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Idiosyncratic Risk in the 1990s:
Is It an IT Story?

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Abstract

This paper examines trends in idiosyncratic risk in different 'new economy' and 'old economy' industries, and explores whether these developments can be attributed to the use of IT. A CAPM-based decomposition of equity returns is employed to estimate idiosyncratic risk. The results provide evidence of an increase in idiosyncratic risk in the 1990s. A substantial part reflects high volatility of firms in the IT sector, and in particular that of new IT firms. However, it is not clear whether the increase in idiosyncratic risk results from changes in the risk perception of financial markets or from new ways of firm organization', production and competition related to IT. The jump in volatility in 1998 supports the view that the perception of risk by equity investors has changed. The positive relation between the share of intangible assets (as a proxy for IT-related changes) and the increase in firm-specific risk in the 1990s is consistent with the view that IT increases the uncertainty with respect to firm valuation, particularly if associated with a fundamental change in the business model.

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Figures and tables given at the end.

1 Introduction

Innovation in information and communication technology (IT) has triggered a period of rapid technological change. The share of computers in capital formation increased dramatically as cheaper IT components stimulated progress in IT equipment production and, through rapidly falling prices, spurred IT use in other sectors. Massive investment in IT, as a new general purpose technology, and its application in traditional industries, has been seen as a core element of a 'new economy' with higher aggregate productivity growth not limited to the IT sector. For the United States, the acceleration of total factor productivity *outside* the IT sector has been seen as indicative of such spillover effects (see, for example, Jorgenson 2001; Oliner and Sichel 2000; for the opposing view see Gordon 2000). For Europe, there is as yet only scarce evidence for spillover effects to other sectors (see, eg., European Central Bank 2001; Oulton 2001).

The debate about macroeconomic productivity effects reinforced the interest in the microeconomic changes brought by IT. That computers enable new ways of organizing firms has been a major theme in the field of information systems. The rapidly growing empirical economic literature looking into firm-level changes associated with the use of IT supports the view that efficiency gains are positively correlated with investments in 'organizational capital'. Micro-based studies identify complementarities between the use of IT and firm reorganization as important in the United States (eg., Black and Lynch 2000)—and in Europe too—in traditional sectors such as textile manufacturing (Bugamelli and Pagano 2001).

The question of if and how IT progress affects the risk profile of firms has received less attention than the productivity effects of IT. However, the literature on closely related issues has grown rapidly. Several studies document the high volatility of stocks of IT sector firms. For example, Fornari and Pericoli (2001) form small portfolios of IT- and non-IT equities and show greater sensitivity of technology equities to shocks. A large body of literature deals with the specifics of new and innovative firms, developing a new technology in an unexplored market (see Bank of England 2001 for an overview). Available evidence broadly supports the view that investment *in the innovative sector* is inherently more risky than in rather mature markets (eg., Chan *et al.* 1999 show that return volatility is positively correlated with R&D intensity).

The dispersion of IT throughout the productive system could also affect the risk profile of firms in many *other sectors*. Bugamelli *et al.* (2002) note that the uncertainty implied by investment in IT capital is similar to that in any large process innovation, because reorganizing productive activities to fully exploit IT-related benefits can imply huge sunk costs. In addition, IT innovation may alter the competitiveness of markets in ways that are difficult to predict. IT provides firms with powerful tools for more effective price discrimination (Varian 2001) because it allows the 'personalization' of goods through highly flexible production processes. It also enables firms to collect and process the information necessary to identify consumer taste. Moreover, supply side and demand side economies of scale ('network effects') create the possibility of boosting profits by increasing supply at very small marginal costs and by achieving a 'critical mass' in demand. Changes in the risk profile are not necessarily limited to firms adopting IT. A study by Baldwin and Sabourin (2001) on the Canadian manufacturing sector suggests that IT innovation has repercussions on firms *not* adapting to new technologies by eroding their competitiveness.

Many of the IT-related innovations in firm organization, production and marketing not only suggest that business risk increases, but also that risk becomes more *firm specific* ('idiosyncratic'). In firm organization and production, greater idiosyncratic risk could be a side effect of an increasing importance of 'soft' production factors as information and knowledge that are highly firm specific. Moreover, the productivity of these factors depends on firm organization supporting the exploration of factor complementarities. Market segmentation through the sale of different versions of basically the same product and, at the extreme end, the production of goods tailored to the preferences of individual customers, could also make risk more firm specific.

Separate from this, IT could alter the *assessment and perception* of firm-specific risk by investors in financial markets. This could happen through the changing quality of corporate information, namely its timeliness and its reliability. First, the use of IT allows disseminating information far more rapidly. This should basically reduce the volatility of returns as information arrives earlier, that is when the cash flows in question are more heavily discounted (Campbell *et al.* 2001). Second, as a consequence of IT-related innovation, substantially more information in usable form about production processes, risks and departures from plans is potentially available. This could facilitate the formation of expectations and reduce volatility through improved monitoring. However, this requires that the benefits of improved monitoring capabilities be passed on to external stakeholders (Committee in the Global Financial System 2002).

From the perspective of corporate finance, a broad-based increase in firm-specific risk would be important, as higher idiosyncratic risk puts greater onus on portfolio diversification and risk management by financial investors. Although idiosyncratic risk can be diversified, a broader range of assets may be required to achieve diversification, and exploiting the potential for risk diversification may require adjustments of existing portfolios. IT is of interest as a factor driving idiosyncratic risk because of its potential to affect simultaneously a very broad range of industries inside and outside the IT sector. Moreover, the complementary character of IT investment may fundamentally change the nature of established businesses, thereby going far beyond the 'normal' innovation process. Hence, risk management issues arising from higher idiosyncratic risk might be relevant for a broad range of financial investors and intermediaries.

This paper examines trends in idiosyncratic risk in different 'new economy' and 'old economy' industries and explores whether these developments can be attributed to the use of IT. Against the background of these results, it raises possible implications for public policy. The paper is organized as follows. The next section outlines the methodology and the data employed to measure idiosyncratic risk. The third part discusses the empirical results. Section four considers possible implications for financial policy. Section five concludes.

