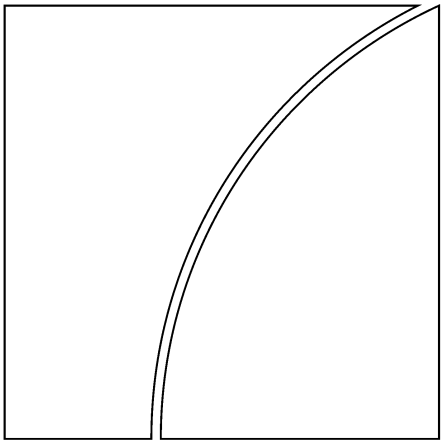
Committee on the Global Financial System



IT innovations and financing patterns: implications for the financial system

Report prepared by a Working Group of the Committee on the Global Financial System

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Executive summary

Innovation in information technology (IT) has changed the way economic activity is carried out and organised. The eventual macroeconomic outcome of these changes and the macroeconomic profile of an IT-based economy are still uncertain. The major global correction in equity prices of IT companies, the dramatic cutbacks in IT investment and the abrupt deterioration in business conditions in the United States and elsewhere have all contributed to the sense that the structural changes in the economy may well be smaller and less beneficial than some of the most enthusiastic proponents of the "new economy" had argued. Since the contribution of the most recent wave of IT development has not been observed over a full business cycle, the outcome remains uncertain. But evidence of structural changes in different countries is abundantly available at the microeconomic level, with implications for firms' financial structure and the character of financial intermediation.

By improving the availability and dissemination of information, IT has the potential to act as a catalyst for fundamental changes in production processes and in the competitive environment within *and* outside the IT sector. IT facilitates more customised production based on flexible work processes. This involves firm reorganisation that allows IT and human capital to be combined in an efficient way. As a consequence of these skill-biased production changes, intangible and non-marketable assets such as intellectual property rights and firm-specific knowledge gain in importance. In addition, incorporating performance-based incentives into compensation schemes becomes more prevalent. This fundamental transformation of the firm is mirrored by changes in the household sector. Households tend to assume more business risk both through the provision of capital and, in tendency, also through labour income.

These trends have implications for the financing needs of firms and the confidence with which firms' performance can be assessed and foreseen. Firm reorganisation towards "soft" and customised production tends to increase idiosyncratic risks. And simultaneous changes in the competitive environment and in business models may alter the risk-reward profile of firms quickly and in an unpredictable way. In tendency, the need increases for capital that bears business risk and for corporate governance structures that create incentives to adapt to new ways of production. This suggests a greater role for equity and for financial contracts that incorporate equity characteristics.

Corporate financing patterns support the notion of an increasing role for equity and equity-like instruments in the financing of both new and established firms. Venture capital has offered a way to combine funding of high-risk projects and managerial support in a flexible way for new and innovative firms, which typically lack collateral, track record and managerial experience. Established firms in the IT sector, but also in other industries, have increasingly relied on public equity and on debt instruments incorporating equity characteristics such as convertible bonds, issuance in the high-yield segment of the bond market, coupon step-up clauses or bank loans with terms contingent on the borrower's performance. The boom and bust in the IT segment of equity markets has clearly influenced external funding, but factors like the establishment of new instruments and markets for equities or related instruments suggest that there will be lasting effects.

Generally, the character and the role of different financial arrangements can be expected to change according to the altering risk-return profile and financing preferences of firms. In addition to modifications in the design of financial contracts, this would include adjustments in the valuation techniques applied by financial intermediaries and in the management of risks and exposures. One example is an increasing specialisation of intermediaries in financing firms in different stages of the corporate life cycle. Another may be greater reliance on credit risk transfer in order to achieve the desired diversification of portfolios. The boom and bust of IT equities and their impact on the financial system highlight several important issues raised in this study.

First, on the positive side the huge loss in equity wealth has not triggered any major default among financial intermediaries. This suggests that the shift of risk from financial intermediaries to investors in financial markets through increasing reliance of firms on market-based financing has provided for a better, more dispersed allocation of risks across sectors that have been able to bear them. This possibly includes the diffusion of IT-related credit exposures through credit risk transfer markets. Overall, business-related risks seem to have been distributed more broadly across the economy.

Second, valuation problems have been substantial and were probably exacerbated by market practices – eg with respect to IPOs – that might not have dealt appropriately with the specific information and valuation problems that characterise new and innovative firms. Looking ahead, greater relevance of firm-specific risks and difficulties in evaluating them is likely to affect volatility clusters in

financial markets and in particular in equity markets. While overall market volatility need not necessarily be higher, heightened price volatility of individual stocks could become a persistent phenomenon. With rising idiosyncratic risk, diversification may require larger portfolios and more widely ranged exposures than before to generate desired levels of risk.

Third, equity market conditions had considerable knock-on effects for other segments of the financial system. The decline of IT equity prices impacted adversely on the provision of venture capital and private equity to high-tech firms. The drop in equity market capitalisation 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. As equity market valuation is likely to become more central, fluctuations in equity prices would be easily transmitted to other markets. One transmission channel that may involve risk is the reliance on the equity market capitalisation of a firm as an indicator of its future earning capacity and hence its ability to service debt.

