.

The above state-space specification requires the estimation of six unknown parameters before the time paths of α_t and β_t can be calculated using the Kalman filter algorithm. These six parameters are: the three θ parameters of equation (4), the two diagonal element of matrix *Q*, and the initial value of the variance of the disturbance term in equation (4). However, it is more convenient for the initial value of the disturbance term to be concentrated out of the likelihood function and subsequently found after the values of the remaining five unknown parameters are obtained after maximization of the corresponding concentrated likelihood function (e.g., see Harvey (1996)). Finally, a fixed-interval smoothing algorithm is applied.

In addition to the above specification we also used, but do not present, the CAPM specification as our measurement equation, i.e.,

$$R_{i,t} - r_{f,t} = \beta_{i,t}\left(R_{M,t} - r_{f,t}\right) + \varepsilon_{i,t},$$

[27] In fact, to express the above system in the state-space representation of the Kalman Filter the state vector should have three elements: the two already mentioned stochastic parameter of the measurement equation and a deterministic element to represent the variance of the error term, σ_t^2. To conduct the calculations we adopt the technique (and the programme) of parameter estimation introduced in Zalewska-Mitura and Hall (1999).

where the state vector is defined as $a_{i,t} = [\beta_{i,t}]$ and its corresponding disturbance term $\eta_{i,t}$ is normally distributed with zero mean and variance q. Although the latter representation has the slight advantage of reducing the number of the parameters to be estimated to five (we do not need to estimate the variance for the equation of the constant term $\alpha_{i,t}$), a choice has to be made concerning the proxy for the risk free rate of return. In our analysis we used both 10 year and 15 year T-bonds as proxies for the risk free rate.[28]

The estimated time paths of the state vector components are virtually identical whether 10 or 15 year T-bonds are used. They are also twin-similar to the time paths estimated for the market model representation specified in equation (3). The only difference, itself small, between the CAPM and market model estimates is in the GARCH effects. Since the main results are the same for all time series specifications we only present the market model here (as specified by equation (3)). Furthermore, since the time paths estimated for the constant term were both virtually zero and insignificantly different from zero in all regressions we report time paths of the beta coefficient only.

As explained in Section 3 we have a sample of 15 regulated companies and a control sample of 18 companies. To test for the difference in the behavior between these two groups we create two (equally weighted) portfolios, one for the regulated sample and one for the control sample. Note that because the CAPM beta is additive, estimating betas for a portfolio is equivalent to estimating our model for each company separately and then averaging the betas. However, the portfolio estimate has an advantage over the average of the individual estimates in that it automatically provides confidence intervals for the estimated time paths. Therefore, we perform our analysis on an equally weighted portfolio of regulated companies and an equally weighted portfolio of control sample companies as dependent variables. In the remainder part of the paper, to simplify the notation, we refer to the time paths estimated for the portfolio of the regulated companies as the ‘regulated beta’ and to the time paths estimated for the portfolio of the control sample companies as the

[28] Our decision to use long term T-bonds, rather than T-bills, as a risk free rate of return was based on the notion that they may better match investment horizons of companies.

‘control beta’. The market portfolio, R_M, is represented by the log-returns on the FTSE All Share index.

The choice of data frequency requires some discussion. As indicated, we use daily observations in this section of the paper. There are advantages in using daily as opposed to lower frequency of the data, i.e., weekly or monthly. First, using daily observations we operate on 1937 data points. 536 of these come from the period we select as the period when profit-sharing was expected (referred to throughout as the profit-sharing period), 349 data points represent the post profit-sharing period and the remaining 1052 data points represent the pre profit-sharing period. This is a considerable amount of data to estimate time paths for both samples. Weekly data also generate a significant amount of data but would be worth doing only if the underlying properties of the time series were more ‘normal’ than in the case of the daily observations. This is not the case so we reject weekly data. Monthly data are more ‘normal’ than daily and weekly data but does not provide sufficient data points to conduct a comprehensive time-varying analysis. In particular, we cannot analyze the latter two sub-periods as separate samples (there are just 25 and 17 observations for the profit-sharing and post profit-sharing period, respectively).[29] We use daily data in this section and monthly data in Section 6. Our decision to limit the analysis to monthly frequency is dictated by the frequency at which additional factors for FF3F model are available.

Finally, it is important to explain how we test for significance of our results. We have explained in Sections 2 and 3 that we expect differences in risk between our two samples during the profit-sharing period, i.e., between July 1, 1997 and August 12, 1999. Although, the fundamental properties of our samples may be different between the pre profit-sharing period (May 1, 1993 – June 30, 1997) and the post profit-sharing period (August 13, 1999 – December 31, 2000), these differences should be similar for the regulated and the control portfolios. In other words, if profit-sharing is a central driving force of the differences between samples, then differences in risk, if any, between the samples should be constant when this factor is absent, although the

[29] At a monthly level Kolmogorov-Smirnov test rejects normality for HYR (at a 10% level) and TW (at a 5% level). In the case of daily and weekly observations the rejection of normality is at 1% for all time series in our study.

level of risk itself may have changed. More precisely, if $R_{reg,t}$ denotes the return on the regulated portfolio, and $R_{c,t}$ is the return on the control portfolio at time t, and it is true that

$$R_{reg,t} = \alpha_{reg,t} + \beta_{reg,t} R_{M,t} + \varepsilon_{reg,t} \tag{6}$$

and

$$R_{c,t} = \alpha_{c,t} + \beta_{c,t} R_{M,t} + \varepsilon_{c,t}, \tag{7}$$

then the difference between the return on the regulated portfolio and the return on the control portfolio can be explained as a function of the market portfolio return:

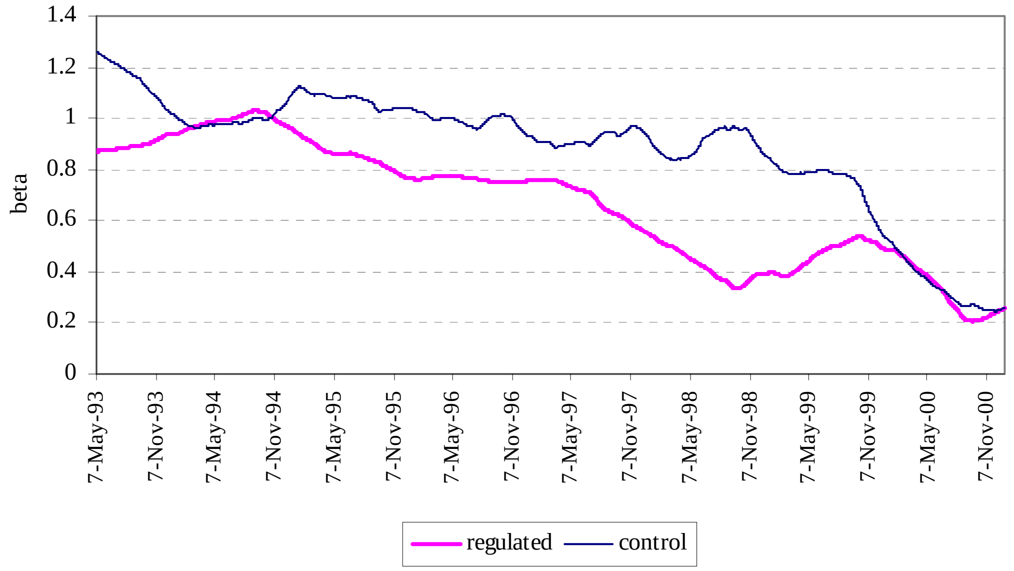
$$R_{reg,t} - R_{c,t} = \alpha_{diff,t} + \beta_{diff,t} R_{M,t} + \varepsilon_{diff,t}, \tag{8}$$

where $\alpha_{diff,t} = \alpha_{reg,t} - \alpha_{c,t}$, $\beta_{diff,t} = \beta_{reg,t} - \beta_{c,t}$, and $\varepsilon_{diff,t} = \varepsilon_{reg,t} - \varepsilon_{c,t}$. We estimate equation (8) using the state-space representation as introduced in equations (3)-(5). The difference in the betas should be greater during the profit-sharing period than in the other periods. It is important to note that a random walk specification of equation (5) for both α and β coefficients is still valid for the 'difference' equation (8).

4.2 Kalman filter estimation results

Figure 1 presents the time paths of the betas estimated for the portfolios of the regulated (thick line) and the control (thinner line) samples. It is apparent that the greatest disparity between the two estimated paths of market risk is in the period from mid 1997 to mid 1999. The regulated and control curves start closely together with the regulated curve below the control one. There is a sharp drop in the curve for the regulated companies around mid 1997 to mid 1999. However, the recovery in regulated betas is limited and the regulated and control curves converge at the end of the sample. The values of betas are lower at the end of the full sample period than at the beginning. Although the cause of this decline is not an issue in itself for the results of the paper (since the hypothesis relates to the difference between the samples) we speculate that this latter effect, common to both the regulated sample and the control sample, is the result of a relative decrease of risk of the ‘old economy’ due to the emergence of e-business.[30]

Figure 1. Regulated and control portfolios' beta coefficient



Although the regression results show a clear pattern in the evolving character of the β_t coefficient, the timing of the changes does not appear to strictly match the approximate dates when the debate on regulatory changes started and ended. One might get an impression that the profit-sharing period had started already in early 1997 and ended in late 1999. This deception comes from the smoothing character of the Kalman filter estimates, which causes a soft bending of the regression line when linking low values of the betas of the middle part of the graph with the higher values estimated for the beginning and end of the sample. Due to the smoothed character of the estimated β_t coefficient, it is difficult to provide precise timing for the commencement of the drop in the average beta for the regulated companies. To address the issue we divide the sample period into three disjoint sub-periods using the dates discussed in Section 3.2:

1) Pre profit-sharing period: May, 1 1993 – June, 30 1997. If our hypothesis is true, both regulated and control samples should exhibit a similar pattern (save

[30] A similar effect will be reported for the US market in Section 5.

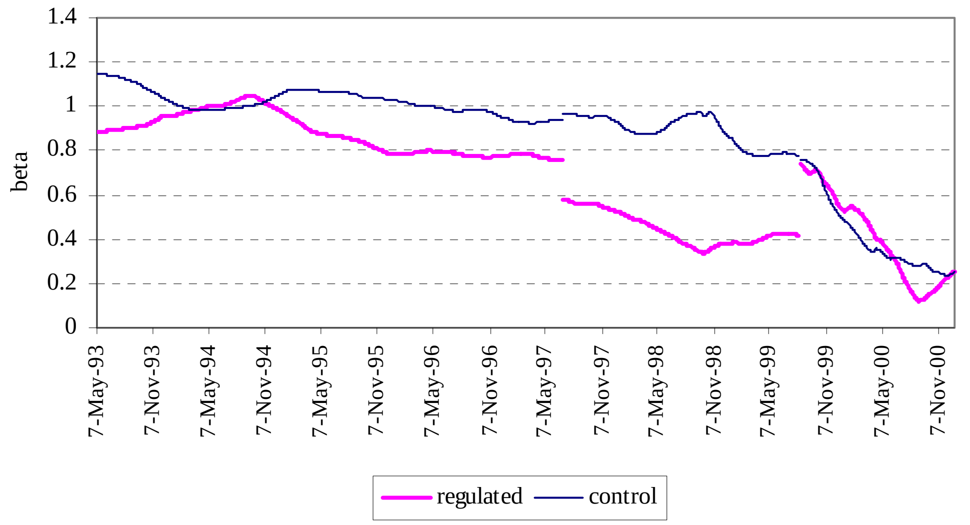
that the betas of the regulated sample may be slightly lower than the betas of the control sample).

2) Profit-sharing period: July, 1 1997 – August, 12 1999. The time path estimated for the regulated sample in this period should be significantly below the time path estimated for the regulated sample in the pre profit-sharing period. This should not be the case for the control sample.
3) Post profit-sharing period: August, 13 1999 – December, 31 2000. The relative risk for the regulated and the control sample should be similar to that observed in the pre profit-sharing period. However, because this period covers the period of the e-business effect, we conjecture that the absolute values may be below the values estimated for the first sub-period.

Figure 2 presents time paths of the betas estimated for the portfolios of the regulated (thick line) and the control (thinner line) samples for each of the sub-periods separately. We plot the results of the six regressions (i.e., three sub-periods for each of the two portfolios) on one graph to give a better comparison with the results presented in Figure 1. The pre and post profit-sharing periods exhibit considerable similarity between the regulated and control samples.

Considering the control sample first, it is clear that, although the time paths for the control betas come from three independent regressions, the plots look very much like the time path obtained from the regression using all the data points for the period 1993-2000 at once (i.e., Figure 1). In particular, there is almost no discontinuity when moving between sub-periods. That is, although none of the information from the first and third sub-periods is used to derive the beta of the middle period and similarly, none of the information of the middle period is used to derive the betas of the first and third sub-periods, there is almost no difference between the end of each time period and the start of the next. This suggests that there is no change in the underlying process that generates the data of the control sample around the critical dates. However, the situation is very different when we come to the regulated sample. The profit-sharing betas display substantial diversity. There is a large discontinuity in the regulated beta between the sub-periods. This indicates that there is a substantial change in the underlying process that generates the data of the regulated sample during the profit-sharing period.