2   Methodology and data

2.1 Methodology

Idiosyncratic risk is usually measured as volatility of the asset-specific return (see, for example, Richards 1999 for different measures of idiosyncratic risk and Malkiel and Xu 2000). This paper employs the CAPM-based approach suggested by Campbell *et al.*

(2001) to decompose equity returns into market and idiosyncratic volatility. This approach appears advantageous for two reasons. First, returns can be split into market, industry and firm-specific components. The possibility of distinguishing between sectoral and firm-specific risk is useful when drawing conclusions about the possible impact of IT innovation on idiosyncratic risk. Second, this approach yields a volatility measure of firms in different sectors without having to keep track of covariances and to estimate firm-level betas.

Let r_{mt}, r_{it}, and r_{fit} denote excess returns of the market portfolio m, the industry i, and a firm f in the industry i at period t. According to the CAPM, common and asset-specific excess return at the industry and the firm level can be written as

$$r_{it} = \beta_{im} r_{mt} + \varepsilon_{it} \tag{1}$$

$$r_{fit} = \beta_{fi} r_{it} + \eta_{fit} \tag{2}$$

(1) substituted into (2) yields:

$$r_{fit} = \beta_{fi} \beta_{im} r_{mt} + \beta_{fi} \varepsilon_{it} + \eta_{fit} \tag{3}$$

This decomposition guarantees that the different components of a firm's return are orthogonal to each other. It permits a variance decomposition in which all covariance terms are zero.

$$Var(r_{it}) = \beta_{im}^2 Var(r_{mt}) + Var(\varepsilon_{it}) \tag{4}$$

$$Var(r_{fit}) = \beta_{im}^2 Var(r_{mt}) + \beta_{fi}^2 Var(\varepsilon_{fi}) + Var(\eta_{fit}) \tag{5}$$

However, the drawback of this approach is that it requires estimation of industry and firm-level betas, which may be unstable particularly at the firm level. One possibility to circumvent this problem is to simplify the model by setting beta = 1 as suggested by Richards [1999] for a simple proxy of idiosyncratic risk). Another approach is to calculate asset specific volatilities as the weighted average of the volatility of all assets in a portfolio instead of the volatility of one individual asset. Here, the weighted asset-specific beta = 1 (i.e., the beta of the portfolio).

$$\sum_i w_{it} \beta_{im} = 1, \sum_{f \in i} w_{fit} \beta_{fi} = 1 \tag{6}$$

Hence, a market-adjusted return model (Campbell *et al.* 1997) can be used as basis for the estimation of returns and volatilities at the industry level:

$$r_{it} = r_{mt} + \tilde{\varepsilon}_{it} \tag{7}$$

and at the firm level:

$$r_{fit} = r_{it} + \tilde{\eta}_{fit} . \tag{8}$$

From substituting (1) into (7) and (8), one obtains:

$$\tilde{\varepsilon}_{it} = \varepsilon_{it} + (\beta_{im} - 1)r_{mt} \quad \text{and} \tag{9}$$

$$\tilde{\eta}_{fit} = \eta_{ft} + (\beta_{fi} - 1)r_{it}. \tag{10}$$

Considering that $\sum_i w_{it}\beta_{im} = 1$ for the weighted average of all industries and that $\sum_{f \in i} w_{fit}\beta_{fi} = 1$ for the firms in a specific industry, the weighted industry and firm-level variances obtained from (7) and (8) are

$$\sum_i w_{it}\beta_{im}Var(r_{it}) = Var(r_{mt}) + \sum_i w_{it}\beta_{im}Var(\tilde{\varepsilon}_{it}) \text{ and} \tag{11}$$

$$\sum_{f \in i} w_{fit}\beta_{fi}Var(r_{fit}) = Var(r_{it}) + \sum_{f \in i} w_{fit}\beta_{fi}Var(\tilde{\eta}_{fit}). \tag{12}$$

Finally, we can substitute (11) into (12), which yields the beta-free variance decomposition

$$\sum_i w_{it} \sum_{f \in i} w_{fit}Var(r_{fit}) = \sum_i w_{it}Var(r_{it}) + \sum_i w_{it} \sum_{f \in i} w_{fit}Var(\tilde{\eta}_{fit}) \tag{13}$$

$$= Var(r_{mt}) + \sum_i w_{it}Var(\varepsilon_{it}) + \sum_i w_{it} \sum_{f \in i} w_{fit}Var(\tilde{\eta}_{fit}).$$

$$= \sigma_{mt}^2 + \sigma_{\tilde{\varepsilon}t}^2 + \sigma_{\tilde{\eta}t}^2.$$

2.2 Data and estimation

Equity returns are daily returns for firms included in the Datastream (DS) total market indices for the United States and the European Union. The indices comprise 996 firms for the US market and 2,055 for the EU, 15 in 36 industries. Industries are aggregated according to the constituents of the DS level 4 sector indices. Total market and industry indices are weighted by the market capitalization of individual firms at the end of the respective day. The safe interest rate over which excess returns are calculated is the three-month treasury bill rate for the US market and the three-month euro interbank deposit rate for Europe. Data frequency is daily for the period from January 1990 until December 2001.

Firm-specific volatilities are calculated for ten industries in the United States and in the European Union, including those with the largest average market capitalization and the 'new economy' sectors (see Table 1). In order to isolate effects arising from changing index constituencies, two series are calculated for each industry. The constant constituent series comprises firms contained in the respective DS sector over the whole time horizon from 1990-2001. The varying constituent series is calculated using the actual index constituents at each day. Hence, it includes new firms that went public during the 1990s. If not explicitly stated, figures are based on the actual constituent series.