Fourth, the difficulties associated with the assessment of credit risk involved in financing innovative activities became apparent. A case in point is the telecoms sector. The quality of telecoms debt declined rapidly and the inability of some telecoms companies to arrange equity market take-outs of bank debt and rising defaults left banks with unanticipated exposures. More generally, in a climate of rapid technological change and intense competition, banks may face a rapidly evolving credit risk environment. Correlation of risk factors among sectors will change when industries expand into new markets. As a consequence, issues related to sectoral exposures or an increasing reliance on credit risk transfer tools would become increasingly relevant. And technological change challenges the reliability of backward-looking indicators (such as default histories) for credit risk assessment.

In a longer-term perspective, these experiences can be seen as part of a learning process for all participants, which may have led to significant improvements in risk management and valuation capability. However, the tentative nature of these arguments should be recognised, as it is still too early to draw final conclusions about the implications of the IT sector boom, its subsequent bust and its future course. Reconsidering and reassessing these implications should be the subject of future investigations.

The general issue for public policy in the face of a technological shock is to strike the right balance between exploiting potential gains and avoiding risks that could threaten the overall system. Financing plays a role in supporting the reorganisation of the corporate sector and in allocating the risks associated with this process. And this role is likely to increase as market-based incentive mechanisms gain in importance and the management of financial risks becomes more complex.

Main risks involved in the financing of new technologies are large-scale failures of investment projects that may damage the financial institutions providing funding and excessive price movements in financial markets resulting from unrealistic expectations. Against this background, the task of financial policy is to set a framework of standards and guidelines that allows for market-driven adjustment of financing mechanisms and encourages ongoing improvement in risk management techniques.

Central banks can play an active role in this process. One aspect of this role is employing the research capabilities and the knowledge of the financial system combined in central banks to improve the understanding of the financial impact of technological change. The other aspect is active monitoring of the financial system. Changing linkages between the real and the financial sphere and across the different segments of the financial system, and in particular the reallocation of risks across the financial system, underline the need for systemic monitoring.

Main report

1. Introduction

1.1 Motivation of the report and mandate of the Working Group

The unexpectedly strong economic performance of the United States in the second half of the 1990s gave rise to presumptions in financial markets that the economy might have undergone a structural change toward higher productivity growth. Rapid technological progress and massive investment in information technology (IT), acting as a catalyst for changes in many sectors of the economy, have been seen as core elements of such a "new economy". Over time, expectations about profitability became increasingly optimistic, especially for those firms and sectors producing or benefiting from IT. This contributed to extremely high equity valuations, notably in the IT sector, and boosted aggregate demand; by placing downward pressure on unit labour costs, rapid productivity gains also helped contain inflationary pressures. Attention has been devoted in the last two to three years to the question of whether the "new economy" phenomenon amounted to a "new economy" paradigm, and whether it was spreading from the United States to other countries together with investment in IT.

The worldwide boom – and subsequent bust – in equity prices of IT sector firms also sharpened awareness of the financial dimension of the "new economy" phenomenon. Heavy borrowing by telecommunications firms in the international bond and syndicated loan markets in 2000, the subsequent deterioration of the terms on which these firms could access financial markets, and rising numbers of defaults by startup telecoms providers have heightened the significance of IT-related developments for banks and other credit providers. And from the research side, increasing microeconomic investigation aimed at assessing possible fundamental changes in the organisation of firms induced by the use of IT capital has raised questions about the role of finance.

In September 2000, the Committee on the Global Financial System (CGFS) established a Working Group, chaired by Jürgen Stark (Deutsche Bundesbank), to explore issues related to financial aspects of changes in real economic activity resulting from the use of new technologies. The work was to involve consideration of innovations and related risks in financing practices, as well as possible changes in the role of different providers of financial services.

Since the Working Group was given its mandate, economic circumstances have changed substantially. The major global correction in equity prices of IT companies, the dramatic cutbacks in IT investment and the abrupt deceleration of economic growth in the United States and elsewhere have all contributed to the sense that the structural changes in the economy may well be smaller and less beneficial than some of the most enthusiastic proponents of the "new economy" had argued. Since the contribution of the most recent wave of IT development to productivity has not been observed over a full business cycle, the magnitude of its lasting effects remains to be determined. It is too early to know whether the sharp drop in IT investment importantly reflects the sector's underlying cyclical volatility – and the likelihood of a strong rebound – or whether it reflects a boom-bust cycle, a phenomenon observed in the course of the introduction of technological innovations such as railroads (mid- to late 19th century) and electricity (early 20th century).

1.2 Structure of the report

The Working Group held three meetings, organised as a series of discussions among senior central bankers. The background material for these discussions was research findings submitted by the central banks represented in the Working Group.[1] At its first meeting, the Working Group discussed macroeconomic and corporate finance implications of IT innovation to set the stage for follow-on

[1] The list of papers submitted to the Working Group is attached as an annex. Papers marked by an asterisk can be accessed on the BIS website (http://www.bis.org/).

discussions of issues for financial markets and intermediaries at subsequent meetings. The second meeting was devoted to the financing aspects of IT innovation, and the implications for different financing instruments and intermediaries. In the third meeting, the Group discussed possible implications for the functioning of the financial system and for financial stability.

The character of these discussions was no doubt influenced by the course of events after the Group's establishment in autumn 2000. These explain the Working Group's decision to emphasise the exploratory character of this report and the tentative nature of its conclusions. Main issues addressed in the study are

- Challenges posed by IT innovation for the financing of innovative activities, capital expenditures and the provision of financial services.
- Changes in the financing needs, funding patterns and risk profile of firms related to IT innovation.
- The impact of these developments on individual segments and the structure of financial markets, including the evolution of new market sectors.
- Possible changes in the character of financial intermediation, as well as in the individual roles of financial intermediaries.
- Implications for the functioning and stability of the financial system.