Figure 2. Regulated and control portfolios' beta coefficients estimated for sub-periods



As explained in Section 4.2, to have a complete comparison between the two samples and across time we estimate time paths of the constant term and the beta coefficient for the difference of returns between the regulated portfolio and the control portfolio (i.e., equation (8)). The $\alpha_{diff,t}$ coefficient is virtually zero and shows almost no variability. Its values vary between 0.0000609 and 0.0000619, and stay within the 95% confidence intervals of approximately (-0.00029, 0.00042). However, the time path of the $\beta_{diff,t}$ coefficient shows a very different pattern. Figure 3 presents the time path of the $\beta_{diff,t}$ coefficient (thick line) and 95% confidence intervals (thinner lines). It is clear that during the profit-sharing period the difference in market risk between the two samples in question is significantly different from zero. In contrast, the $\beta_{diff,t}$ coefficient in both the period before and after the regulatory debate is not statistically different from zero.[31] This result is confirmed when coefficients of equation (8) are estimated for each of the three sub-periods independently. The results are presented in Figure 4. The most dramatic jump in the betas is observed between the profit-sharing and the post profit-sharing sub-periods. The time path for the last sub-period displays much smaller fluctuations than the time paths estimated for the other two sub-periods.

[31] We have repeated this whole exercise on weekly data and found no differences in results.

Figure 3. Beta coefficient for the difference in returns between the regulated and the control portfolios

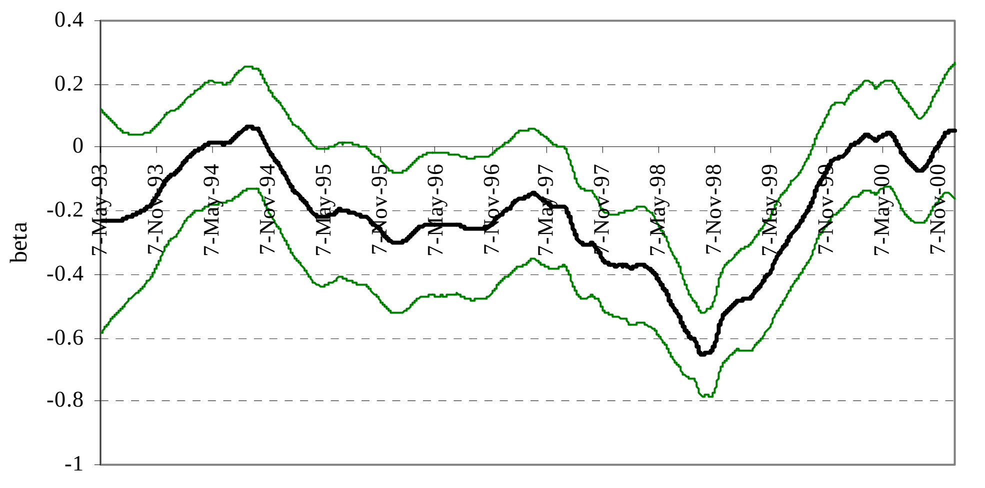
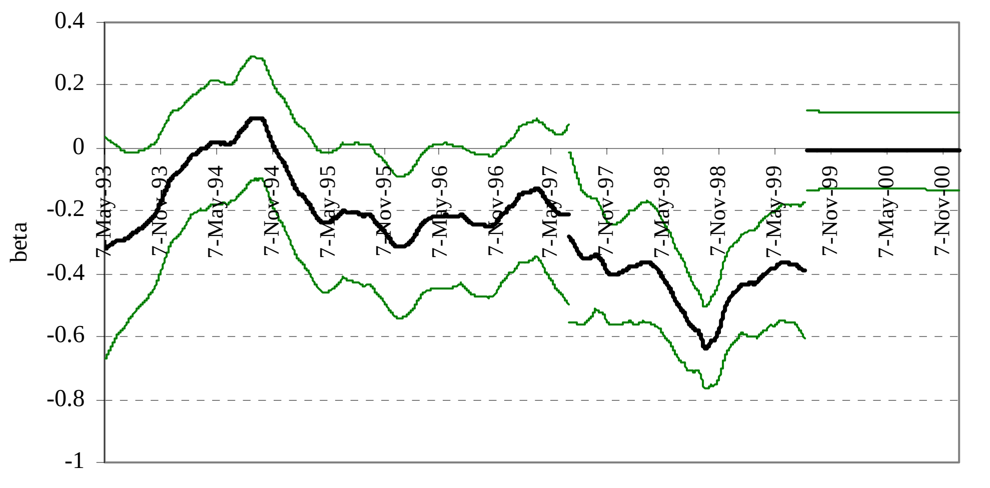


Figure 4. Beta coefficient for the difference in returns between the regulated and the control portfolios estimated for sub-periods



The above results are conducted on the regulated and control samples but we also wish to observe the phenomena for individual companies both to ensure that it is present at the disaggregated level and to identify any companies that may exhibit different trends. The latter point is important since there are some differences between companies in the regulated sample. In particular, telecommunication companies (i.e., BT and to a lesser extent NGC) may exhibit a different pattern over time, since they could be affected by the e-commerce bubble in a different way to the remaining companies in the sample.

The analysis at a company level is performed using equation (8) as the measurement equation when $R_{reg,t}$ represents the return at time t for an individual regulated company rather than the return on the equally weighted portfolio of all the regulated companies included in the study. The comparator, $R_{c,t}$, remains the equally weighted average return for the control sample at time t. The estimated time paths can be found in Appendix 2.[32]

There is a strong pattern (i.e., larger difference in systematic risk between the company and the control sample during the profit-sharing period) for all companies but one company in the sample. That is, the results obtained with the regulated sample are confirmed at the company level analysis. The outlier is NGC. However, the 'anomaly' of NGC could have arisen because the pre profit-sharing period estimates are based on a period when NGC was newly listed. Therefore, the NGC results may be driven by strong company-specific factors. Both BT and NGC exhibit a relative increase in their systematic risk in the post profit-sharing period. This is consistent with the fact that both companies (BT as a whole, and NGC partly) are telecommunication services providers and hence would be affected by the e-commerce bubble in a different way to other regulated companies. Finally, BAA is the only company that displays weak support for a fall in beta during the profit-sharing period. Even here the company has lower values of the beta coefficient in the profit-sharing period but this difference is not significant.

Appendix 3 presents GARCH equations estimated for the regulated portfolio, the control portfolio, and the difference of returns between them. It is apparent that several of the time series manifest strong heteroskedasticity.

Finally, to complete this section it should be mentioned that the results remain unaffected when the control sample is divided into subgroups. To create divisions with the maximum difference (i.e., four companies shift groups) we first cut the control sample 'randomly' by taking the first and then the latter half of the sample

[32] We have also estimated sub-period time paths for all fifteen regulated companies. The results for sub-period were very similar and even stronger than the results obtained from regressions for the whole period 1993-2000 (similar comparison as Figures 3 and 4). Due to the space shortage, we present the 'whole period' regressions only. However, the results obtained for the sub-periods can be obtained from the authors on request.

when ranked alphabetically and then repeat the process by cutting the control sample into the largest and smallest companies according to market capitalization (in December 2000).[33] The divisions do not affect our results, i.e., all the differences between the regulated portfolio and the sub-samples of the control portfolio are significant at 5% within the profit-sharing period (see Appendix 4 for figures equivalent to Figure 3).

4.3 OLS WHC and ML with GARCH(1,1) estimation results

To complete our discussion of the differences in systematic risk between the regulated and the control samples and to obtain some feel for the significance of these effects we also adopt a more traditional approach and assume that, save for the specific changes being investigated here, the betas are fairly constant over sub-periods (indeed, this is true to different degrees for the above defined sub-periods). In this case it is possible to introduce a 'profit-sharing' dummy, D_{ps}. D_{ps} takes the value 1 between July, 1 1997 and August, 12 1999, otherwise 0. The analysis is conducted on the returns on the regulated portfolio, on the difference between the return of the regulated and the control sample portfolio, and on the differences between the returns for individual regulated companies and the return of the portfolio of the control sample.

More precisely, the regression takes the form:

$$R_{reg,t} = \alpha + \alpha_{ps} D_{ps} + \beta R_{M,t} + \beta_{ps} D_{ps} R_{M,t} + \varepsilon_t ,$$

or

$$R_{Ireg,t} - R_{c,t} = \alpha + \alpha_{ps} D_{ps} + \beta R_{M,t} + \beta_{ps} D_{ps} R_{M,t} + \varepsilon_t ,$$

where $R_{Ireg,t}$ refers either to the return on the portfolio of the regulated sample, $R_{reg,t}$, or the return on one of the regulated companies (denoted later by an individual company code). Estimates are obtained using OLS WHC and ML GARCH(1,1). We need to use OLS to have a consistent comparison of the monthly and daily results

[33] We do not provide the results of regressions on the difference between the regulated sample and each individual company in the control sample since this requires eighteen graphs.

(ML analysis is not possible for the lower frequency data due to the small sample size). However, ML GARCH(1,1) is used to give a comparison of results of the time-varying and time-invariant models applied to daily data.

Table 2 gives the OLS WHC and the ML GARCH(1,1) results when the difference between the returns of the regulated and control portfolios, and when the returns on the regulated portfolio are used as a dependent variable. Tables 3 and 4 give the results for the OLS WHC and ML GARCH(1,1) using the difference between the returns of individual companies and the returns of the control sample. The profit-sharing dummy, β_{ps}, in Table 2 is significant at 1% both with OLS and ML regressions and has the correct sign. Similarly, the profit-sharing dummy is significant at 1% for almost all the companies in Tables 3 and 4. This is strong confirmation that the regulatory change has had the predicted effect on market risk.

If the market model is the correct empirical specification then profit-sharing will have an effect on β not α. If the market model is a proxy for the CAPM then there should in theory be an effect on α but the value of α_{ps} and α should be miniscule relative to β_{ps} and β. Either way any effect we can observe on α_{ps} and α should be minute relative to any effect on β. This is exactly what we find in Tables 2, 3 and 4.

Table 2
Regression results with the profit-sharing dummy (daily observations)
(standard errors in parenthesis;* -significance at 10%,** - significance at 5%; *** - significance at 1%)

		Equation coefficients				***GARCH effects***		
Dependent Variable		α	α_{ps}	β	β_{ps}	θ_0	θ_1	θ_2
OLS WHC	$R_{reg,t}$- $R_{c,t}$	-0.000 (0.000)	0.000 (0.000)	-0.056 (0.037)	-0.416*** (0.055)			
	$\boldsymbol{R_{reg,t}}$	-0.000 (0.000)	0.000 (0.000)	0.638*** (0.038)	-0.208*** (0.049)			
ML GARCH(1,1)	$R_{reg,t}$- $R_{c,t}$	0.000 (0.000)	0.001 (0.000)	-0.112*** (0.028)	-0.325*** (0.037)	0.000*** (0.000)	0.829*** (0.019)	0.112*** (0.013)
	$\boldsymbol{R_{reg,t}}$	0.000 (0.000)	0.000 (0.000)	0.727*** (0.030)	-0.268*** (0.043)	0.000*** (0.000)	0.860*** (0.031)	0.099*** (0.023)

Table 3
Results for the OLS regressions with the profit-sharing dummy (company level)
(White HC standard errors in parenthesis;* -significance at 10%,** - significance at 5%; *** - significance at 1%)

$R_{Ireg,t}$	α	α_{ps}	β	β_{ps}
AW	-0.000 (0.000)	0.000 (0.001)	-0.165** (0.077)	-0.550*** (0.103)
BAA	-0.000 (0.000)	0.000 (0.001)	-0.114* (0.067)	-0.084 (0.091)
BT	-0.001* (0.000)	0.002* (0.001)	0.677*** (0.101)	-0.437*** (0.132)
HYR	-0.000 (0.001)	-0.000 (0.001)	-0.248** (0.111)	-0.520*** (0.123)
KEL	0.000 (0.001)	-0.001 (0.001)	-0.251** (0.101)	-0.516*** (0.125)
NGC	0.000 (0.001)	0.001 (0.001)	-0.223** (0.105)	-0.484*** (0.132)
NPR	-0.000 (0.001)	-0.001 (0.001)	0.054 (0.129)	-0.410*** (0.159)
PNN	-0.000 (0.000)	0.001 (0.001)	-0.400*** (0.090)	-0.369*** (0.102)
PWG	0.000 (0.000)	-0.001 (0.001)	-0.031 (0.080)	-0.413*** (0.113)
SPW	-0.000 (0.000)	-0.001 (0.001)	0.116* (0.067)	-0.440*** (0.099)
SSE	0.000 (0.000)	0.001 (0.001)	-0.060 (0.075)	-0.553*** (0.104)
SVT	-0.000 (0.000)	0.000 (0.001)	-0.143** (0.073)	-0.434*** (0.100)
TW	0.000 (0.000)	0.000 (0.001)	-0.195** (0.078)	-0.197* (0.110)
UU	-0.000 (0.000)	0.000 (0.001)	0.090 (0.068)	-0.498*** (0.103)
VRD	0.000 (0.000)	0.000 (0.001)	-0.318*** (0.058)	-0.407*** (0.082)

Table 4
Results for the ML GARCH(1,1) regressions with the profit-sharing dummy (company level)
(standard errors in parenthesis;* -significance at 10%,** - significance at 5%; *** - significance at 1%)