Daily excess returns for the total market, for industries and for firms are calculated as the differences in log returns of the respective equity and the safe rate. Monthly

volatilities at the different levels are estimated as follows (see Campbell *et al.* 2001). For the total market *M*, that is

$$M_s = \hat{\sigma}_{ms}^2 = \sum_{t \in s} (r_{mt} - \bar{r}_m)^2 .$$ (14)

Corresponding to the construction of market volatility as the sum of squared deviations from the mean market return over a month, industry-specific volatility *I* is estimated as the weighted sum of squared residuals over the sample period.

$$I_s = \hat{\sigma}_{\varepsilon s}^2 = \sum_i w_{is} \sum_{t \in s} \hat{\varepsilon}_{it}^2$$ (15)

Finally, firm-specific volatility is also estimated as weighted sum of squared residuals of the firms in the respective industry over the sample period.

$$F_s = \hat{\sigma}_{\eta s}^2 = \sum_i w_{is} \sum_{f \in i} w_{fit} \sum_{t \in s} \hat{\eta}_{fit}^2$$ (16)

Calculating firm-specific risk for *individual* industries *FI* requires the estimation of industry betas on the market. The betas are estimated using OLS of the daily excess return data for the full sample. Hence it is assumed that the betas are constant over time:

$$FI_s = \hat{\sigma}_{\eta is}^2 = \sum_{f \in i} w_{fit} \sum_{t \in s} \hat{\eta}_{fit}^2 .$$ (17)

3   Results

3.1   Aggregate trends

Figure 1 shows market, industry and firm-specific volatilities as constructed form equations 14, 15 and 16. The three variance components exhibit a marked difference between a rather 'calm' period in the early and mid-1990s and a time of relatively high volatility beginning in late 1998. This pattern is very similar for the United States and for Europe. Market volatility moves differently from other components in the early 1990s – when firm and industry volatilities remained low – and in 1997, when it picked up earlier than firm and industry volatility. As one would expect, market volatility is particularly sensitive to shocks to general market sentiment as in the context of the Gulf crisis in 1990, the Asian crisis in 1997 or LTCM in 1998 (see bottom panel of Figure 1). In relative terms, it is striking that firm-specific volatility was more than twice as high as that of industries and the overall market. In relative terms, volatility at the firm level accounted for 70 per cent of total return volatility in the United States and 72 per cent in Europe.

No clear picture emerges with respect to volatility trends during the 1990s. Visual inspection gives the impression that any trend in industry and firm-specific volatility is dominated by the period of high volatility beginning in autumn 1998. The first spike in volatility at all three levels in 1998 coincides with the correction in equity prices during the LTCM crisis. One explanation for the simultaneous jump in volatility at all levels could be (temporary) concerns about the systemic impact of the turbulences. However,

volatility remained at elevated levels even through the 1999/2000 bull market. Industry and firm-specific risk peaked in spring 2000, when the decline of tech sector equities began, and again in the late 2000 in the US market, when evidence of an economic slowdown mounted. In 2001, industry- and firm-level volatility has receded, but was still relatively high by the end of 2001. Taken together, the persistence of high volatility since late 1998 could be indicative of a shift in the volatility regime in addition to possible long-term trend and cyclical variations.

Table 2 presents descriptive statistics and the results of linear regressions testing for the existence of a deterministic trend, a structural break in 1998 and the influence of cyclical fluctuations in real activity.[1] The results clearly show that the volatility of the average firm is much higher than that of the average sector and the overall market both in the United States and in Europe. The deterministic trend, which is significant for all components and markets when used as the only right-hand variable (model I), remains significant only for US industries and firms when introducing a structural break in autumn 1998 (model II). Model III, which includes a 'production gap' variable for cyclical fluctuations, yields significant results for Europe only at industry level.[2] For the United States, the production gap has explanatory power for industry and firm-level volatility in addition to the trend and the structural break variable.

Taken together, three stylized facts, and issues arising from these, can be highlighted from the analysis of aggregate timeseries for market industry and firm-level volatility.

The increase in firm-specific volatility in the late 1990s coincides with the sharp rise and subsequent decline of IT equity prices. Is idiosyncratic risk therefore a genuine IT story in a sense that it is attributable to the weight of the IT sector in the overall equity market?

Most of the upward shift in firm-specific volatility occurred abruptly in 1998. Does this reflect a change in the financial market perception of firm-specific risk? Or is it indicative of actual changes in the production function and/or the competitiveness of individual firms or industries, which could be expected to impact on idiosyncratic risk gradually and over an extended period of time?

A trend increase in idiosyncratic risk is observable in the United States. Is this related to IT-driven permanent changes in economic activity?

The following section addresses these questions by analysing the pattern of idiosyncratic risk of firms in individual industries.

3.2 Individual industries

Figure 2 plots firm-level volatilities for different industries in the United States and in Europe. It exhibits a clear distinction between 'new economy' industries (information

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1   The regressions were run using volatility levels. The hypothesis of a unit root in volatility levels could be rejected at the 5% level for all series.

2   The variable captures cyclical influences as trend deviations. It is estimated as the residuals of a HP filter smoothing of monthly data on industrial production. For the residual series, the hypothesis of a unit root could also be rejected at the 5% level.

technology hardware and software, telecom services, and media; and pharmaceuticals and biotech) and companies in the 'old economy'. Firms in all sectors considered here experienced an increase in idiosyncratic risk in the late 1990s. However, the jump in volatility was much more pronounced in the 'new economy'. In contrast to this, idiosyncratic risk of firms in more traditional industries (in particular banks, insurance and oil and gas) increased only temporarily in 1998 and 1999 but returned to the earlier levels relatively quickly.

Table 3 shows descriptive statistics and the structural break coefficients for model II in Table 2 for the individual industries. The coefficient for the structural break is significant for all 'new economy' sectors. The coefficients show that idiosyncratic risk virtually doubled relative to the mean for firms in the hardware and software producing industries and in the media sector in the United States and in Europe and for European telecoms. The largest relative increase is reported for the US telecom sector.