This report is structured according to the general themes addressed in the three meetings of the Working Group. Focusing on the financial aspects of IT innovation, it discusses how this new technology affects the risk-reward profile of firms and the overall economy (Section 2), how this is reflected in the financing needs of firms and the use of specific types of financial contracts (Section 3) and how these financing needs and practices affect financial markets and intermediaries (Section 4). At the end of each of the next three sections, there is an outline of remaining issues for research and policy. They are issues which the Working Group believes require further investigation. Section 5 sets out the Working Group's views on possible implications for the functioning and stability of the financial system.

2. IT innovation, investment opportunities and financial risks

Innovation in IT – comprising computer hardware, software and telecommunications equipment[2] – has triggered a period of particularly rapid technological change. At the centre of the IT innovation "shock" have been advances in the production of IT components, namely semiconductors. Cheaper IT components have stimulated progress in IT equipment production and, through rapidly falling prices, have spurred IT use in other sectors. The preparations for Y2K and very optimistic expectations regarding the business opportunities offered by IT – and in particular the internet – added to the global demand for IT goods in the late 1990s. Across G10 countries, the share of IT expenditures in GDP was in a 4% range (see Table 1). By contrast, the share of IT in trade ranged from 7.1% to 19.2%. The differences in the ranges suggest that international specialisation has played a part.

[2] There is no generally agreed definition of IT or the IT sector. In this report, the IT sector is defined as computer hardware and software producing firms, telecoms service providers and telecoms equipment manufacturers, and internet firms. The term "tech sector" is used synonymously with "IT sector" in this report (it should be noted that "tech sector" is often used to also capture high-tech industries other than IT, for example biotechnology).

Table 1

The IT sector in G10 countries

	BE	CA	DE	FR	GB	IT	JP	NL	SE	US
IT expenditure as % of GDP[1]	5.6	7.5	5.2	5.8	8.0	4.2	6.0	6.7	8.2	8.0
Value added of IT production as % of business sector value added[2]	5.8	6.5	6.1	5.3	8.4	5.8	5.8	5.1	9.3	8.7
IT total share of trade[3]	7.1	9.8	9.8	10.2	14.9	6.3	19.2	15.6	14.6	15.9

[1] Average 1992-99. [2] 1998. [3] Sum of IT exports and imports as share of total exports and imports.

Source: OECD.

On the one hand, these developments in the real economy highlight the relevance of IT capital spending and suggest that it has had an impact on the way firms are organised and markets function. On the other hand, the pronounced swing in IT investment underlines the uncertainty surrounding many of the economic implications of IT innovation, in particular the difficulties in separating cyclical effects and structural changes.

2.1 IT innovation and the risk-reward investment profile

IT innovation, production and competition

IT is a general purpose technology that can alter the efficiency of almost every *production process* by improving the availability and dissemination of information and through more decentralised, customised production.[3] An example of the former is augmented data flow within the units of a firm responsible for different stages of the production process, thereby economising on working capital requirements. An example of the latter is the ability to shift from mass production of standardised products to customised "on demand" production. Compared to past general purpose technologies, these processes may be labelled "soft manufacturing", suggesting that enhancing human capital through IT systems is more important than enhancing it by adding production machines (see box).[4]

Central to the exploitation of efficiency gains is the complementary use of IT with other factors of production, particularly computer-literate labour. Academic and central bank research looking at linkages between actual efficiency gains and the use of new technology at the firm level finds strong complementarities between the use of IT on the one hand and the quality of labour and organisation of firms on the other.[5,6] Evidence from various studies points to the key role of organisational innovations

[3] See Bugamelli et al (2001)*.

[4] See Baldwin and Sabourin (2001).

[5] Two papers submitted by the Bank of Italy analysed efficiency gains from IT use outside the computer manufacturing industry and the role of labour quality. The first study assesses the impact of IT investment on Italian banks over the past decade (Casolaro and Gobbi (2001*)). It analyses to what extent IT investment explains movements of individual banks and shifts along the efficiency frontier. The main finding is that IT capital is strongly positively correlated with cost efficiency, contributing in this way to total factor productivity increases at the firm level. The paper also finds sizeable shifts in the efficiency frontier over the sample period. These shifts can be correlated with production organisation, which may also have been a consequence of IT investment. The second paper (Brandolini and Cipollone (2001*)) estimates the impact of labour composition on multifactor productivity in the overall economy and in individual sectors. The study finds that a substantial part of the observed growth of total factor productivity vanishes when adjustments for labour quality, hours worked and capital utilisation are applied.

which enhance the competitive positions of firms that have invested in IT, eg the joint significance of IT investment and organisational innovations in traditional industries such as textile manufacturing.[7]

Changes in firm organisation and past general purpose technological "revolutions"

General purpose innovations perform or facilitate some generic function that is vital to a large segment of existing or potential products and production systems.[8] The steam engine allowed energy to be transformed into motion on a huge scale. Later, the electric motor added a high degree of accuracy and flexibility, by decoupling the location of energy production and its use. Such innovations fundamentally changed the organisation of production activities, the scope of goods provided and the character of product market competition. They also occurred alongside strong complementary changes in the use of labour.

Firm organisation. With the steam engine, factories emerged in which the motion was transferred by belts and shafts to different kinds of machines. These methods allowed the creation of large factories, but imposed serious constraints on the organisation and workflow, which had to be sited close to the energy source. The electric motor made it possible to design factories in a far more flexible way. Without energy source constraints, productivity could be improved through the rearrangement of workflow within the factory. More generally, energy could be employed in much finer dosage, supporting the specialisation of companies.