	Equation coefficients				***GARCH effects***		
$R_{Ireg,t}$	α	α_{ps}	β	β_{ps}	θ_0	θ_1	θ_2
AW	0.000 (0.000)	0.001 (0.001)	-0.238*** (0.054)	-0.386*** (0.070)	0.000*** (0.000)	0.923*** (0.008)	0.063*** (0.007)
BAA	0.000 (0.000)	0.000 (0.001)	-0.029 (0.042)	-0.148** (0.067)	0.000*** (0.000)	0.925*** (0.006)	0.071*** (0.007)
BT	-0.001* (0.000)	0.002*** (0.001)	0.233*** (0.049)	-0.075 (0.085)	0.000*** (0.000)	0.944*** (0.006)	0.058*** (0.006)
HYR	0.000 (0.000)	0.000 (0.001)	-0.465*** (0.047)	-0.286*** (0.060)	0.000*** (0.000)	0.849*** (0.008)	0.134*** (0.007)
KEL	0.000 (0.000)	0.000 (0.001)	-0.323*** (0.058)	-0.385*** (0.077)	0.000*** (0.000)	0.888*** (0.010)	0.093*** (0.008)
NGC	0.000 (0.000)	0.001 (0.001)	0.084 (0.070)	-0.340*** (0.085)	0.000*** (0.000)	0.918*** (0.007)	0.062*** (0.006)
NPR	0.000 (0.000)	0.000 (0.001)	0.042 (0.052)	-0.342*** (0.080)	0.000*** (0.000)	0.649*** (0.015)	0.319*** (0.011)
PNN	-0.001*** (0.000)	0.001*** (0.000)	-0.639*** (0.031)	-0.052 (0.049)	0.000*** (0.000)	0.670*** (0.011)	0.424*** (0.013)
PWG	0.000 (0.000)	-0.001 (0.001)	-0.146*** (0.052)	-0.227*** (0.070)	0.000*** (0.000)	0.905*** (0.010)	0.077*** (0.008)
SPW	0.000 (0.000)	0.001 (0.001)	0.008 (0.054)	-0.334*** (0.084)	0.000*** (0.000)	0.907*** (0.010)	0.079*** (0.008)
SSE	0.000 (0.000)	0.001 (0.001)	-0.219*** (0.051)	-0.417*** (0.067)	0.000*** (0.000)	0.937*** (0.007)	0.059*** (0.006)
SVT	0.000 (0.000)	0.000 (0.001)	-0.146*** (0.057)	-0.393*** (0.078)	0.000*** (0.000)	0.971*** (0.004)	0.025*** (0.003)
TW	0.000 (0.000)	0.001 (0.001)	-0.186*** (0.048)	-0.144** (0.058)	0.000*** (0.000)	0.676*** (0.024)	0.226*** (0.013)
UU	0.000 (0.000)	0.000 (0.001)	0.024 (0.058)	-0.455*** (0.075)	0.000*** (0.000)	0.955*** (0.007)	0.036*** (0.005)
VRD	0.000 (0.000)	0.001 (0.001)	-0.360*** (0.037)	-0.365*** (0.060)	0.000*** (0.000)	0.698*** (0.029)	0.096*** (0.014)

We have not presented adjusted R-squared statistics. Most regressions are calculated on the differences between the returns on two portfolios or on the difference between company returns and the returns of the control portfolio. Since the difference in beta of the two portfolios (save for the profit-sharing period) is assumed to be constant regardless of the market portfolio return the R-squares are likely to be low. The R-squared for most regressions using differences is between 5% and 10% as expected. In the case of regressions using the returns on the regulated portfolio as a dependent variable the adjusted R-squared is 26%.

5. International comparison and leverage effects

The effects reported in Sections 4.2 and 4.3 are strong. Although the timing of the decline in market risk is aligned with the profit-sharing debate, it is important to show that it cannot be attributed to other factors such as a change in worldwide conditions or a change in the debt structure of the analyzed companies. To address this issue we provide a comparison of the time paths of market risk for comparable portfolios in the UK and US (Section 5.1) and show that the decline in market risk during the profit-sharing period is not observable on the US market, therefore, it is not caused by a worldwide phenomenon. Further, in Section 5.2 we discuss changes in the debt structure of the companies and show that they cannot explain different time paths of market risk for the two portfolios.

5.1 US and UK comparison

The aim of this subsection is to draw a comparison with the US market to control for changes in supply and demand conditions (worldwide) that may impact on companies but are unrelated to the regulation of ownership structure inside the UK.

During the full sample period there are two changes that we observe in the estimated risk of the portfolios. The first fall in market risk of the regulated portfolio (but not the control portfolio), occurring between July 1997 and August 1999 and attributed to the regulatory debate, intensified during that time. The second decline in the estimated values of market risk occurs in the post profit-sharing period, i.e., between later 1999 and December 2000. This change is present in both the regulated and the control portfolios. We have conjectured that this is a result of the e-commerce 'bubble'. If our interpretation of the observed UK phenomena is correct then, when replicating our analysis on comparable US data, (i) we should not expect to observe any discrepancy between equivalent US portfolios during the profit sharing period but (ii) we should observe a decline in the estimates of beta for both groups of companies after 1999 since the companies in the US should not be exposed to any change in the regulatory regime but should display similar sensitivity to the e-commerce 'bubble'.

To construct comparable UK and US samples we use DataStream (DS) sector indexes. We approach the problem in two steps. First, we take DS sector indexes for the UK that match the UK regulated and the control samples. Then we select the equivalent US-DS indexes. To construct the UK-DS regulated portfolio the Water, the Electricity and the Telecom Fixed Line DS indexes are used.[34] The regulated portfolio also includes BAA (an airports company) so there might be an argument for the inclusion of the Airline and Airports index (which includes BAA) in the UK-DS regulated portfolio. However, the Airlines and Airports index also includes BA, a company that is in our control portfolio. We exclude the Airline and Airports index from the UK-US and US-DS regulated portfolios but include it in the UK-DS and US-DS control portfolios for two reasons. One is that the UK Airline and the Airports Index contains six other (non-regulated) companies. The second is that the corresponding Airline and Airports index calculated for the US market does not contain any airports. The regulated and control portfolios (based on individual companies) used throughout the paper are equally weighted. We weigh the constituent indexes in the UK-DS and US-DS regulated portfolios to reflect the distribution of companies in the regulated sample. That is, because there are seven water companies, six electricity companies and one telecom company in the regulated portfolio (see Table 1), the weights allocated to the corresponding UK-DS and US-DS regulated portfolios are $7/14$, $6/14$ and $1/14$ respectively.

[34] To avoid confusion, given that we have six portfolios, we use the following terminology throughout this subsection. The regulated and control portfolios defined in Section 3.3 and 3.4 are still called the regulated and control portfolios (or samples). Their equivalents based on the DS sector indexes will be called the UK (or US)-DS regulated and the UK (or US) -DS control portfolios (or samples). Note, we use the terminology UK-DS (or US-DS) regulated although not every company in these 'regulated' portfolios are directly price regulated.

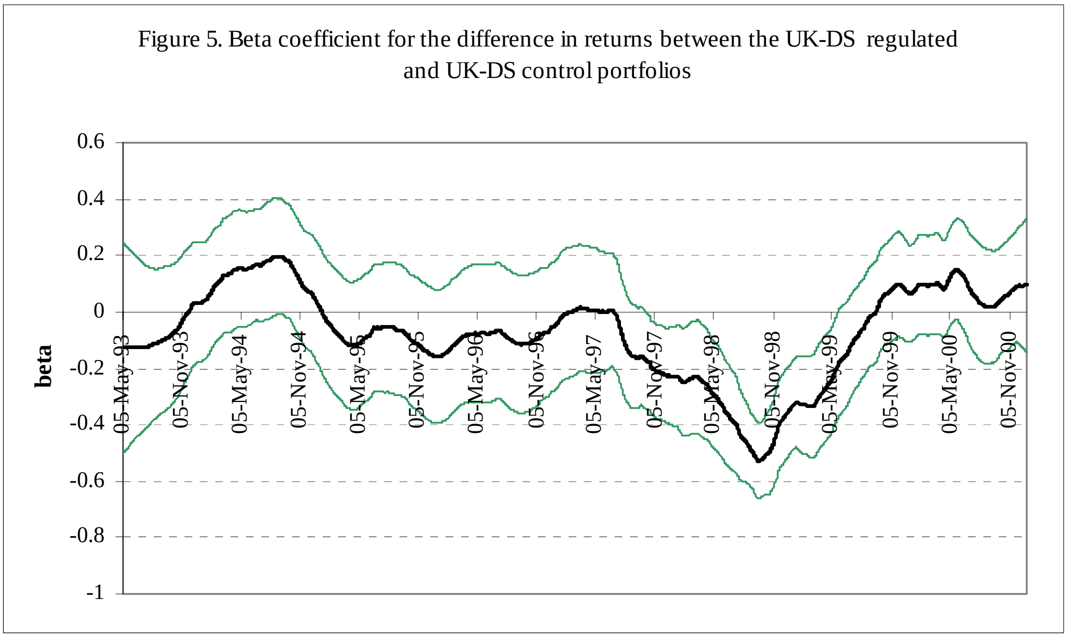
The UK-DS control portfolio consists of thirteen sector indexes. They are chosen to match sectors of individual control portfolio companies. Each control portfolio company belongs to one DS index only. However, the Distillers and Vintners Index, Chemicals Index, Food Producers and Processors Index, Pharmaceuticals Index and Retailers-Department Index contain two companies each from the control sample. The list of the indexes selected for the portfolios is presented in Table 5. The 13 indexes in the UK-DS and US-DS control portfolios are equally weighted.

Finally, for both markets DS Total Market Indexes are used as the market portfolios. The UK sample consists of 1938 daily observations and the US sample contains 1939 daily observations.

Table 5
Constituents of the DS-UK and the DS-US portfolios

Regulated portfolio indexes	**Control portfolio indexes**
Water	Airline and Airports
Electricity	Aerospace Defense
Telecom Fixed Line	Auto-Parts
	Chemicals
	Construction and Building Materials
	Distillers and Vintners
	Food Producers and Processors
	Food and Drug Retailers
	Oil Integrated
	Pharmaceuticals
	Retailers-Departments
	Shipping and Ports
	Leisure and Hotels

Figure 5 shows the estimates of the time path of the $\beta_{diff,t}$ coefficient for the UK-DS portfolios. This is the UK-DS equivalent to Figure 3. Figure 5 and 3 display almost identical patterns.



To show changes taking place on the US market and to provide a comparison with the changes occurring in the UK we present two graphs for the US-DS portfolios. Figure 6 shows time paths of the β_t coefficient estimated for the US-DS control portfolio (thick line) and for the UK-DS control portfolio (thinner line).[35] The UK-DS and US-DS control portfolios have very similar time paths of the β_t coefficient. The similarity is present both in the level during the first two sub-periods and decline during the final period (i.e., the post-profit sharing period).

Figure 7 presents the time path of the $\beta_{diff,t}$ coefficient estimated for the US-DS portfolios, i.e., the US equivalent to Figure 5. The presented pattern of the $\beta_{diff,t}$ coefficient is very different from the one presented for the UK-DS portfolios. In particular, there is no decline in the $\beta_{diff,t}$ coefficient between 1997 and 1999.[36] This indicates that the observed decline of market risk for the regulated portfolio and the UK-DS regulated portfolio is a UK phenomenon. Note, that at the end of the investigated period the difference between the betas of the US-DS regulated and the

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[35] Because the time series of US–DS portfolio is one data point longer than the UK–DS portfolio time series, for presentational purposes we deleted the first estimated US-DS beta.

[36] The slight, insignificant deepening in the beta time path observed in the second half of 1998 is smoothed out when August observations are removed from the data. As the implications of the Asian and Russian financial crises at that time are not the core of this paper we do not discuss this finding further. The deletion of August 1998 observations from the UK data does not change the results.

US-DS control portfolios narrows. The decline in the market risk of the US-DS control portfolio (from the average value of about 0.8 to values around 0.3-0.4 towards the end of the period (see Figure 6)) is matched by a similar but slightly more moderate decline in the risk of the US-DS regulated portfolio.

Figure 6. Beta coefficient for the UK-DS and US-DS control portfolios

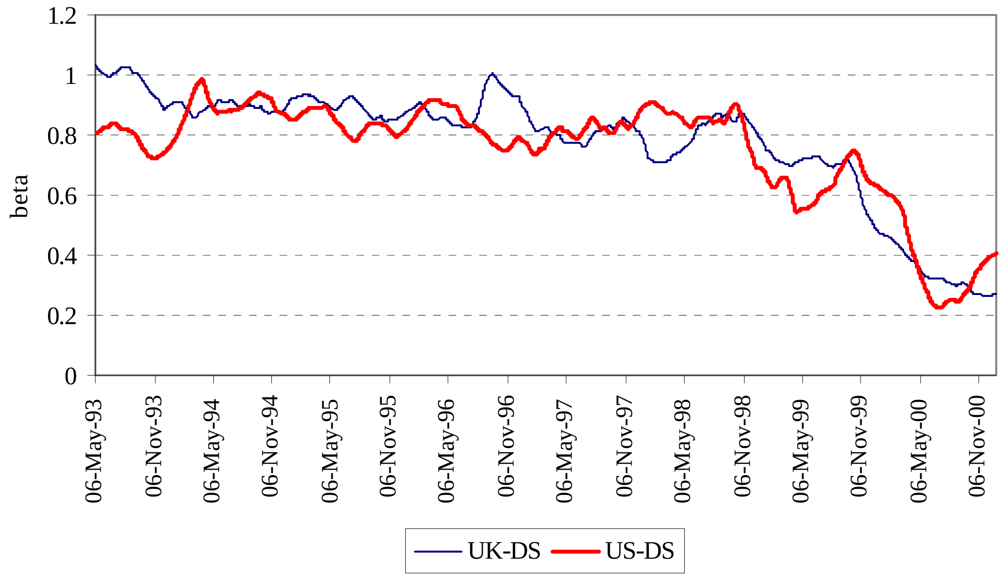
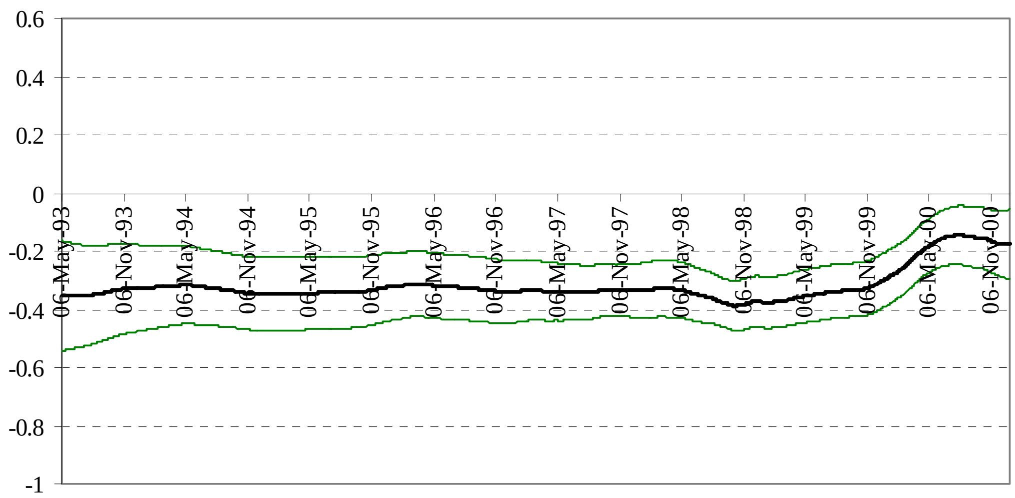


Figure 7. Beta coefficient for the difference in returns between the US-DS regulated and US-DS control portfolios



In summary, we find that the changes identified in the risk of the regulated portfolio and the UK-DS regulated portfolio are not matched by changes in the risk of the US-

DS regulated portfolio in the profit-sharing period. That is, the changes we have identified are not caused by changes in worldwide conditions.