Turning to the 'old economy' industries, the relatively strong rise in idiosyncratic risk in the United States and European retail sectors stands out. One IT-related explanation could be the dramatic change in the competitive environment in parts of the retail sector as a consequence of e-commerce. In contrast to this, the change in firm-specific volatility of oil and gas producers, banks, insurance firms and car manufacturers is moderate.

The sectoral breakdown clearly supports the view that the rise in idiosyncratic risk was particularly pronounced in the IT sector. The aggregation of firm-specific risk across industries following equation (17) implies that the high volatility translates into high overall firm-specific volatilities according to the high weight of the IT sector (see Table 3).

An additional question is whether the increase in firm-specific volatility in the IT sector is attributable to the young and innovative firms that went public during the 1990s. Several factors can explain particularly high idiosyncratic risk of relatively young innovative firms. Economic literature emphasizes that the success of new and innovative firms is linked to difficult-to-value growth options derived from scientific knowledge and intellectual property (see Brierley and Kearns 2001). Another key characteristic is that such firms have little track record and are largely untested in markets. Against this background, one would expect new firms to add to average idiosyncratic risk in a sector. The impact should be significant if the number of new entrants (and their market capitalization) were sufficiently large.

The two timeseries constructed for each sector on the basis of constant (1990) constituents and actual constituency capture these effects. Table 4 reports the means of the actual constituents series in the period from October 1998 until December 2001 and the change compared to the constant constituents mean. In the United States, the index, including new constituents, shows a significantly higher average firm-level volatility for all new economy sectors, and for retail and oil and gas. In Europe, volatility is significantly higher only in the case of software (which includes Internet companies) and telecom firms and in the automobile sector (with new constituents in the latter case actually reducing volatility). However, it should be noted that the change in constituency, although significant, only explains part of the total increase in volatility in these industries. Therefore, the question remains about the possible role of IT for the increase of risk for the 'established' firms.

One variable that could capture IT-related changes is the share of intangible assets in total assets. The accumulation of intangible assets can reflect the impact of IT innovation both on the production process and on market structure and competition. As regards the former, computer-related intangible assets ideally capture computer related investment on organizational change (Brynjolfsson and Yang 1999). Examples include capitalized adjustment costs, software, new business practices and other complementary organizational innovations to exploit benefits of computer technology. Related to market structure changes are capitalized advertising costs and goodwill. For example, goodwill from takeover activity could rise because IT involves supply-side and demand-side economies of scale (network effects) that favour business strategies trying to gain market share or to establish industry standards. Examples are the Internet and the telecom sector where firms followed an aggressive acquisition strategy in the late 1990s.

Finally, a rising share of intangibles could also affect idiosyncratic risk by reducing the quality of firm-specific information. One source of volatility could be difficulties in measuring the value of intangible assets. Many intangibles lack market prices. In addition, accounting rules and conventions do not correctly capture all the firm's productive assets, namely intangible assets associated with the use of IT because they are accounted for as immediate expenses (Brynjolfsson and Yang 1999). Firm valuation could also be challenged by factor complementarities involved in the use of intangibles. For example, the value of a customer list depends on the ability of the firm's marketing to translate this information into sales and profits.

These conceptual shortcomings have also to be borne in mind when employing empirical measures of intangibles. Here, the ratio of intangible assets for the individual sectors is calculated as the average of intangible assets as percentage of total assets, weighted by the total assets of each firm. Intangible assets include goodwill, patents, copyrights, trademarks, formulae, franchises of no specific duration, capitalized software development costs and computer programmes, organizational costs, customer lists, licenses of no specific duration, capitalized and purchased servicing rights.

Figure 3 shows the share of intangible assets for the established firms (ie the 1990 index constituents) in different old and new economy industries. During the 1990s, intangibles particularly in the form of goodwill became much more important in the telecom sectors in the United States and in Europe, in the software industry (partly reflecting the buoyant takeover activity mentioned earlier), and in the retail business.

Finally, we look at intangibles and the shift in idiosyncratic risk in the late 1990s. If there were difficulties in valuing intangibles that increase firm-specific volatility and if there was a change in financial markets' perception of risk, then the magnitude of the volatility increase should be positively related to the share of intangibles. Figure 4 plots the percentage increase in idiosyncratic risk for established firms and their average share of intangible assets.

The pattern for the United States and for Europe is quite different. In Europe, two groups of industries can be identified. One is established firms in the IT sector, for which idiosyncratic risk roughly doubled irrespective of the share of intangibles. The other (small) group consists of established 'old' economy firms with a low share of intangibles and a moderate increase in idiosyncratic risk. For the United States, the moderate increase in idiosyncratic risk for 'old' software firms is striking despite a

relatively large share of intangibles. On the other extreme, volatility jumped for firms in the telecom sector. One explanation for this pattern could be that valuation uncertainties are more important if the accumulation of intangibles goes hand in hand with a fundamental change in a firm's business model. This was, for example, the case in the telecom sector in Europe, where the national incumbents aggressively expanded into new markets as third generation mobile phone services.

4   Implications for financial policy

The general challenge for financial policy in the face of a technological shock is to strike the right balance between exploiting potential gains and avoiding risks that in the extreme could threaten the stability of the overall system. Dealing with the financial risk associated with technological innovation is important because, on the one hand, the availability of risk-bearing external finance is one precondition for the implementation and dissemination of innovation. On the other hand, insufficient understanding and management of these risks can be costly in terms of wealth losses and possibly financial instability.

To the extent that higher idiosyncratic risk is attributable to the adoption of new technologies that involve higher risk, the need increases for financial contracts that provide for a close monitoring of these risks and that facilitate their dispersion across the economy. Dealing with these risks requires adequate techniques for evaluating individual firms (perhaps including quite extreme assumptions about possible changes in business risk), as well as sufficient risk-bearing capacity of investors and corporate control mechanisms that create incentives to employ new technologies. Different combinations of financial institutions and markets can basically perform these functions. But the character of these intermediation services is such that they increasingly tend to include equity-like elements (Committee on the Global Financial System 2002). However, the proper design of such instruments and markets is not trivial.