Complementarity in the use of new technologies and labour. The mechanisation of production brought by the invention of the steam engine did not replace human skills. Rather, the profitable use of machinery required workers who caused few faults and fixed them rapidly. Research supports the notion that the social conditions and institutions that encouraged the acquisition of such skills were essential to technological change.[9] Similar evidence exists for complementarities associated with the adoption of electric motors. Industries using more electricity employed relatively more educated blue-collar workers and paid them substantially higher wages.[10]

IT innovation affects the competitive position of firms both through production efficiency and changes in the goods markets. A study for the Canadian manufacturing sector shows that the adoption of many of the new advanced technologies built around computers was associated with increased growth in labour productivity and market share during the period 1988 to 1997.[11] Gains were larger when software, hardware and network communications were adopted jointly. And again, the adoption of IT appears to have the greatest impact where it is effectively combined with human cognitive capabilities.

In addition to changes in the production process, IT innovation may alter the *competitiveness of markets*.[12] IT provides firms with powerful tools for more effective price discrimination. These include 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. IT is crucial in this respect not only because it allows such "personalisation" of goods, but also because it enables firms to collect and process the information necessary to identify consumer taste. Another factor is supply side and demand side economies of scale ("network effects"). These effects create the

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6 A recent study by McKinsey also emphasises the importance of business process changes for reaping the full productivity benefits of IT (McKinsey Global Institute (2001)).

7 Empirical evidence for factor complementarity between IT, human capital and reorganisation is presented in Bugamelli and Pagano (2001)*.* For the United States, see eg Black and Lynch (2000).

8 See Bresnahan and Trajtenberg (1992) for a discussion of the features of general purpose technologies.

9 See Bessen (2000).

10 See Goldin and Katz (1998).

11 See Baldwin and Sabourin (2001).

12 For an overview see Varian (2001) and the discussion in DeLong and Summers (2001).

possibility to boost profits by increasing supply at very small marginal costs and by achieving a "critical mass" in demand. As a consequence, economies of scale favour business strategies trying to gain market share or to establish industry standards. Finally, there is substantial competition arrives alternative technologies, such as fibre-optic cable versus high-speed telephone lines.

Implications for the character of financial investments

In sum, IT innovation may – through the reorganisation of production activities and changes in the competitive environment – alter the productivity and profitability of firms in the IT sector and in other industries rather quickly in ways that cannot be readily forecast. As a consequence, individual investment projects tend to become riskier. However, if the firm successfully adapts to the new technology, the return on investment can also be expected to be higher than otherwise.

Higher individual investment risk puts a greater onus on risk diversification. The shift towards "soft", customised and information-based production probably reinforces the tendency toward higher idiosyncratic risk.[13] As a consequence, a broader range of assets may be required to achieve diversification. Although the IT innovation "shock" does not necessarily mean increased systematic, non-diversifiable risk, exploiting the potential for diversification may require portfolio adjustments.

Changes in production towards more skill-based activities may also require adjustment of incentive structures and corporate control mechanisms. A likely response would be a heightened reliance on equity markets for setting compensation of staff and management, through mechanisms that link the level of remuneration to overall corporate performance. These changes not only affect firms in the IT sector, but – through changes in the competitive environment – also create pressures for many firms outside the IT sector.

The role of the labour market may also change. Remuneration of labour tends to become more flexible, with company practice more frequently aimed at linking workers' pay more closely to company performance. In addition, households might be increasingly exposed to business risk through larger holdings of equities (or other financial instruments bearing higher business risk).[14] As a consequence, the demand for mechanisms that facilitate risk mitigation may well rise for the household sector. Possible adjustments to such changes include changes in portfolio composition and, possibly, increased household saving.

2.2 IT innovation and financing conditions at the macroeconomic level

IT innovation, productivity and asset prices

A sustained increase in aggregate productivity growth has been considered as the headline feature of a "new", IT-based economy.[15] Faster productivity growth will boost equity prices by raising expected corporate earnings growth. This may occur through different channels. A pickup in the growth rate of output per hour as a result of a more rapid pace of innovation for a certain period of time would affect growth via additional investment and higher consumption (because of increasing permanent income and rising equity wealth). The potential growth rate of the economy would rise and the equilibrium rate of unemployment might decline temporarily. As a result, earnings – and hence equity prices – would

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[13] For empirical evidence on the increase in idiosyncratic risk, see Campbell et al (2001).

[14] It should, however, be noted that real estate still forms the major part of household wealth.