Furthermore, Figures 6 and 7 show the robustness of the drop in risk of the selected 'old-economy' stocks in the period 1999 - 2000. All six portfolios (drawn across the UK and the US companies) display a similar pattern of decline. This paper is concerned with isolating and measuring the impact of changes in expectations of regulation in the UK during the profit-sharing period and for this reason the implications of the paper do not depend on any impact in the final sub-period providing it is common across samples. However, the fact that the effects we find are consistent across all six samples strengthens the interpretation of the evidence (i.e., the third period is not a 'freak' result of the UK sample). We have conjectured that this fall in risk is likely to be the result of e-commerce effects during this period and we close this sub-section with a brief discussion of why this might be the case.[37]

The impact on risk and return of high-tech companies in the period 1999-2000 is well documented although the cause, i.e., correct valuation versus bubble, is still the center of debate (see for example, Ofek and Richardson (2003), Pastor and Veronesi (2004a, 2004b), Schultz and Zaman (2001), Schwert (2002)). The effect of e-commerce was most pronounced on the Nasdaq exchange and it would be no surprise that the betas would drop down heavily against such an index. However, all three of the market indexes we employ were also affected. Over the sample period these indexes were changing and the 'old-economy' type stocks were a smaller proportion of the market in 2000 than they were in 1993. Table 6 shows that whichever of the three approaches is considered, i.e. (FTSE, UK-DS or US-DS) the relevant regulated and control portfolios have grown less than the market index. That is, price changes have been such that the companies within the regulated and control samples have experienced relative decline overall. This decline is before one considers the effect of

[37] Note, the final decline in the market risk of the 'old economy' stocks on both the UK and the US markets cannot be attributed to their over-performance of the local market indexes. The only group of shares that over-performs the corresponding index is US-DS regulated portfolio in the third sub-period. Even if the sharp increase in the share price of the US-DS regulated portfolio in the third sub-period could drive the equity betas down, it could not explain an even bigger decline in the market risk of the US-DS control portfolio and any of the UK portfolios. Note that the same argument applies to the profit-sharing period share performance.

changes in the composition of companies over the period. Therefore, the market indexes may have become more similar to Nasdaq over the sample period, in particular, the daily returns may have become more correlated. Table 7 shows this was the case. For the first sub-period and the final sub-period it gives the correlation of daily returns (adjusted and not for the exchange rate) between Nasdaq and the market indexes we use.

Table 6
Performance of indexes and portfolios (%)

Return	UK						US		
	FTSE All Shares	regulated	control	DS total market	DS regulated	DS control	DS total market	DS regulated	DS control
Whole period									
Total	102.1	83.2	97.4	107.3	94.5	84.5	127.8	92.1	94.1
Average monthly	1.1	0.9	1.1	1.2	1.0	0.9	1.4	1.0	1.0
Annualized average monthly	13.3	10.8	12.7	14.0	12.3	11.0	16.7	12.0	12.3
Pre profit-sharing period									
Total	62.6	56.4	73.8	64.6	60.0	59.1	82.1	43.2	68.7
Average monthly return	1.3	1.1	1.5	1.3	1.2	1.2	1.6	0.9	1.4
Annualized average monthly	15.0	13.5	17.7	15.5	14.4	14.2	19.7	10.4	16.5
Profit-sharing period									
Total	34.3	32.0	26.2	37.2	34.7	26.5	46.0	37.3	24.2
Average monthly	1.4	1.3	1.0	1.5	1.4	1.1	1.8	1.5	1.0
Annualized average monthly	16.5	15.3	12.6	17.9	16.7	12.7	22.1	17.9	11.6
Post profit-sharing period									
Total	5.2	-5.2	-2.5	5.5	-0.3	-1.1	-0.3	11.6	1.1
Average monthly	0.3	-0.3	-0.1	0.3	0.0	-0.1	0.0	0.7	0.1
Annualized average monthly	3.6	-3.7	-1.8	3.9	-0.2	-0.8	-0.2	8.2	0.8

Table 7
Correlations of daily returns with Nasdaq

Index	**Pre profit-sharing period**	**Post profit-sharing period**	**Change**
US-DS total market	0.797	0.877	10%
Exchange rate adjustment			
FTSE All Share	0.223	0.373	67%
UK-DS total market	0.223	0.370	66%
No exchange rate adjustment			
FTSE All Share	0.262	0.408	56%
UK-DS total market	0.265	0.404	53%

The US DS total market includes both Nasdaq and NYSE companies which is one reason accounting for the high correlation of daily returns and the smaller change over time. The fact that the risk changes of the US-DS and the UK-DS control portfolios (Figure 6) are very similar provides separate evidence that the UK market was affected by the e-commerce 'bubble' (there is no real equivalent to Nasdaq in the UK). We believe that it is the changing nature of the indexes combined with use of the Kalman filter on daily data that is responsible for the large fall in risk at the end of the sample period.[38] Note, that the corresponding Nasdaq/NYSE return correlations are 0.733 in the opening sub-period and 0.688 for the final sub-period (i.e., correlation of daily returns declines). Furthermore, the pure correlation of indexes of the Nasdaq and NYSE were 0.984 in the first sub-period and 0.181 in the final sub-period compared to 0.986 and 0.824 for the US-DS total market index we use in this sub-section to derive US risk.

5.2 Leverage

It is theoretically feasible that differences in the development of leverage ratios over time between the regulated and control samples could have been responsible for the evidence we attribute to the change in regulation. For instance, it would be the case if

[38] Effects that may be concentrated and smoothed away in conventional econometric techniques are visible in the Kalman filter estimates of risk on daily bases. For example, in the case of the decline in betas at the end of the period, the US evidence shows that the US-DS control sample (see Figure 6) has already dipped and is rising again by the end of the period. Thus the maximum effect may only have lasted for a very short period of time.

the leverage of the regulated companies decreased significantly compared with the leverage of the control companies during the profit-sharing period. Note that because we consider the difference between the two portfolios, it is the relative change in leverage ratios that is relevant. Information on the total market value of debt for the companies is unavailable. Many of the companies in the samples did not have debt that was traded for the full sample period and even for those companies that had this only relates to a fraction of their total debt. Therefore it is not possible to obtain a market value of the entire debt for these companies.[39] In this sub-section we first address the effect of leverage using book values and then consider the market price of debt to show that changes in leverage cannot be responsible for the diversion of betas between regulated and control portfolios during the profit sharing period.

Figure 8. Average annual leverage ratios for the regulated and the control portfolios

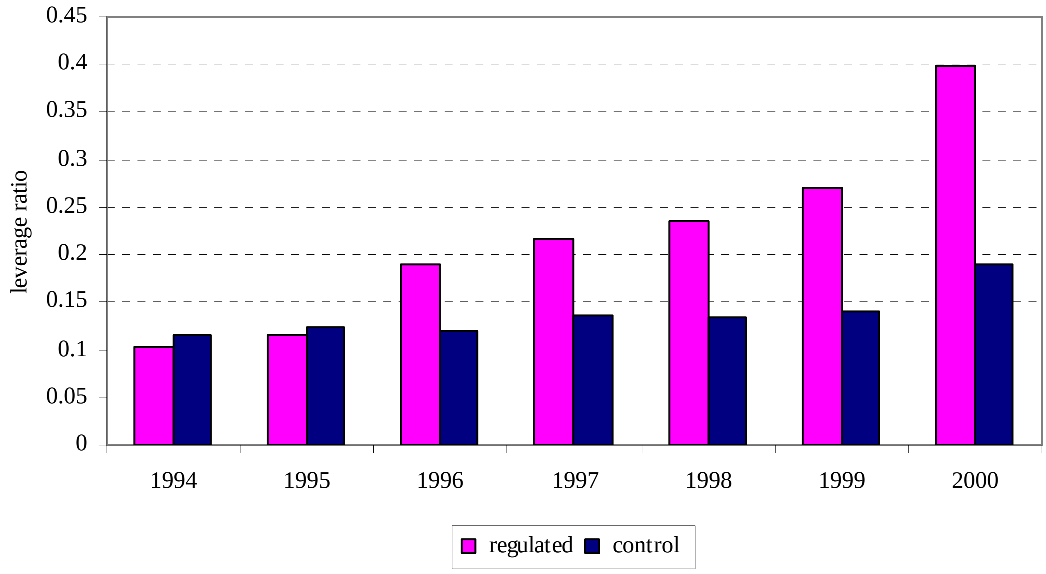


Figure 8 shows the leverage ratios of both the regulated and the control portfolios for each full calendar year based on book value of debt.[40] The leverage for both samples grows steadily throughout the period, albeit at different rates. The leverage ratio of

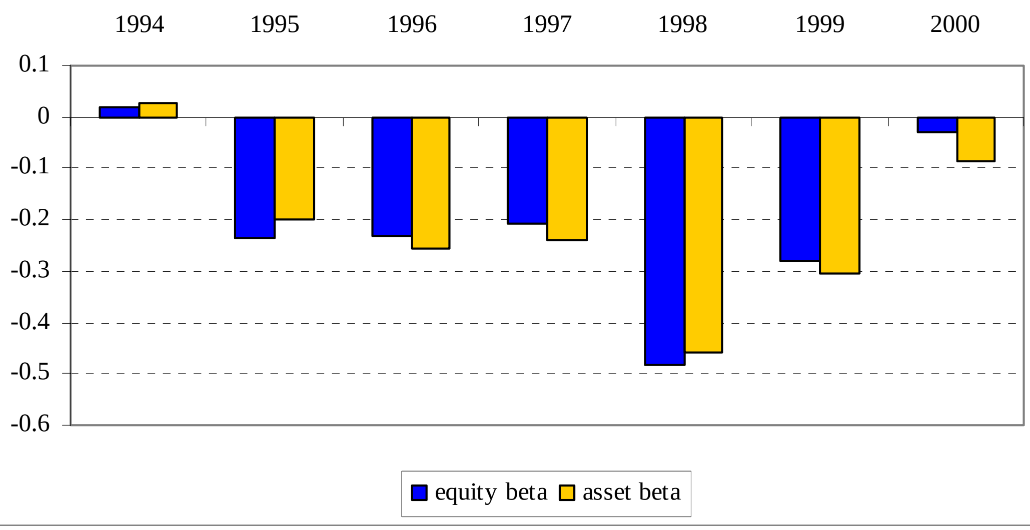
[39] Because we are addressing the difference between portfolios conversion of some companies debt to market value is likely to be more misleading than using book value for all.

[40] We define leverage as l = net debt/(net debt+ market value of equity).

the regulated sample grew more than the leverage of the control sample so, other things being equal, this would tend to increase the regulated beta relative to the control beta. This effect would reinforce the core result that the regulated beta relative to the control beta was much lower during the profit-sharing period.

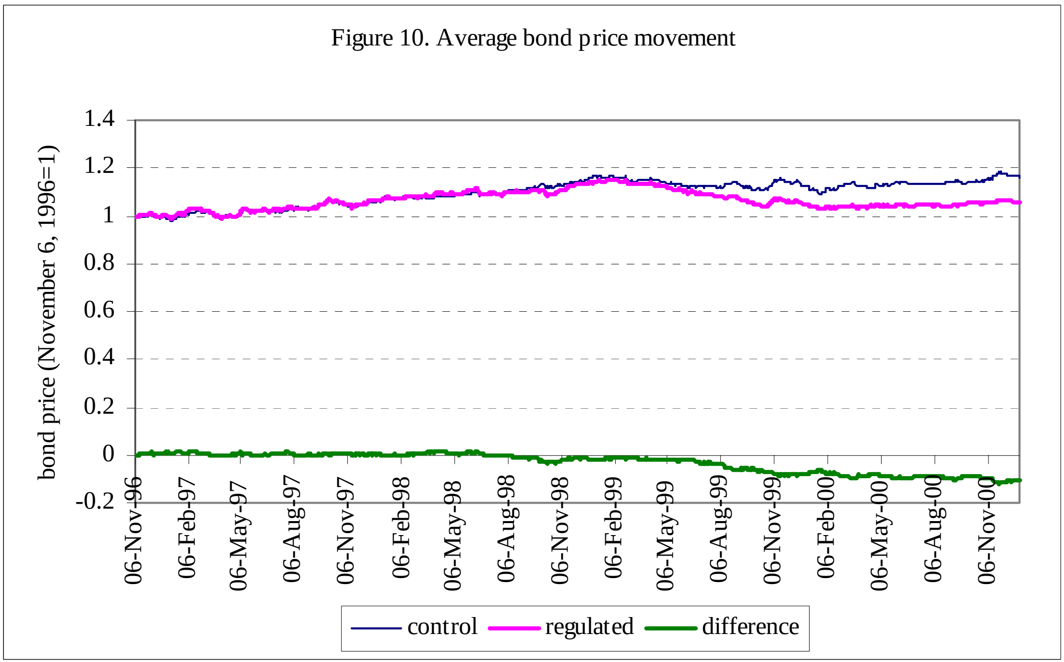
To calculate asset betas for the portfolios we use the formula $\beta_{asset} = (1-l)\beta_{equity}$. First, we calculate an average beta per calendar year from the Kalman filter regressions for the control and the regulated portfolios. We then use the annual leverage figures to convert the average annual differences in equity betas between the two portfolios into average annual differences in asset betas between the two portfolios. The results are presented in Figure 9. The trend identified from the Kalman filter regressions for the difference in equity betas (Figures 3, 4 and 5) are confirmed in the differences of the annual equity and asset betas. The correlation between the differences in equity betas and differences in asset betas is 0.98.