The boom and bust cycle of global IT equity markets highlights some of the issues involved. Total wealth losses on IT equities amounted to about 6 trillion US dollar by the end of 2001 (see Figure 5). On the positive side, the huge loss in equity wealth did not trigger any major default among financial intermediaries, and the financial system showed considerable resilience. Generally, this suggests that markets provided for an allocation of risks to those sectors that were able to bear them. One aspect of this was the ability to absorb losses through sufficiently high equity. Taking into account that idiosyncratic risk made up for the bulk of volatility in total returns, risk diversification was presumably another important factor in avoiding financial instability. Risk diversification included the dispersion of exposures in the portfolios of institutional investors, but possibly also the diffusion of IT sector-related credit exposures through credit risk transfer markets.

On the other side, the boom and bust of IT equities demonstrated the challenges that innovation may pose to equity markets. Valuation problems have been substantial and do probably, as argued earlier, at least partly reflect issues with respect to the quality of information provided to financial markets. In the late 1990s, these issues were probably exacerbated by market practices and institutional settings that might not have dealt

appropriately with the specific information and valuation problems that characterize new and innovative firms. One example may be incentives to bring firms to the public equity market at a very early stage of the corporate life cycle. Another example may be the creation of exchanges for equities of new and innovative firms without having in place adequate mechanisms or standards for the provision of information about these firms or without a sufficiently broad investor base that has the capabilities to analyse information and to monitor firms.

The proper functioning of the equity market appears even more important as conditions in equity markets had considerable knock-on effects for other segments of the financial system (Committee on the Global Financial System 2002). They impacted adversely on the provision of venture capital and private equity to high-tech firms. The drop in equity market capitalization also reduced the willingness of banks and other financial institutions to provide new finance to these sectors, as the validity of earlier assumptions about the ease of refinancing existing debt finance through equity markets was undermined.

5   Conclusion

This paper calculates idiosyncratic risk based on the return of individual equities. The results provide evidence of an increase in idiosyncratic risk in the 1990s, namely of a sharp rise in firm-level volatility since autumn 1998. This pattern is directly attributable to IT insofar as a substantial part of it reflects high volatility of firms in the IT sector, and in particular that of new firms in the sector. However, it is not clear whether the increase in idiosyncratic risk results from changes in the risk perception of financial markets or from new ways of firm organization, production and competition related to IT. The jump in volatility in 1998 supports the view that the perception of risk by equity investors has changed. Finally, the positive relation between the share of intangible assets (as a proxy for IT-related changes) and the increase in firm-specific risk in the 1990s is consistent with the view that IT increases uncertainty with respect to firm valuation, particularly if associated with a fundamental change in the business model.

This paper is clearly only a first step and its conclusions are tentative. Future work will include (1) broadening the scope of the sectors analysed; (2) improving the database, for example by extending the sample and by including additional explanatory variables that capture factors as changes in corporate governance or changes in firms' leverage; (3) further develop the methodology, ideally by including fundamental factors in a multi-factor asset pricing model. Areas for further research include the actual portfolio implications of changes in idiosyncratic risk and measures of idiosyncratic credit risk.

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Chart 1

Trends in idiosyncratic risk[1]

Market risk

Industry-specific risk

Firm-specific risk

Memo item: Equity prices (Jan 1990 = 100)
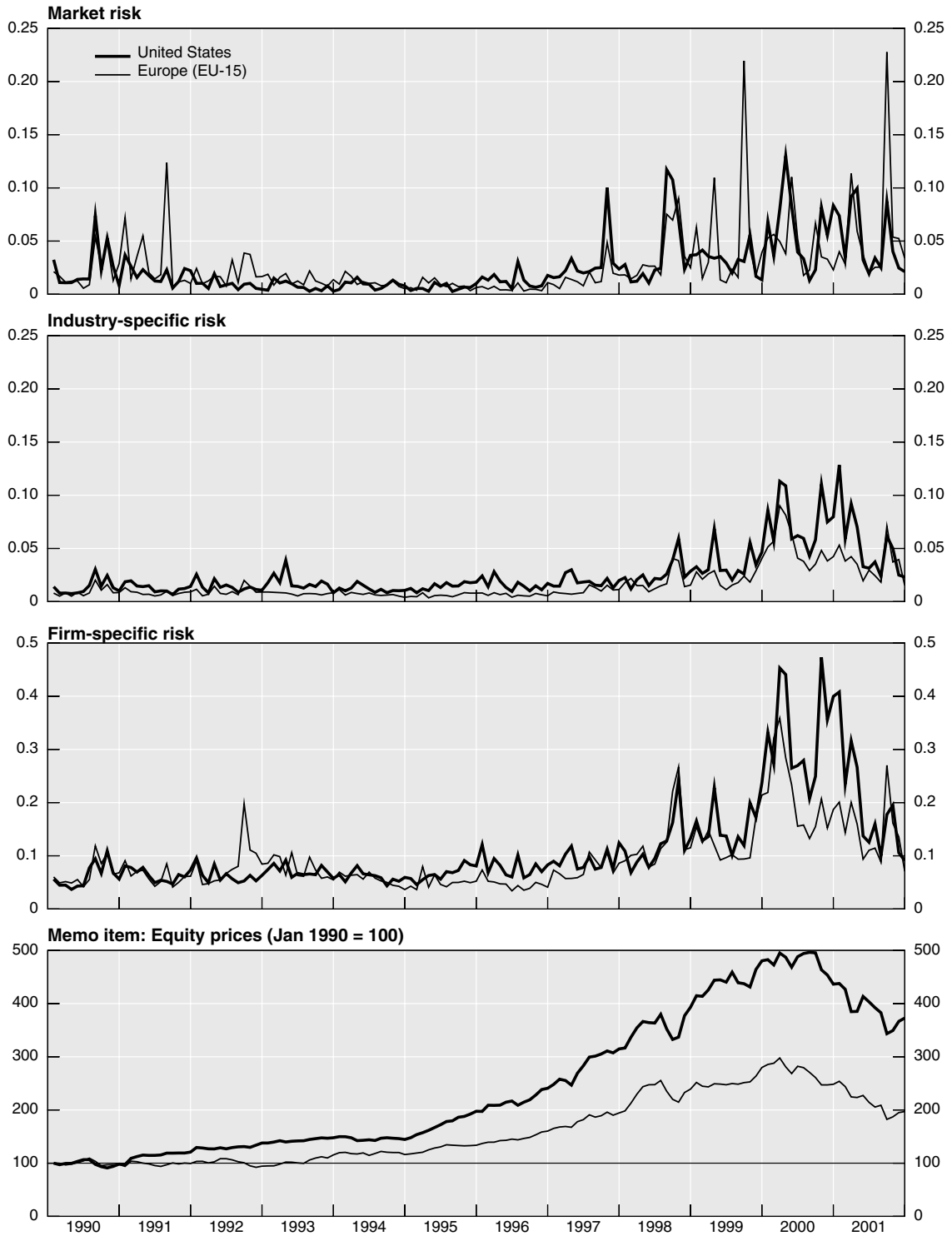
[1] Monthly annualised volatilities constructed from equation 14 (market risk), 15 (industry-specific risk) and 16 (firm-specific risk).