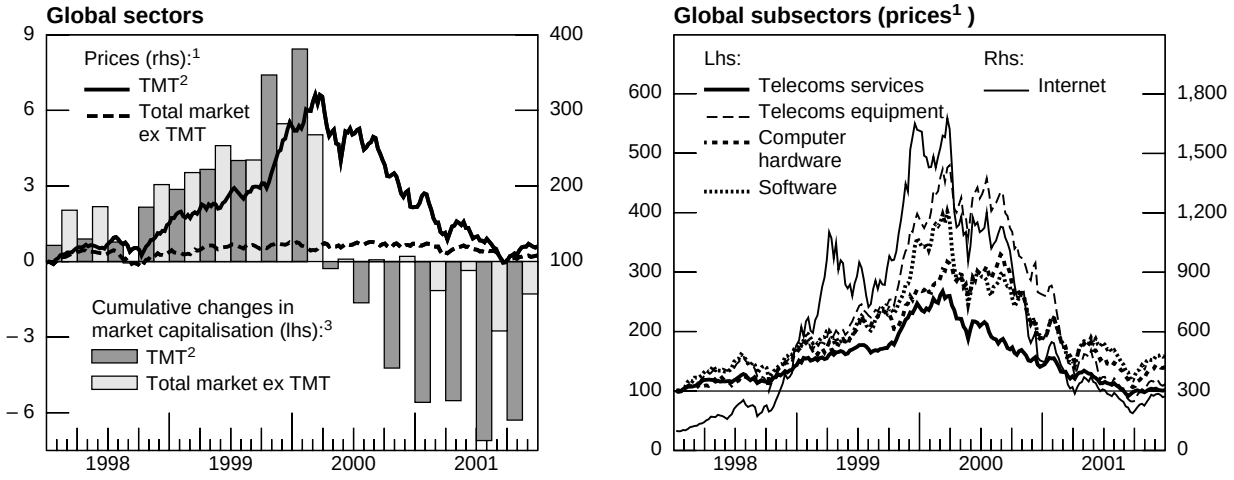
[15] The strong US productivity growth in the second part of the 1990s has the potential to explain much of the macro performance observed in the United States. Plausible simulations support the view that three fundamental and interrelated factors – a technology-led acceleration in productivity, an increase in government saving caused in part by that acceleration, and changes in international conditions (especially the appreciating US dollar) – account for a large part of the overall evolution of the US economy from 1995 to 2000. The recent data revisions do not fundamentally change these results. See Brayton and Reifschneider (2001)*.

rise, in particular in the IT sector, but also in other industries benefiting from productivity gains and higher demand.[16]

Given that financial market prices tend to reflect expected future outcomes in current valuations, they will tend to move before the underlying changes in earnings growth actually materialise. The fact that expected productivity and profitability drive asset prices is particularly relevant during periods of rapid technological progress that are vulnerable to overly optimistic expectations regarding the profit opportunities of new technologies. The boom and bust of global IT equity markets underlines the dynamics that such changes in expectations can unleash (see Graph 1). Sharp movements in the prices of financial assets can threaten the stability of financial institutions when they encourage an overexpansion of balance sheets and excessive risk-taking during the up phase. Although the decline of IT sector equities – with the benefit of hindsight – strongly supports the notion of a sharp overshooting of equity prices, there is no one answer as to what constitutes an "appropriate" valuation level.[17]

Graph 1

Equity prices in the technology sector



[1] Weekly averages, 1 January 1998 = 100. [2] Telecoms services, media and information technology. [3] Cumulative quarterly changes for the periods January 1998–March 2000 and April 2000–December 2001, in trillions of US dollars.

Source: Datastream.

Sharp movements in the prices of broad categories of financial assets are not a unique feature of the IT sector boom. In the past, the development of other general purpose technologies, such as railroads, had also been accompanied by overshooting in financial markets (see box). However, in contrast to earlier technology-related boom-bust cycles in equity markets, the huge loss in equity wealth since spring 2000 has not triggered any major default of financial intermediaries. This suggests that the actual distribution of losses is crucial for the financial system impact of such episodes.

In an international perspective, actual and expected productivity and growth *differentials* are likely to influence international portfolio diversification and capital flows.[18] The patterns of countries' external

[16] Several background papers submitted by Working Group members discuss issues related to IT, productivity and macroeconomic performance. For the United Kingdom, see Bakhshi and Larsen (2001)* and Oulton (2001)*; for Canada, see Lalonde and Lecavalier (2001)*, Crawford (2001)* and Macklem and Yetman (2001)*.

[17] Several factors could contribute to high valuation levels, such as declining equity risk premiums or lower discount rates. See eg Bosomworth and Grittini (2001)*.

[18] Internationally, substantial productivity differentials remain, even after taking into account that some of the divergence in productivity growth – particularly between the United States and Europe – can be explained by the significant problems in comparability and availability of IT related data. Issues related to the statistical measurement of IT innovation are discussed in, eg, Cette et al (2001)*, Oulton (2001)*, and Scheuer (2001)*.

current account positions (and corresponding gaps between domestic saving and investment) that have emerged or been accentuated since the mid-1990s may be attributed in part to differences in growth rates of investment in capital employing new technologies. The strong US dollar and high net foreign investment have indicated relatively favourable expectations regarding the return on investments in the United States. Existing "imbalances" associated with IT innovation may persist as long as expectations of high productivity growth and elevated expected returns on investment prevail. But if expectations are not realised, the question arises as to whether an unwinding of such "imbalances" will occur smoothly or abruptly.

The international correlation of tech sector equity prices has been strong, with the Nasdaq generally taking the central role. This underlines the global character of the IT "shock" and emphasises the particular relevance of sector-specific factors.

Past general purpose technological "revolutions": macroeconomic patterns

Innovation in IT is frequently classified as a technological "revolution" comparable to those brought about by general purpose technologies such as steam power in the early 19th century or electricity in the early 20th century.

From a macroeconomic perspective, these innovations exhibit some common patterns, although the overall effects on growth differ considerably and are extended over a very long period. In most cases, the gains from innovation involve three stages: productivity increases in the innovating sector; falling prices that encourage capital deepening; and gains from significant reorganisation of production activity around the new technology. The IMF presents figures for the use of the steam engine in the United Kingdom and electricity in the United States, indicating that the benefits arising from the reorganisation of production activities in the long run outweighed those from productivity increases in the innovative sector itself.[19]

Turning to financial markets, another similarity is the high volatility of equity prices of firms active in the innovative sector. For example, the financing of railroads in the United Kingdom in the 1840s was accompanied by a boom and the subsequent collapse of the equity market capitalisation of railways. Sizeable fluctuations in equity markets driven by swings in sentiment about the prospects of railways also occurred in continental European countries.