Figure 9. Differences between the annual averages of betas of the regulated and the control portfolios



As indicated, it is impossible to provide a full analysis of market value of debt but for many companies there is a market price for some trances of debt. In addressing this data it is useful to distinguish between two issues (i) the impact on our core result concerning the effect of regulation and (ii) identification of any impact of the regulation on market debt prices.

(i) The relative changes in asset betas between sub-periods (and hence the core result) would only differ from those presented above if there were very large and systematic differences in the differences between market and book value of debt between the two portfolios. This is extremely unlikely. To test this we have created two portfolios (regulated and control) of bonds that were traded by companies in the samples. To have a relatively good representation of bond issues and maximize the amount of companies for which information is available prior to the profit-sharing period we start the sample on November 6, 1996. This allows us to collect information on price movement of bonds for eight regulated companies (all together 19 time series) and 14 control companies (32 time series). More details can be found in Appendix 5. Each time series of prices is normalized to one on November 6, 1996, so both the regulated and control bond portfolios start at one.[41] The time paths of equally weighted portfolios are given in Figure 10.



[41] Time series that were in US$ have been converted into pound sterling.

The above figure shows that there is nearly no difference in the price of traded debt in the two portfolios during the profit-sharing period. Thus there is no suggestion from this evidence that the results obtained using book value leverage ratios are not robust.[42]

(ii) The market price of debt data show the two portfolios moving together during the profit-sharing period but the market price of debt for the regulated company falling slightly relative to the market price of debt for the control sample. We expect that the similarity of prices for the regulated and control sample in the profit sharing period is the result of two counteracting effects. One is that the gearing is increasing for regulated companies relative to the control sample, which should reduce the price of debt for the regulated companies relative to that of the control sample. The other is that the proposed regulatory changes should make regulated debt more attractive. These two effects will counteract each other. However, once the profit-sharing period stops then the difference in leverage should predominate and the price of regulated debt should fall relative to that of the control sample. This may explain the effect observed in Figure 10.

Taken together, the calculated asset betas and the evidence provided on the market price of debt during the profit-sharing period show that the regulatory changes we identify are robust.

6. Empirical analysis: FF 3F model

Fama and French (FF, 1992, 1993) enrich the CAPM model specification by introducing two additional factors: the difference between returns on portfolios of small and of large stocks (the SMB factor) and the difference between returns on portfolios of high and of low book-to–market ratios (the HML factor). The results of FF indicated that in the sample of American companies during the period of 1964-1993, the risk premiums estimated for the non-CAPM factors were large (the annual

[42] Figure 10 weighs each bond equally. We have also weight bond portfolios per issuer to give each company equal representation in the average. The outcome is not sensitive to the form of aggregation.

excess return on HML was even higher than the excess return of the market over the risk-free asset) and CAPM betas very close to unity.

These results have found support in further studies by Fama and French (1995, 1996, 1998) and Davis et al. (2000). Chung et al. (2004) suggest that the two additional FF factors are proxies for higher order co-moments. However, several papers are critical about the significance of FF's findings (e.g., Berk (2000), Campbell (2001), Campbell and Vuolteenaho (2003), Daniel and Titman (1997), Dimson et al. (2001), Korthari et al. (1995), MacKinlay (1995), Siegel (1998), Wang (2000)). The main criticism is that the proposed factors do not have any theoretical roots[43] and that the empirical evidence is based on a relatively short and single sample. This suggests that, although the empirical evidence for the CAPM is mixed, this is clearly also the case for the FF3F model. This is one of the reasons that we investigated a single-factor market model in detail, but it is important to investigate the FF3F model to check whether it can offer extra insight.

As indicated in the previous section we have to use monthly data for the FF3F specification because the HML factor could only be constructed on a monthly basis.[44] The regression equation estimated is

$$R_{i,t} = \alpha_{i,t} + \beta_{iM,t} R_{M,t} + \beta_{iSMB,t} R_{SMB,t} + \beta_{iHML,t} R_{HML,t} + \varepsilon_{it} \ , \qquad (9)$$

where $R_{i,t}$ refers to return on the portfolio of regulated companies, the portfolio of the control portfolio, or the difference between these two portfolios at time t, $R_{M,t}$ is a return on the market portfolio (represented by FTSE All Shares index), $R_{SMB,t}$ and $R_{HML,t}$ refer to the two additional factors suggested by FF. The state vector is defined as $a_{i,t} = \left[\alpha_{i,t}, \beta_{iM,t}, \beta_{iSMB,t}, \beta_{iHML,t}\right]'$ and this time $\eta_{i,t}$ is a 4x1 vector of serially uncorrelated disturbances with zero mean and covariance matrix Q. We assume that the covariance matrix is diagonal, which helps with numerical tractability of the model (the small number of observations makes it impossible to expand the

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[43] Possible theoretical linkages between FF three factor model and the underlying economic variables have been suggested in Brennan et al. (2002), Gomes et al. (2003) and Liew and Vassalou (2000).

[44] We would like to thank Alan Gregory for providing SMB and HML factors (used in Gregory et al. (2003)).

covariance matrix structure). We believe that this simplification does not impact on the results because the unconditional correlation of the factors is low.[45] In the case of OLS regressions for differences between the regulated and control portfolios on monthly observations, tests on residuals show that the Jarque-Bera test cannot reject the null hypothesis of normality (probability of 0.986) and that the White heteroskedasticity test cannot reject the null hypothesis of no heterskedasticity (probability 0.194). Therefore there is some justification for dropping the GARCH specification, especially since the calculations were cumbersome due to the limited number of observations. This simplification in the model specification reduces the number of parameters to be calculated for the Likelihood function from eight, if the GARCH structure of the error term is adopted, to just five.

Our primary aim is to see whether and to what degree the results presented in Section 4 are sensitive to the SML and HML factors. To investigate this, as in the previous section, we run time-varying regressions as specified in equation (9) using monthly observations, and later use OLS WHC (because the White test is positive, i.e., heteroskedasticity is present, for several individual companies).

We have estimated the time paths of all four coefficients in equation (9) for the regulated sample, for the control sample, and for the difference of returns between the portfolios at each point in time. However, for the sake of space we only present the time paths of the difference between returns of the regulated and the control samples as they have most explanatory power in our analysis.[46] Figures 11-13 present time paths (thick lines) and their corresponding 95% confidence intervals (thin lines) for the market factor (Figure 11), the SMB factor (Figure 12) and the HML factor (Figure 13).

[45] Correlation of the market portfolio returns with the SMB factor is –0.21, and with the HML is 0.005; the correlation of SML and HML factors is -0.31.

[46] The other six graphs, i.e., for the regulated and the control samples, can be obtained from the authors on request.

Figure 11. Time path of risk estimated for the market factor

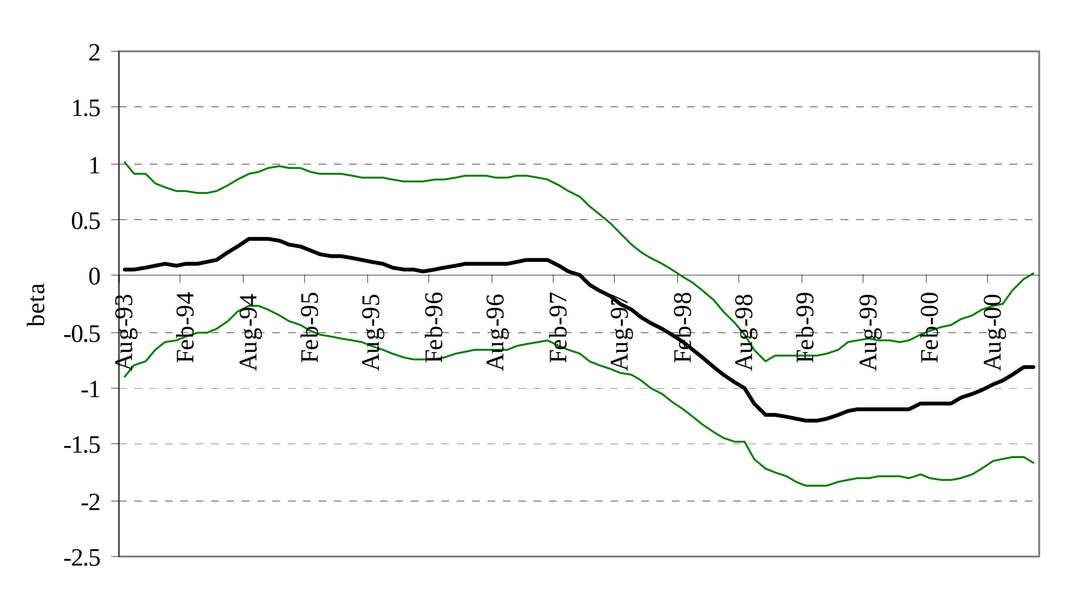
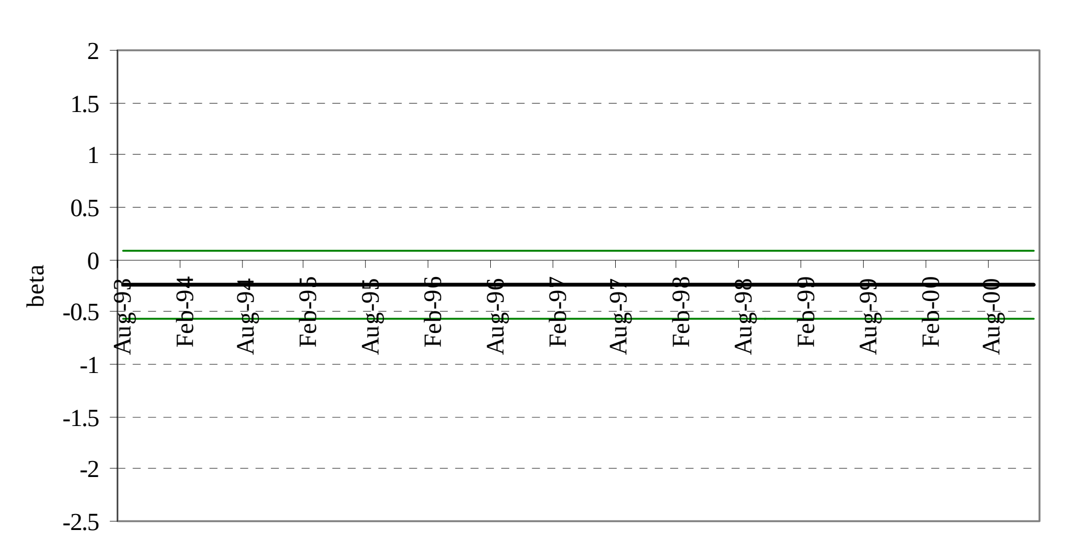
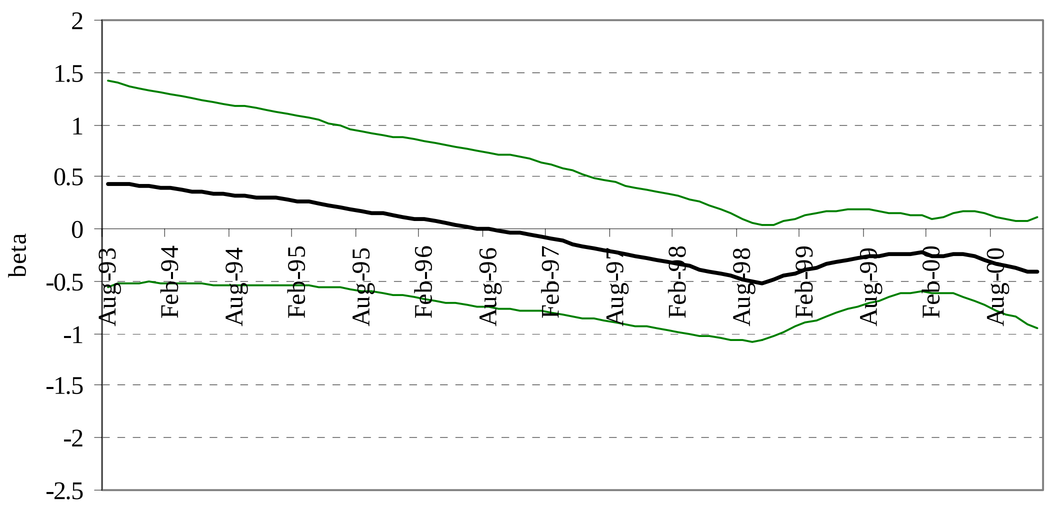


Figure 12. Time path of risk estimated for the SMB factor



The results for the market factor closely replicate the pattern previously estimated using higher frequency data for the single factor model. Although there is weaker convergence in the post profit-sharing period relative to the single factor model, the upward trend back towards the previous level of risk is still very clear. The estimated value of the constant term is, as expected, close to zero (i.e., –0.000088) and statistically insignificant from it (the 95% confidence bounds were –0.009 and 0.009).