Chart 2

Firm specific volatility in different sectors[1]

Information technology, hardware

Retailers, general

Software and computer services

Banks

Pharmaceuticals & biotechnology

Insurance

Media

Automobiles and parts

Telecom services

Oil and gas
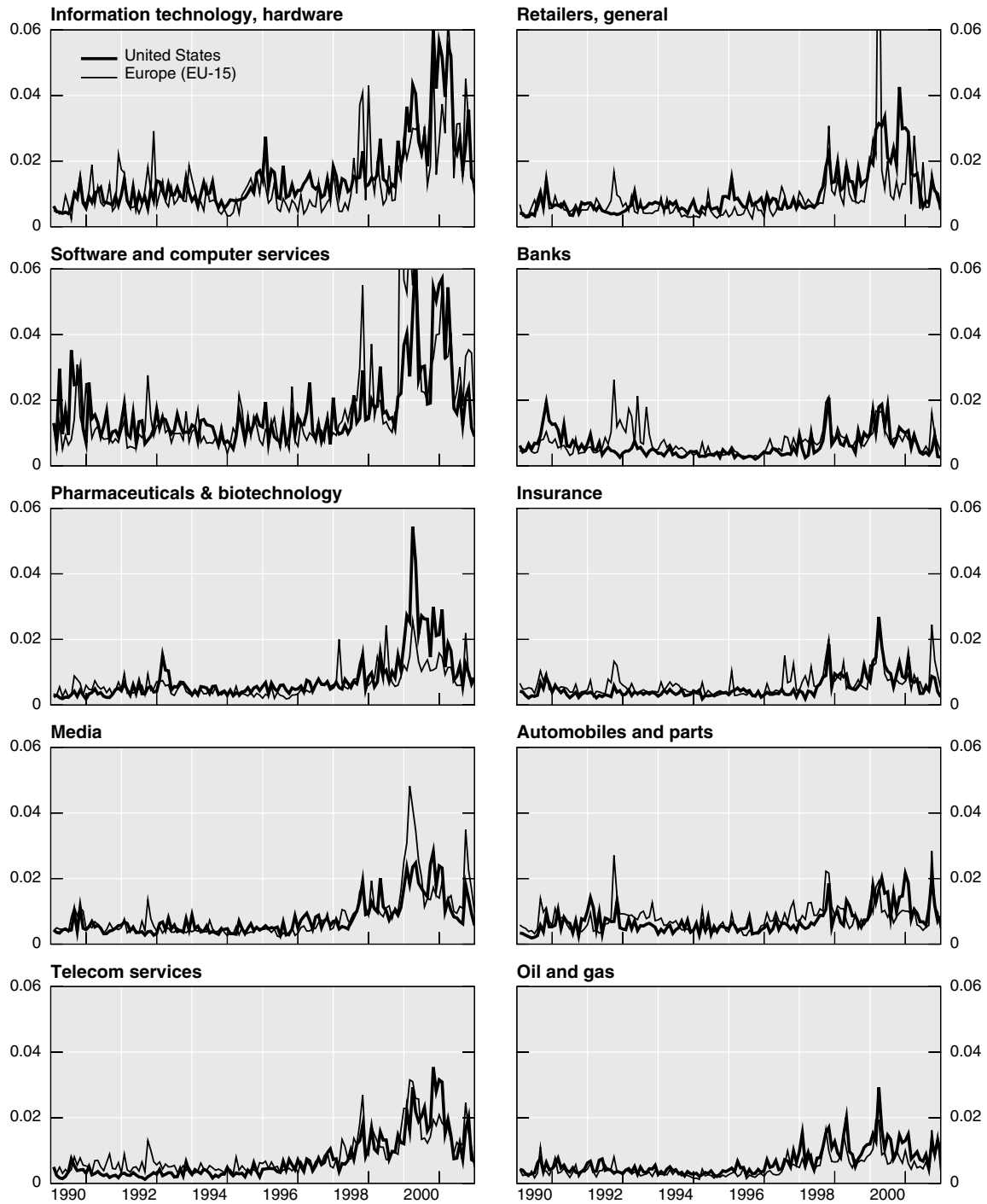
[1] Monthly annualised volatilities constructed from equation 17.