IT innovation and the variability of aggregate output

It is still unclear whether IT has a significant and lasting effect on the volatility of aggregate output and hence on financing needs and risks over the business cycle. One possible influence that has been addressed in research is inventory management. The decline of inflation and output volatility in the United States since the mid-1980s may partly reflect the fact that the application of IT improved inventory management in the durable goods sector.[20] Updated information about anomalies could be incorporated into production schedules in a more timely fashion, thereby reducing volatility in the inventory component of aggregate demand.

More efficient management of inventories by firms should be mirrored by a corresponding decline in their working capital needs and hence in the costs of financing their inventories. This would reduce the impact of movements in short-term interest rates on financing costs. Better inventory management could therefore mitigate the adverse effect of a rise in interest rates on corporate cash flow and profitability, thereby dampening the overall business cycle.

[19] See IMF (2001).

[20] See Kahn et al (2001)*.

Another factor possibly affecting the volatility of aggregate output is increased use of stock options and profit-linked compensation in the remuneration of labour. The effect may be ambiguous. On the one hand, increased pay flexibility may – by acting as a shock absorber – improve the ability of companies to deal with economic downturns, and in this way contribute to a less disruptive economic cycle (eg by lowering pressures for layoffs). On the other hand, workers' likely procyclical preference for stock options versus cash compensation may exacerbate the swings in overall economic activity (eg employees demanding increasingly to be compensated in cash when firms are financially more pressed because of adverse economic developments).

Major questions, and areas for future research, remain with respect to the cyclical behaviour of the economy. One is whether the behaviour of aggregate demand components other than inventories has also changed. Another is what possible changes in the real business cycle imply for the need for specific types of financing, for example short-term loans to bridge cyclical financing needs.

IT investment itself may be an important source of macroeconomic volatility. In the early stages of realising the productivity benefits from IT as a new general purpose technology, uncertainty associated with the long-term profitability of IT-related investment projects may make investment decisions prone to swings in sentiment. Greater flexibility in the timing of IT investment, reinforced by the possibility that IT investment is more sensitive to changes in the cost of capital than other capital spending, may work in the same direction.[21] However, it is not clear a priori how important these effects are in practice. For example, competitive pressures and the need to update IT equipment may limit the discretionary character of IT investment.

2.3 Issues for public policy and research

From a financial perspective, the IT innovation "shock" can be interpreted as a shift of the investment opportunities curve towards a much greater supply of high-return, high-risk projects. While a higher level of output volatility at the firm level may therefore well be an inherent feature of an economy experiencing an increased rate of innovation, the shift of the investment opportunities curve also increases the ex ante margins of error and uncertainties for potential investors and market participants.

These uncertainties have implications for financing arrangements, such as the menu of available financial contracts, and for the degree of confidence attached to forecasts of firms' performance. As past episodes of general purpose innovation suggest, the shift of the investment opportunity curve towards higher-risk, higher-return projects goes together, seemingly inevitably, with perceptions of heightened difficulties in evaluating risks and returns and probably also with large swings in sentiment.

Given the problems that exist with respect to the diagnosis of asset price misalignments, one main issue is what specific financial mechanisms or conditions in the financial system might have contributed to an overshooting of prices. In addition, in an effort to strengthen the resilience of the financial system to shocks, it is useful to review mechanisms that might have helped to mitigate the disruption caused by the collapse of equity prices in the technology sector. Some of these issues are discussed in later parts of this report.

One specific aspect related to avoidance is the quality of statistical data. Inaccurate and perhaps misleading data may increase uncertainty and hence add to volatility in financial markets. This may be particularly relevant because economic agents' improved ability to modify their behaviour may have made the economy as a whole more responsive to the timely reception of information. Rapid technological change and the emergence of new activities heighten the trade-off between the timeliness of statistical information and its comprehensiveness. The magnitude of the statistical discrepancies highlights the risks to the preparation of informative economic statistics presented by IT. Such potential adverse effects underline the case for consistent statistics in order to address the issue of comparability and interpretability.[22]

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[21] Tevlin and Whelan analyse the aggregate behaviour of capital stock in the United States and find that IT investment is far more sensitive to the cost of capital than non-computing equipment (see Tevlin and Whelan (2000)).

[22] More generally, it points to the broader issue of deteriorating quality of macroeconomic data. Deteriorating data quality may, for example, affect the central bank, as labour market conditions become more difficult to assess. One aspect of this is

3. IT innovation and firms' financing needs

IT facilitates complementary innovation, enabling firms to increase output via the introduction of new processes and altering the competitive environment, thereby creating pressure for firms to adjust. Meeting these challenges will require changes in the organisation of firms, eg in the form of vertical disintegration, streamlining of managerial levels and more decentralised production, and a well educated labour force able and motivated to exploit the opportunities offered by new technology. This may have far-reaching consequences for the nature of the firm and for the issues involved in the financing of such a transformation:[23]

- Firms are becoming increasingly "knowledge-based" and intellectual property rights define an increasingly important part of the firms' assets.[24]
- The corporate control dimension of financial contracts is important. Only if firms are willing to change their production process and internal organisation will skilled workers be able to make more profitable use of advanced technologies. In other words, effective incentive structures for management and, increasingly, for staff are necessary to exploit potential advantages based on factor complementarities.
- Potentially, a very broad range of corporations in different industries, of different sizes and at different stages of product life cycles is affected. The financing arrangements of this broad variety of companies do, and indeed should, vary considerably.[25]

In assessing the firm-level financing implications of IT innovation, three different types of firms should therefore be considered: new, small high-tech firms seeking start up and early stage finance; established firms in the high-tech sectors seeking later stage finance; and established firms outside these sectors in the process of financing their adoption of new technologies. There are likely to be marked differences in financing needs between these different groups and in the barriers they face when seeking external finance.