Figure 13. Time path of risk estimated for the HML factor



The other two factors do not seem to provide extra explanation. The HML factor displays a very similar pattern to the market portfolio. However, given the standard error, it is not possible to conclude that the time path is significantly different from zero for the whole period in question. In contrast, the SMB factor is virtually flat. We do not present time paths estimated for the FF3F model for the regulated portfolio separately, but we should mention that neither of the time paths estimated for the two additional FF factors are significantly different from zero.

The smaller number of data points (because monthly data is used in this section) may be partly responsible for the outcomes we observe. Changing data frequency changes standard errors. Going from higher to lower frequency will increase standard errors by $\sqrt{n}$, where n is the difference in the relative number of observations per period, e.g., $n = 20$ when moving from daily to monthly observations. Although the shape of the time paths presented in Figures 3 and 11 are very alike, the absolute values of the estimates and the corresponding errors differ. The 95% confidence intervals presented in Figure 11 are approximately five times of those presented in Figure 3, which is consistent with the predicted increase by factor $\sqrt{20} \approx 4.47$. While the level of the betas differ between Figures 3 and 8, the difference between the two paths is not statistically significant. Overall, we are able to conclude from the Kalman filter analysis that the pattern displayed by the market portfolio is strongest and consistent with the theoretical predictions.

Before moving on to time-invariant regression analysis of the FF3F model it is helpful to estimate the market model on the monthly data. Table 8 presents results of the OLS WHC regression, analogous to those shown in Table 2. The sign of the coefficients and their significance are preserved. The monthly estimates for the profit-sharing dummy are larger than their daily counterparts but the differences between these two are not significant.

Table 8
Regression results with the profit-sharing dummy (monthly observations, OLS WHC)
(standard errors in parenthesis;* -significance at 10%,** - significance at 5%; *** - significance at 1%)

	Equation coefficients			
Dependent variable	α	α_{ps}	β	β_{ps}
$R_{reg,t}$- $R_{c,t}$	0.000 (0.005)	0.009 (0.012)	-0.144 (0.199)	-0.831** (0.387)
$R_{reg,t}$	0.002 (0.004)	0.004 (0.009)	0.634*** (0.203)	-0.474* (0.283)

Having replicated the single factor estimates on monthly data as a benchmark we move to the analysis of the FF3F model. Table 9 shows the results on the difference between the regulated and the control portfolios, and the regulated portfolio for the FF3F model with a profit-sharing dummy. Table 10 shows company level results (i.e., company minus control portfolio) with a profit-sharing dummy.

Table 9
Regression results of the FF3F model with the profit-sharing dummy, OLS WHC
(standard errors in parenthesis;* -significance at 10%,** - significance at 5%; *** - significance at 1%)

	Equation coefficients							
Dependent variable	α	$\alpha_{,ps}$	β_{M}	$\beta_{M,ps}$	β_{SMB}	$\beta_{SMB,,ps}$	β_{HML}	$\beta_{HML,ps}$
$R_{reg,t}$- $R_{c,t}$	0.000 (0.005)	0.007 (0.011)	-0.113 (0.207)	-0.977*** (0.375)	0.210 (0.247)	-0.825** (0.367)	0.062 (0.191)	-0.870* (0.495)
$R_{reg,t}$	0.001 (0.004)	0.003 (0.009)	0.676*** (0.178)	-0.599** (0.289)	0.235 (0.200)	-0.644** (0.279)	0.4452*** (0.156)	-0.756** (0.335)

We find in Table 9 that all three dummies for the FF factors are significant. The profit-sharing dummy for the market factor is significant at 1%, the profit-sharing dummy for the SMB factor is significant at 5%, and the profit-sharing dummy for the HML factor is significant at 10% for the difference of the portfolios, and at 5% level for the regulated portfolio. The strength of the market factor relative to the other factors, found in the Kalman filter estimates, is confirmed but now the other factors display significance since the imposition of the assumption of constant beta (save for the profit-sharing period) eases the requirements on the data. Comparing Tables 7 and 8 we also note that the market factor is more significant in the FF3F specification than in the pure market model.

Table 10

Results for the OLS regressions of the FF3F with the profit-sharing dummy (company level)

(White HC standard errors in parenthesis;* -significance at 10%,** - significance at 5%; *** - significance at 1%)

$R_{Ireg,t}$	α	$\alpha_{,ps}$	β_M	$\beta_{M,ps}$	β_{SMB}	$\beta_{SMB,,ps}$	β_{HML}	$\beta_{HML,ps}$
AW	-0.003 (0.008)	0.010 (0.015)	-0.101 (0.259)	-1.260*** (0.419)	0.086 (0.375)	-0.702 (0.505)	0.293 (0.290)	-0.553 (0.772)
BAA	0.000 (0.005)	0.000 (0.017)	-0.062 (0.155)	-0.256 (0.325)	0.299 (0.271)	-0.359 (0.542)	0.429** (0.168)	-0.969* (0.497)
BT	-0.018** (0.009)	0.041*** (0.018)	0.581** (0.289)	-1.514*** (0.550)	-0.926*** (0.342)	0.143 (0.643)	-0.649* (0.335)	-0.281 (0.662)
HYR	-0.007 (0.008)	-0.003 (0.015)	-0.251 (0.317)	-0.843* (0.485)	0.023 (0.372)	-0.608 (0.513)	0.602* (0.324)	-1.529** (0.720)
KEL	0.000 (0.011)	0.005 (0.019)	0.001 (0.374)	-1.118** (0.562)	-0.055 (0.450)	-0.632 (0.583)	0.293 (0.404)	-1.058 (0.798)
NGC	0.007 (0.009)	0.009 (0.016)	-0.227 (0.266)	-1.021** (0.441)	-0.532 (0.335)	-0.478 (0.489)	-0.709*** (0.243)	-0.268 (0.658)
NPR	0.006 (0.011)	-0.017 (0.017)	-0.079 (0.367)	-0.739* (0.454)	0.725 (0.569)	-1.075* (0.634)	-0.321 (0.374)	-0.963 (0.59)
PNN	-0.006 (0.010)	0.023 (0.016)	-0.455 (0.330)	-0.731 (0.497)	0.720* (0.516)	-1.253** (0.611)	0.772*** (0.274)	-1.416** (0.673)
PWG	0.010 (0.009)	-0.018 (0.020)	-0.042 (0.316)	-1.083** (0.507)	1.250* (0.642)	-1.921** (0.756)	0.489 (0.330)	-1.773*** (0.664)
SPW	0.003 (0.008)	0.003 (0.015)	-0.079 (0.264)	-0.842** (0.414)	0.018 (0.275)	-0.845* (0.455)	-0.245 (0.280)	-0.408 (0.544)
SSE	0.001 (0.009)	0.011 (0.020)	-0.019 (0.318)	-0.906 (0.563)	0.368 (0.424)	-1.045* (0.632)	0.246 (0.427)	-1.027 (0.929)
SVT	0.001 (0.009)	0.007 (0.018)	-0.269 (0.322)	-1.159** (0.551)	0.518 (0.440)	-1.005* (0.579)	0.419 (0.296)	-1.015 (0.630)
TW	0.011 (0.013)	0.001 (0.019)	-0.654 (0.674)	-0.772 (0.812)	0.546* (0.313)	-1.179** (0.512)	0.189 (0.240)	-0.597 (0.615)
UU	-0.004 (0.007)	0.011 (0.014)	0.032 (0.275)	-1.234*** (0.423)	0.050 (0.248)	-0.497 (0.373)	-0.224 (0.222)	-0.678 (0.591)
VRD	0.008 (0.009)	0.009 (0.018)	0.130 (0.308)	-1.380** (0.536)	-0.070 (0.337)	-0.787 (0.522)	-0.656** (0.408)	-0.509 (0.662)

Addressing the company specific data (Table10) gives less clear results. The main reason for this we believe is that at this level the company specific variability combined with monthly data makes it hard to pick up the changes due to regulation. The portfolio of regulated companies smoothes out these company specific effects, which is why the results are stronger on the portfolio. However, at the company level we find evidence that is consistent with the portfolio results (i.e., strong results for the market factor dummy, slightly weaker results for the SML dummy and significant but weak results for the HML dummy). The profit-sharing dummy for the market factor is significant for 11 of the companies, the profit-sharing dummy for the SMB factor is significant for seven companies and the profit-sharing dummy for the HML factor is significant for four companies.

Taken together, the results obtained from the FF3F model confirm the view of Section 4 that there is a consistent profit-sharing effect. The primary aim of the paper is to assess the impact of regulation on risk, but the results also provide a tangential contribution to the literature on the significance of the FF3F.

7. Conclusions

We have identified the lack of literature that gives clear evidence how the time-varying nature of risk responds to expected changes in regulation that were designed to change risk. We believe that the dearth of evidence is because, although regulatory changes will typically impact on risk, there is a lack of relatively 'clean' cases that isolate the risk effect for investigation. This paper provides a detailed study of a case where regulation was introduced specifically to change the risk transfer between parties but not to create a wealth transfer. In the late 1990s the UK government proposed a change in the regulation of prices of all regulated UK utilities from price-cap to a system of explicit profit-sharing between companies and customers. We apply Kalman filter techniques, OLS with White error corrections and ML with GARCH effects to a single factor market model and FF3F model to identify risk changes.

Using daily data with a market model the effect is clear on time-varying betas for a portfolio of regulated companies. This is true whether we apply the Kalman filter technique to the full sample period or to three sub-samples (before, during and after the treatment). The effect is also clear when applying Kalman filter to individual companies. Applying OLS with White error correction and ML with GARCH effects we find that the effect on the risk of the companies is significant at a one percent level on a portfolio of regulated companies, and on almost every company at the individual company level. We use US data to confirm that we are not identifying a worldwide effect. We also address the issue of leverage changes and show that they do not explain differences between the regulated and control portfolios.

We also investigate the effect of the impact of the change of regulation on risk using the FF3F model on monthly data. Here the effect is confirmed although the two additional factors appear to contribute less than the market factor. The Kalman filter approach only confirms the effect as significant through the market factor. However, we are using monthly data and an imposition of an assumption of constant beta (save for the profit-sharing period) eases the requirements on the data. Applying OLS to the portfolios shows that the profit-sharing dummies are significant for all three factors. This is true but far weaker when we address individual company level data. As pointed out in the introduction, the case study provides a tangential but intriguing contribution to the debate on the role of the FF3F.

Taking the single factor and three-factor evidence together the paper shows that the impact on risk of changes in regulation that are specifically designed to change risk is both significant and consistent with theory.

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Appendix 1

The table presents a list of FT30 index companies as of the end of December 2000, the description of the main business activity and indicates whether the company is included/excluded from the control sample. Companies are excluded either because they are regulated, or are in the financial, electronic, information, communications and media sectors.

FT30 Index[1]

Company	**Core Business**	**In Sample**
Allied Domecq	Distillers	Yes
BG Group	Regulated	No
Blue Circle Industries	Industrial materials	Yes
BOC Group	Chemicals	Yes
Boots	Drug stores	Yes
BP Amoco	Oil refiners & distribution	Yes
British Aerospace	Aircraft manufacture	Yes
British Airways	Airlines	Yes
British Telecom	Regulated	No
Cadbury Schwepps	Confectionery goods	Yes
Diageo	Distillers	Yes
Emi Group	Music	No
GKN	Metal product manufacturers	Yes
Glaxo Wellcome	Pharmaceuticals	Yes
Granada Compass	Leisure services	Yes
Imperial Chemical Industries	Chemical manufacture	Yes
Invensys	Electronics & engineering	No
Lloyds TSB	Financial services	No
Marconi	Electronics	No
Marks & Spencer	Clothes/food retail	Yes
P & O Steam Navigation	Sea transport	Yes
Prudential Corporation	Financial services	No
Reuters	Information services	No
Royal & Sun Insurance	Financial services	No
Royal Bank Of Scotland	Financial services	No
Scottish Power	Regulated	No
Smith Kline Beecham	Pharmaceuticals	Yes
Tate & Lyle	Sugar production	Yes
Tesco	Food retail	Yes
Vodafone Airtouch	Communications	No

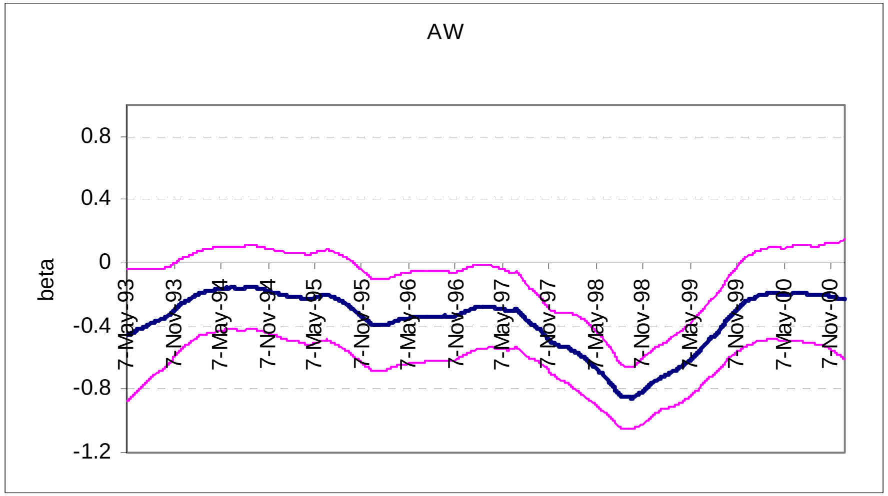
Source: www.ftse.com/ft30.txt & www.corporateinformation.com

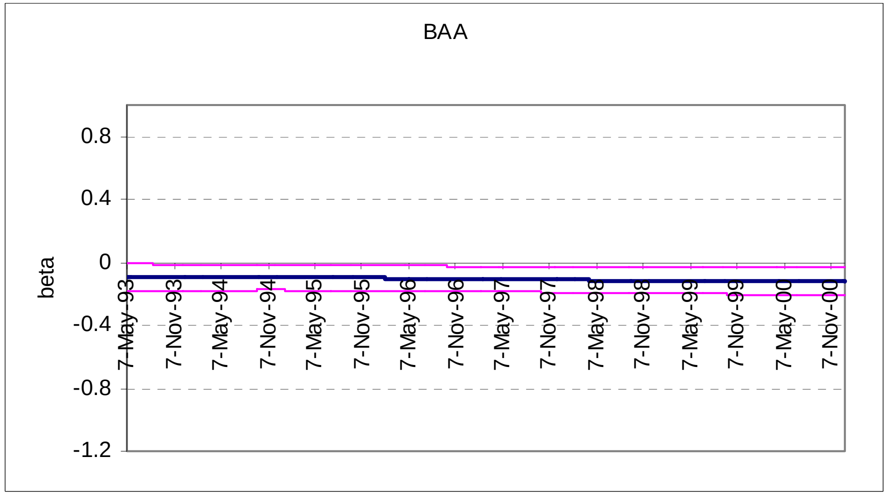
Appendix 2

Each graph contains a time path of the beta coefficient (bold line) estimated for the equation:

$$R_{Ireg,t} - R_{c,t} = \alpha_{diff,t} + \beta_{diff,t} R_{Mt} + \varepsilon_{diff,t},$$

where R_{Ireg} denotes a series of daily log-returns calculated for one of the fifteen regulated companies studied in the paper, R_c denotes a series of daily log-returns on equally weighted control portfolio, and R_M refers to daily log-return on the FTSE All Share Index. Thin lines mark the 95% confidence intervals.