Chart 3
Share of intangible assets in different sectors[1]

United States

Oil & gas
Software & computer services
Retailers, general
Pharmaceuticals & biotechnology
Information technology & hardware
Automobiles & parts
Telecom services

1990 1992 1994 1996 1998 2000

Europe (EU-15)

1990 1992 1994 1996 1998 2000
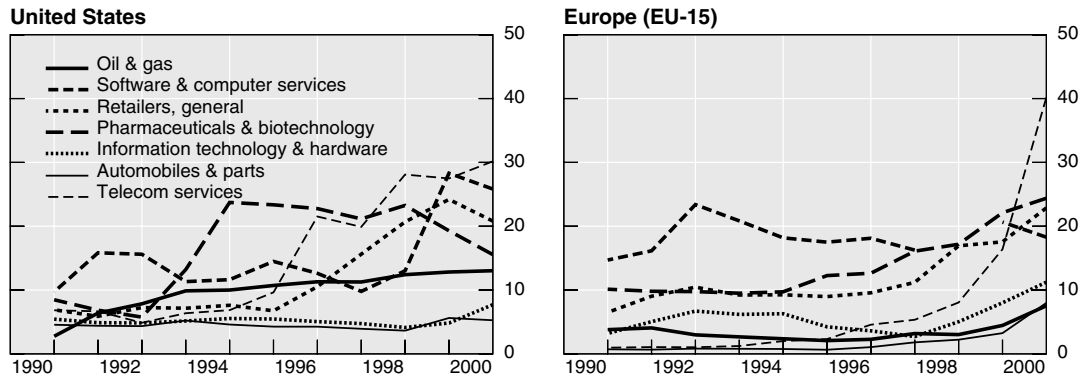
[1] Intangible assets as a percentage of total assets.

Chart 4
Change in firm specific risk and share of intangible assets

United States

Telcm

Pharm

Infoh
Autmb

Oil

Retail

Softw

5 10 15 20 25 30

Share of intangible assets[2]

Europe (EU-15)

Change in idiosyncraticrisk[1]

Retail
Infoh
Softw Pharm Telcm

Autmb
Oil

0 10 20 30 40

Share of intangible assets[2]
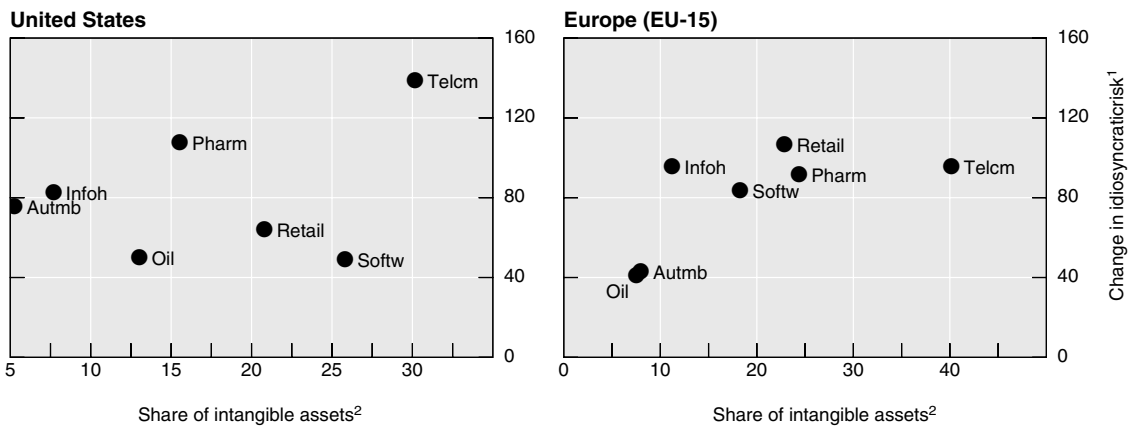
Note: Autmb = Automobiles and parts; Infoh = information technology, hardware; Oil = oil and gas; Pharm = Pharmaceuticals and biotechnology; Retail = Retailers, general; Softw = Software and computer services; Telcm = Telecom services.

[1] Average increase in idiosyncratic risk in 1999 - 2001 compared to 1990 - 1998; in percentages. [2] Intangible assets as a percentage of total assets, weighted average of the firms in the industry.

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Chart 5

Equity prices in the technology sector

Global sectors

Prices (rhs):[1]
— TMT[2]
- - - Total market ex TMT

Cumulative changes in market capitalisation (lhs):[3]
▓ TMT[2]
☐ Total market ex TMT

Global subsectors (prices[1])

Lhs:
— Telecom services
- - - Telecom equipment
····· Computer hardware
········ Software

Rhs:
— Internet
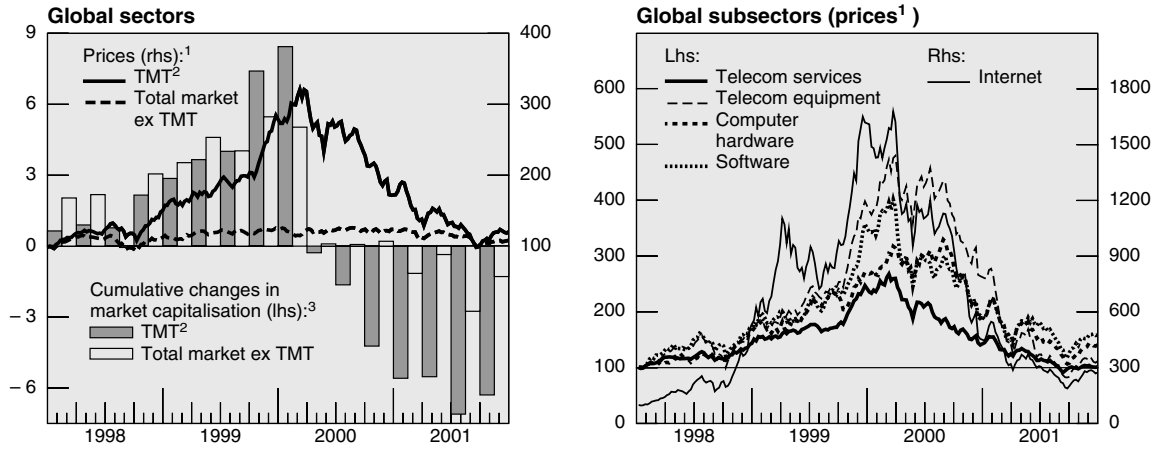
[1] Weekly averages, 1 Jan 1998 = 100.   [2] Telecom services, media and information technology.   [2] Cumulative quarterly changes for the periods January 1998 to March 2000 and April 2000 to December 2001, in trillions of US dollars.