3.1 Financing of tech sector firms

Funding of IT sector firms was considerable in the second half of the 1990s. National statistics indicate *net funding* of such firms of about 16% of total funding of non-financial enterprises in G10 countries in the period from 1995 to 2000 (see table).[26] In addition to the general boom in IT demand, several country- and subsector-specific factors contributed. Investment in telecommunications infrastructure in recent years (in the form of fibre-optic networks in the United States and mobile phone infrastructure in Europe) generated financing needs exceeding the amount of internally generated funds even in the case of large and established firms. IT equipment manufacturers expanded in line with the overall buoyant demand, with providers of telecoms equipment benefiting from the infrastructure investment

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understating labour productivity, which may in turn wrongly indicate increases in unit labour costs. Another aspect is a widespread use of compensation schemes (such as stock options) whose operation not be adequately captured by traditional survey techniques.

[23] See Frankel (2001)*.

[24] Several empirical studies confirm an increasing weight of intangibles in the IT sector and innovative firms in general. Brierley and Kearns (2001)* employ company accounting data to calculate the ratio of intangible to tangible assets for the United Kingdom. The ratio rose from very low levels between 1974 and 1986 to nearly 100% in 1996 for both old and new economy firms. Since then, however, the ratio has fallen back for non-IT firms, while continuing to rise for IT firms (to 129% by 1998). Planès et al (2001)* show disproportional investment in intangibles for innovative French companies as opposed to non-innovative firms. Several authors use equity market capitalisation as a proxy for firm value in order to calculate intangible-tangible asset ratios (see eg Brynjolfsson et al (2000)). While supporting the view of an increasing share of intangibles in corporate assets, such a methodology depends on equity market valuations of firms and may hence be subject to large fluctuations.

[25] See Brierley and Kearns (2001)*.

[26] It should be noted that the figures presented in the table are based on national definitions which are not fully consistent across countries (see footnotes). In addition, the aggregation over several years masks the generally high volatility of IT sector funding. Thus, the purpose of the table is merely to provide a general picture of the overall size of IT sector funding and its structure.

boom. External funding of internet firms soared in 1999 from a very low level, but fell back dramatically in 2000.[27]

Turning to the *structure* of funding, great caution needs to be exercised when talking about "the high-tech sector", as it may comprise quite different technologies with different financing needs and risks even within the IT sector. For example, while in the software industry development costs are relatively low and lead times from product to market launch are relatively short, upfront investment may be very high and lead time very long in the case of a telecoms provider. Beyond technology-specific differences, the firm population within the different segments of the IT sector may differ considerably in terms of the size of firms and their position in the business life cycle.

Table 2

External funding of IT sector firms in G10 countries[1]

	BE	CA	DE	FR	GB	IT	JP	NL	US
in billions of US dollars									
funds raised by IT sector firms	8	64	68	33	97	9	48	33	310
equity	4	50	33	4	23	6	20	13	–76
bonds	–	5	–18	11	63	0	–4	20	272
Bank loans	3	2	–1	8	12	3	–3	–	–
in % of total IT firm funding									
equity	46	78	49	12	24	61	42	40	–25
bonds	–	7	–26	33	65	1	–9	60	88
bank loans	39	3	–2	26	12	32	–7	–	–
in % of total funding of non-financial enterprises	5	30	8	8	29	9	na	15	15

[1] Sum of net funding 1995-2000, US$ figures calculated at year-end exchange rates. DE: 1996-2000 equity includes public and private equity; FR: 1996-2000, equity includes public and private equity; GB: estimated figures for 1998-2000, equity and bonds: gross issuance; IT: 1996-1999; JP: 1996-2000, equity: gross issuance.

Source: National statistics.

Although lack of comparability and comprehensiveness of data makes cross-country comparisons fraught with difficulty, it does appear that the great variations in the funding structure of the IT sector on aggregate in different countries partly reflect differences in the sectoral composition. The available data on specific subsectors (telecoms service providers, hardware and software producing firms) show more similarities across countries, although substantial differences are also discernible (see Graph 2). For example, telecoms service providers heavily relied on bond markets in all countries concerned. In contrast, public equity was the most important source of funding for hardware and software firms. This

[27] Net external funding of internet-related firms in the United States considered in a study by Antoniewicz increased by about 400% to $10.5 billion in 1999, declined to $6.7 billion in the first half of 2000 and contracted by $0.8 billion in the second half of 2000 (see Antoniewicz (2001)*).

[28] There is no generally agreed definition of IT or the IT sector. In this report, the IT sector is defined as computer hardware and software producing firms, telecom service providers and telecom equipment manufacturers, and internet firms. The term "tech sector" is used synonymously with "IT sector" in this report (it should be noted that "tech sector" is often used to also capture other high-tech industries than IT, as for example bio technology).