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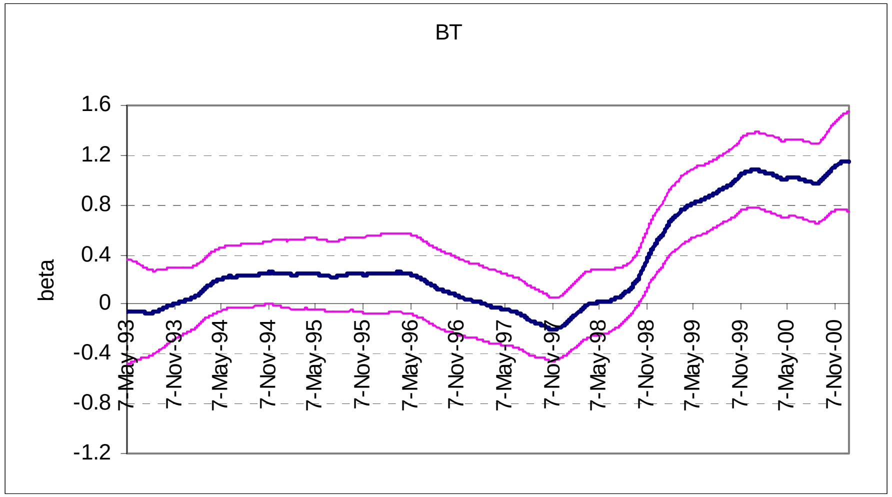

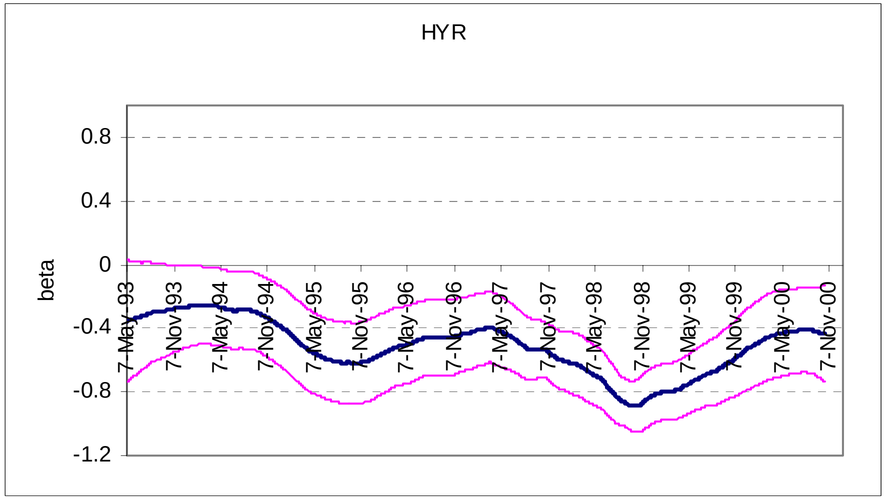

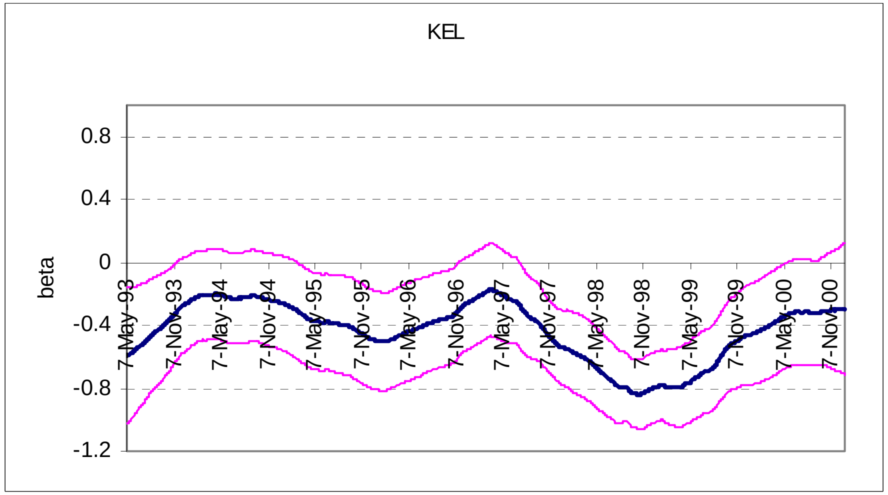

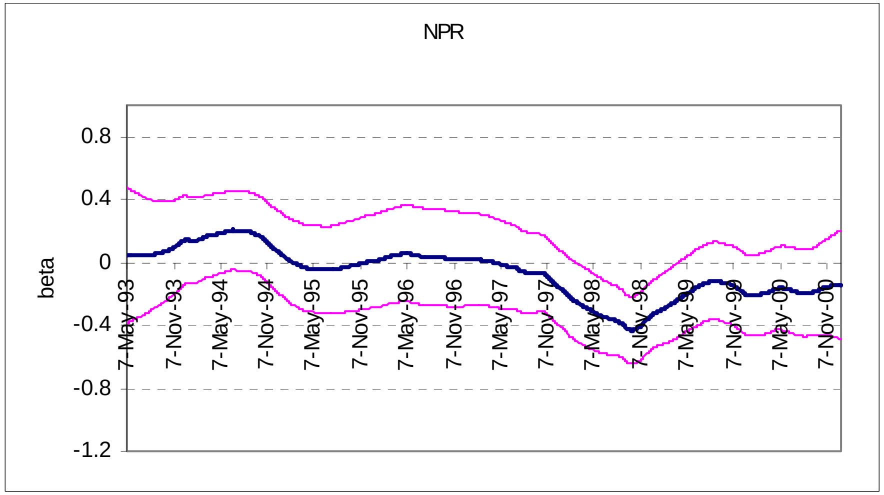

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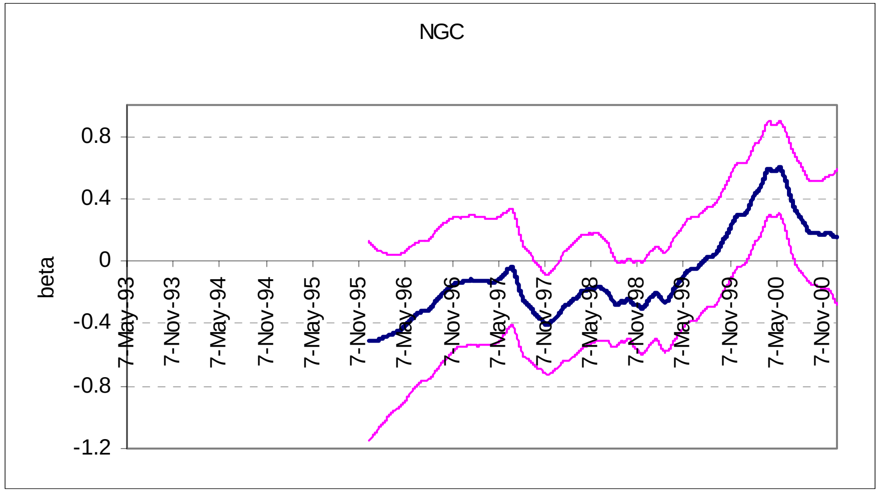
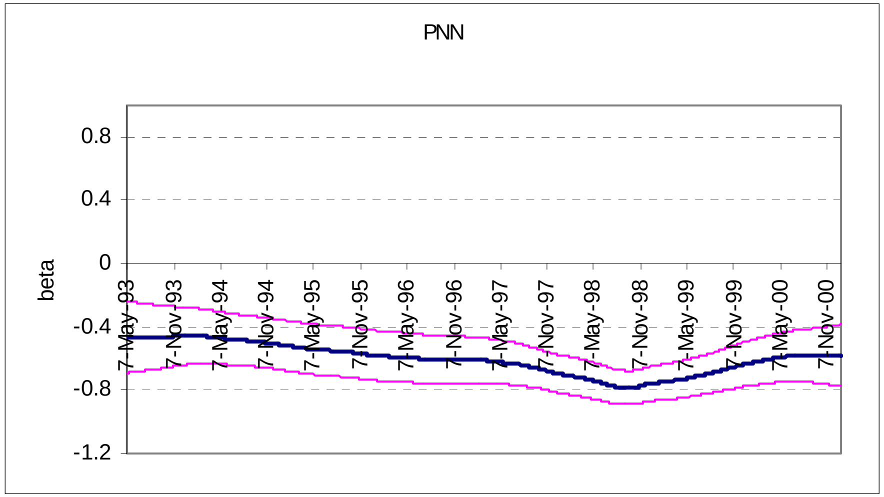
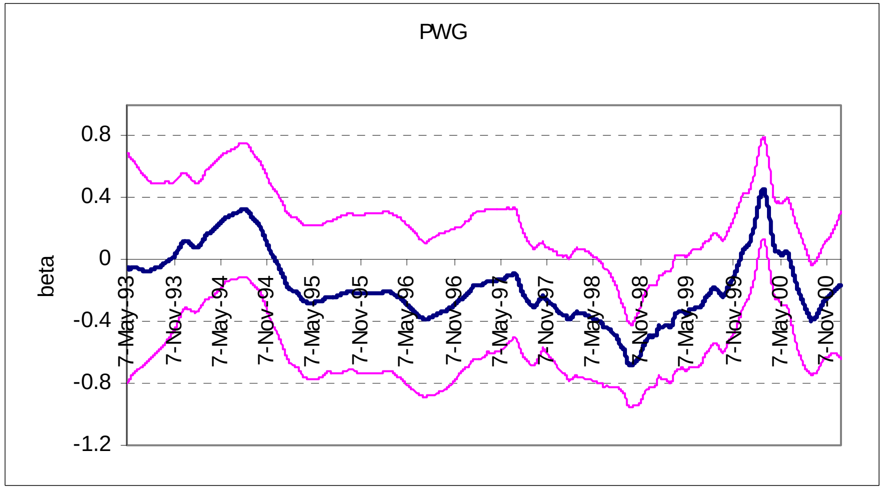
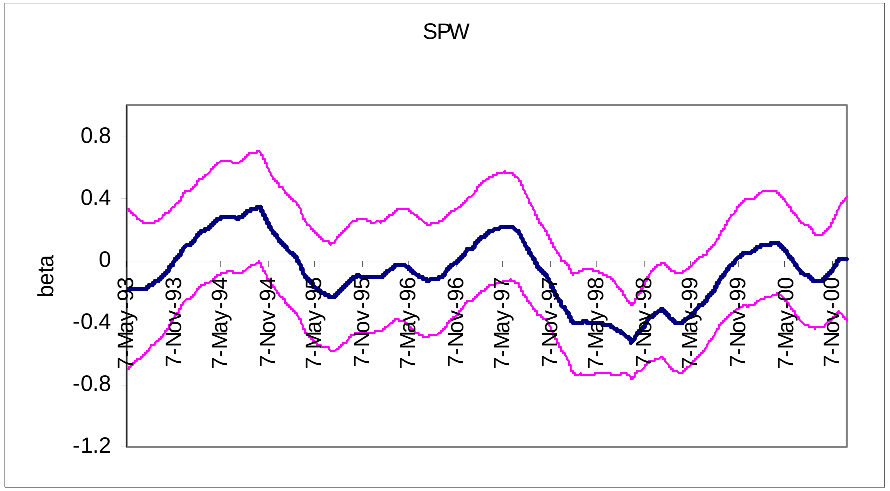
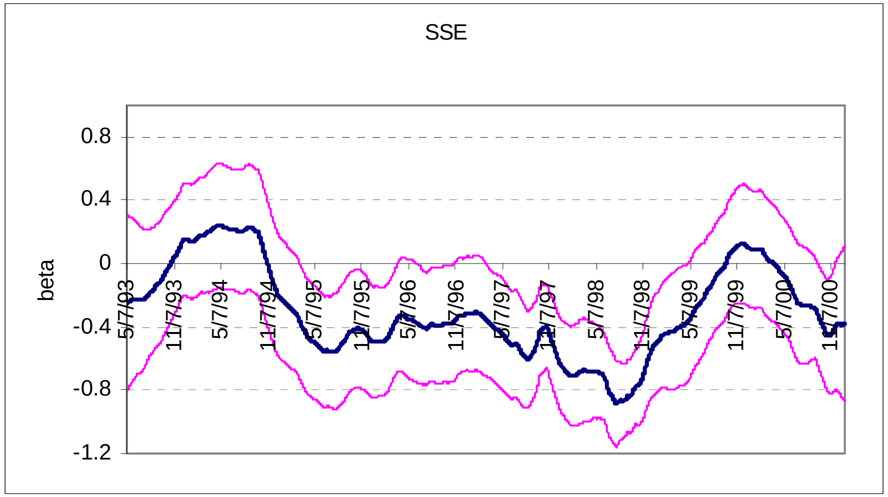