Source: Datastream.

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Table 1
Industry characteristics [a]

Industry	United States		Europe	
	Share in market capitalization	No. of firms	Share in market capitalization	No. of firms
Pharma and biotech	10.2	83	9.1	75
Information technology, hardware	9.7	73	3.8	35
Banks	9.1	78	16.3	148
Information technology, software	6.1	42	1.9	77
Retail	5.7	46	2.1	44
Oil and gas	5.6	51	8.5	49
Telecom services	4.5	13	10.6	52
Insurance	4.2	21	5.5	53
Media	2.7	53	3.8	73
Auto and parts	1.0	26	2.0	39
Total market	(11,661) [b]	996	(6,212) [b]	2,055

Notes: [a] Datastream level 4 sector indices. Shares in market capitalization and number of firms as of end-2001;

[b] Market capitalization in billion US$.

Table 2
Trends in idiosyncratic risk – descriptive statistics and regression results

Parameter	United States			Europe		
	Market	Industry	Firm	Market	Industry	Firm
Mean	2.498	2.593	11.964	2.692	1.619	9.436
as % of total return vola	14.22	15.29	70.48	17.30	10.79	71.91
Standard deviation	2.543	2.302	8.888	3.281	1.572	5.988
Model I: Time trend						
TREND	2.49	2.99	12.91	2.15	1.91	6.79
SE	(0.37)	(0.15)	(0.56)	(0.52)	(0.40)	(0.83)
R^2 adj	0.24	0.39	0.43	0.52	0.40	0.32
Model II: Time trend and structural break						
TREND		2.05	9.57			
SE		(0.22)	(1.51)			
BREAK	2.45	1.92	9.93	2.94	2.24	7.69
SE	(0.34)	(0.34)	(1.42)	(0.45)	(0.16)	(0.65)
R^2 adj	0.27	0.50	0.58	0.23	0.59	0.51
Model III: Time trend and cyclical fluctuation						
CYCLE	0.12	0.11	0.46		0.0001	
SE	(0.03)	(0.02)	(0.08)		(0.00004)	
TREND		1.89	8.93			
SE		(0.20)	(0.76)			
BREAK	2.81	2.23	8.03		0.15	
SE	(0.18)	(0.33)	(1.21)		(0.02)	
R^2 adj	0.32	0.58	0.61		0.62	

Note: Means and standard deviations are annualized monthly figures and multiplied by 100. The trend coefficient is multiplied by 10^5, the break coefficient is multiplied by 10^3.

<div align="center">Table 3</div>
<div align="center">Average idiosyncratic risk of firms in different sectors*</div>

Industry	United States						Europe					
	w	beta	mean	SD	trend	break	w	beta	mean	SD	trend	break
Pharmaceutical	10.9	0.95	7.20	7.10	–	8,57	5.1	0.84	7.04	4.68	–	5.69
Telecom	4.6	0.89	6.83	6.52	0.04	7.08	9.9	1.28	8.37	6.07	–	8.50
Banks	9.5	1.01	5.55	3.04	-0.04	3.74	14.2	1.06	8.40	4.71	–	2.15
Hardware	11.1	1.60	14.08	9.94	0.06	8.58	3.6	1.65	9.25	7.11	–	7.79
Software	6.6	1.55	16.49	11.18	–	13.01	1.9	1.32	17.79	16.49	–	18.51
Oil and gas	5.9	0.48	4.50	2.15	–	2.29	8.9	0.73	3.99	1.91	–	1.64
Retail	6.5	1.15	8.93	5.60	–	7.51	2.6	0.87	9.55	9.45	–	8.43
Insurance	4.9	0.76	4.76	2.40	–	2.65	6.2	1.08	6.85	3.84	–	2.94
Media	2.8	0.89	8.21	5.49	–	7.59	3.7	1.01	9.34	7.51	–	10.02
Auto	1.1	0.89	5.04	2.97	–	3.75	2.9	1.04	8.18	3.78	–	1.39

Note: *Annualized monthly volatilities for January 1990 to December 2001. Mean and SD = $*10^2$, annualized. Structural break and trend coefficient = $* 10^3$.

<div align="center">Table 4</div>
<div align="center">Effect of changes in sector constituency on idiosyncratic risk</div>

	United States					Europe				
	mean[a]	%[b]	F	n_{new}	n_{old}	mean[a]	%[b]	F	n_{new}	n_{old}
Auto	8.318	+11.0	1.11	5	9	9.091	-18.3	4.80**	11	32
Banks	6.076	+1.5	0.02	8	59	9.990	-1.0	0.01	51	87
Hardware	25.469	+25.8	4.43**	42	51	15.676	+7.6	0.28	23	13
Insurance	7.076	+14.7	1.75	18	27	9.280	-3.9	0.09	17	42
Media	14.851	+25.1	5.08**	19	20	17.994	16.2	1.55	47	46
Oil and gas	6.501	+15.6	2.92*	14	25	5.287	10.6	1.24	14	25
Pharmaceutical	14.700	+44.4	5.43**	30	21	11.920	+7.5	0.35	31	16
Retail	15.500	+1.1	11.7**	18	28	16.834	+1.1	0.00	39	41
Software	27.868	+58.1	12.2**	39	22	33.961	+43.8	5.75**	90	21
Telecom	15.262	+55.2	16.7**	10	12	15.598	+26.4	5.46**	39	9

Notes: [a] Calculated as average annualized volatility of the all constituents series from Oct 1998-Dec 2001;

[b] Percentage by which the mean of all constituents series exceeds the mean of the constant constituent series. * = 10% significance level, ** = 5% significance level. n_{new} = number of new constituents. n_{old} = number of constituents by January 1990.