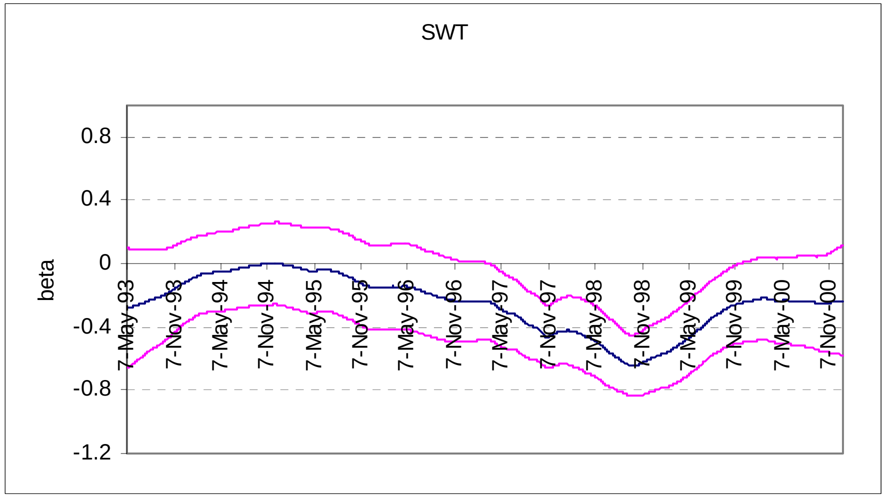


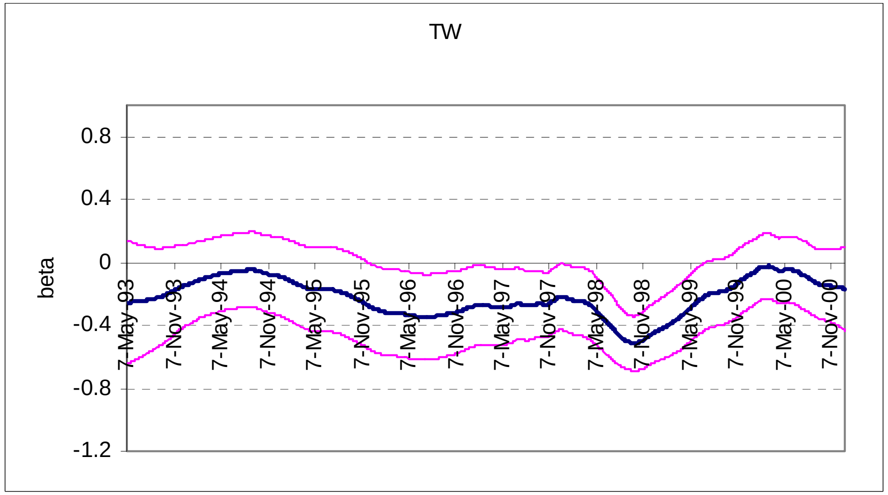


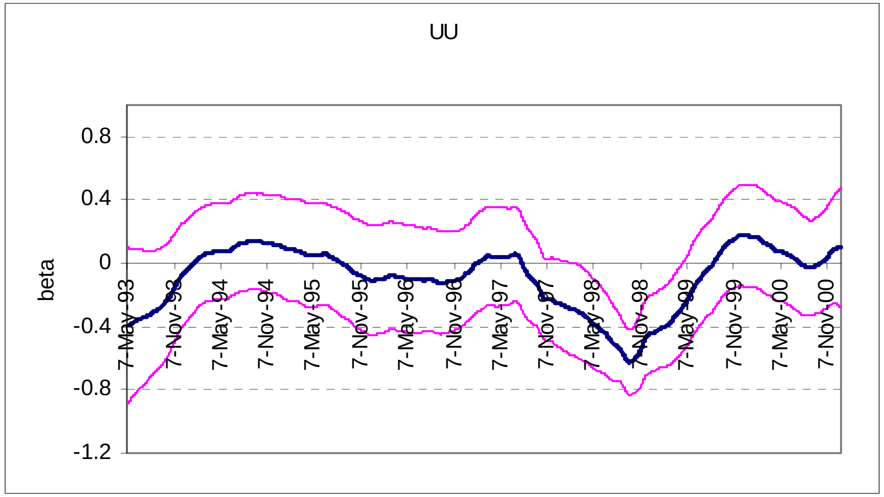


Appendix 2 (continued)

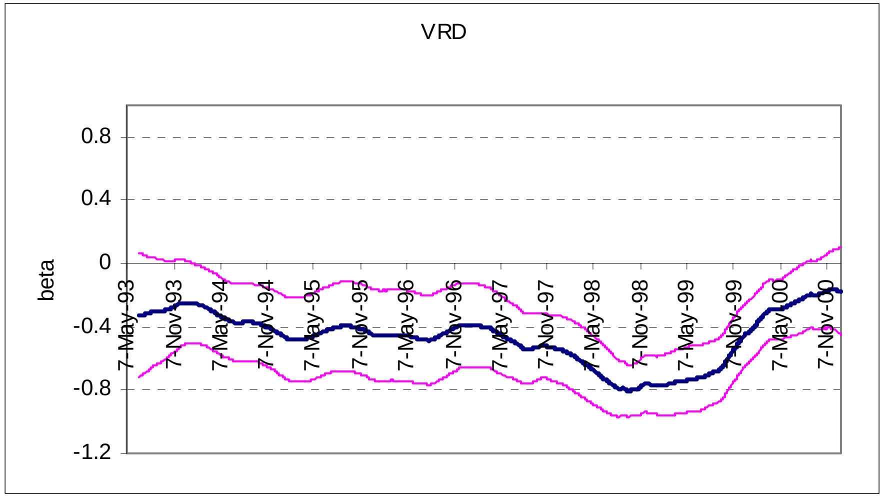








Appendix 2 (continued)



Appendix 3

GARCH effects estimated for $\sigma_t^2 = \theta_0 + \theta_1 \sigma_{t-1}^2 + \theta_2 \varepsilon_{t-1}^2$.

(Standard errors in parenthesizes;** - significance at 5%; *** - significance at 1%).

Time series	θ_0	θ_1	θ_2
R_{reg}	0.000*** (0.000)	0.623*** (0.020)	0.139*** (0.004)
R_c	0.000** (0.000)	0.935*** (0.030)	0.061*** (0.002)
Difference analysis where $R_{Ireg,t}$ denotes:			
R_{reg}	0.000** (0.000)	0.499*** (0.080)	0.227*** (0.034)
AW	0.000*** (0.000)	0.932*** (0.030)	0.053*** (0.002)
BAA	0.000 (0.000)	1.001*** (0.035)	0.000 (0.000)
BT	0.000*** (0.000)	0.918*** (0.029)	0.052*** (0.002)
HYR	0.000*** (0.000)	0.851*** (0.028)	0.125*** (0.004)
KEL	0.000*** (0.000)	0.0897*** (0.029)	0.084*** (0.003)
NGC	0.000*** (0.000)	0.219 (0.091)	0.230*** (0.040)
NPR	0.000 (0.000)	0.576*** (0.057)	0.349*** (0.044)
PNN	0.000*** (0.000)	0.500*** (0.055)	0.431*** (0.049)
PWG	0.000 (0.000)	0.045 (2.177)	0.001 (0.342)
SPW	0.000*** (0.000)	0.915*** (0.029)	0.071*** (0.002)
SSE	0.000 (0.000)	0.939*** (0.030)	0.054*** (0.002)
SVT	0.000 (0.000)	0.976*** (0.032)	0.021*** (0.001)
TW	0.000*** (0.000)	0.467*** (0.015)	0.208*** (0.007)
UU	0.000 (0.000)	0.966*** (0.033)	0.028*** (0.001)
VRD	0.000*** (0.000)	0.041 (0.047)	0.141*** (0.141)

Appendix 4.

Figure A4.1. Beta coefficient for the difference in returns betw een the regulated sample and the 9 smallest companies in the control sample

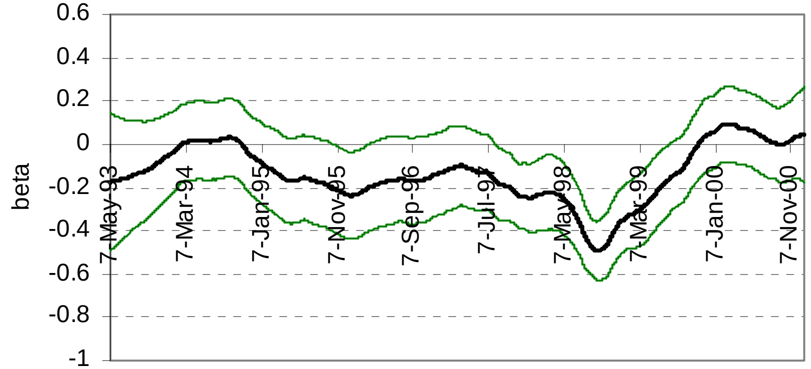


Figure A4.2. Beta coefficient for the difference in returns betw een the regulated sample and the 9 largest companies in the control sample

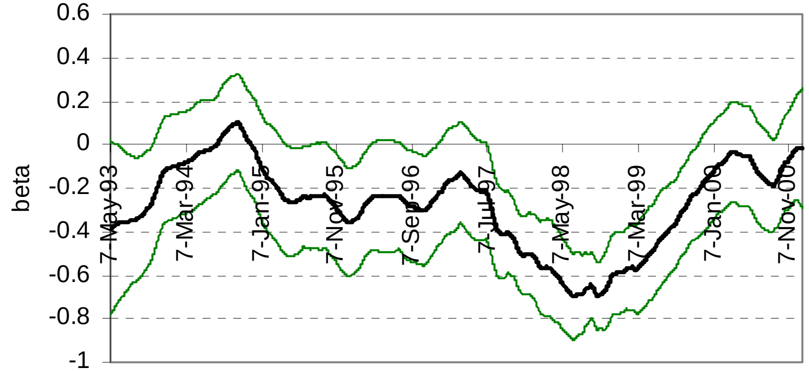


Figure A4.3. Beta coefficient for the difference in returns betw een the regulated sample and the first half of control sample w hen ranked alphabetically

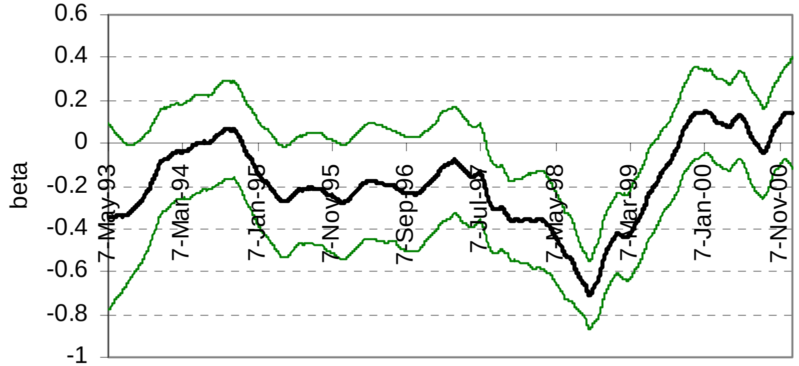
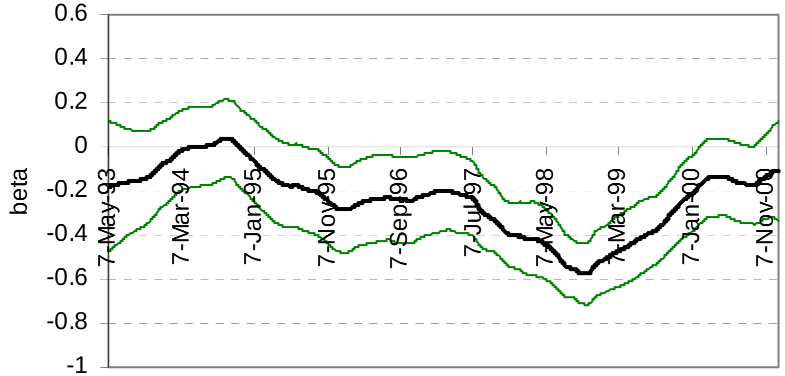


Figure A4.4. Beta coefficient for the difference in returns betw een the regulated sample and the latter half of control sample w hen ranked alphabetically



Appendix 5

Regulated and control companies for which bond prices are analyzed

Regulated companies		**Control companies**	
Name	**Number of bonds**	**Name**	**Number of bonds**
AW	3	Blue Circle Industries	1
BAA	3	BOC Group	3
BT	5	BOOTS	1
HYR	2	BP	2
NGC	2	British Aerospace	1
PWG	1	British Airways	2
SVT	2	Cadbury Schwepps	2
TW	1	Glaxo Wellcome	3
		Granada Compass	2
		Imperial Chemical Industries	1
		P&O Steam Navigation.	4
		Smith Kline Beecham	5
		Tate & Lyle	2
		TESCO	3