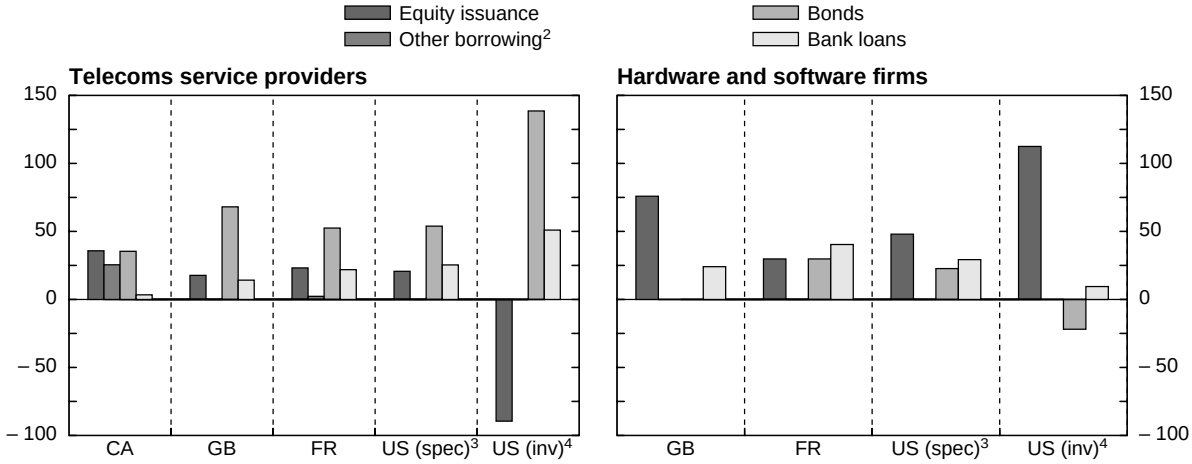
supports the view that the technology, "corporate life cycle" considerations[29] and the prevailing business model – eg in the case of telecoms, massive infrastructure investment and takeover activity in order to position firms in perceived "winner takes all" markets – are important for financing patterns. One common element, irrespective of these differences, is the relatively high importance of equity funding compared both with other sources of funding and with the financing of non-IT sector firms.

New tech sector firms

Theoretical studies suggest an optimal overall capital structure for new, small tech sector firms that is rather different from that which generally applies to new firms in the non-tech economy.[30] The majority of the firms outside the IT sector are financed broadly in line with the "pecking order hypothesis", which states that internal finance is less costly than external funding because of the absence of informational problems. Firms that require external financing tend to opt initially for debt rather than equity. The pecking order hypothesis emphasises that it reflects the fact that equity investors facing information asymmetries in assessing the risk-reward relationship may require a deeper discount on newly issued equities than banks that have built a relationship with firms require on debt. Such a relationship may help to mitigate information problems to the extent that knowledge acquired by the bank may (partly) substitute for the firm's track record.

Graph 2

Financing patterns of telecoms and computer firms[1]



[1] Share of total funding calculated on the basis of 1998 and 1999 net funding. [2] For France, private equity. [3] Speculative grade. [4] Investment grade.

Theoretical considerations suggest some alteration of this pecking order for tech startups. Once internal funds are exhausted (and this may occur more quickly if high-tech firms are slower to progress to sustained profitability), such firms will need to seek equity finance if their only remaining assets are intangible (or without a certified market value) and therefore unsuitable as collateral for debt finance. In addition, large informational problems may remain even in the case of an established banking relationship, as it may not assist in assessing the prospects of a new technology in an unexplored market. But substantial fixed costs, such as underwriting and advisory fees, make it uneconomical for high-tech firms to raise small amounts of public equity at these early stages. Their lack of size and trading record will also tend to preclude them from meeting the listing criteria of public exchanges. This suggests that these firms will need to seek private equity finance, especially from the venture capital industry, at an earlier stage than equivalent non-tech small firms.

[29] For a discussion for the financial growth cycle, see Houben and Kakes (2001)*.

[30] For an overview, see Brierley and Kearns (2001)*.

This partial reversal of the pecking order hypothesis for external financing of high-tech startups will be dependent on the ability of venture capitalists to mitigate information asymmetries, and thereby reduce potential agency conflicts with entrepreneurs. One possibility is that while entrepreneurs may have better information on project-specific aspects such as the feasibility of the technology, venture capitalists may have a comparative advantage in business management and the project's marketability and operational implementation. In addition, contractual arrangements that give the venture capitalist the right to take managerial control under specific circumstances help to reduce potential agency conflicts.[31]

The funding structure of the internet sector is basically in line with the modified pecking order as the subsector is populated by rather new firms. Both in France and in the United States – the two countries for which figures on this subsector are available – internet firms relied largely on public and/or private equity. However, in 1999 and the first half of 2000 high-yield corporate bonds became the most important source of funding for US internet firms.[32] This analysis leads to an identification of the period (1999 and the first half of 2000) as deviant – an assessment confirmed by the speed with which the market subsequently dried up. With credit spreads widening dramatically in the high-yield bond markets in the fourth quarter of 2000, the market basically closed to new IT sector firms.

Established firms in the tech sector

As noted above, the optimal capital structure of established firms in the tech sector should differ from that of startups. Firms that have successfully launched a new product typically face rising financing needs for the exploitation of business opportunities. At the same time, access to public equity and bond markets becomes easier and cheaper, even though the value of such – in many cases large – firms still depends to a high degree on intellectual property rights. However, valuation problems are mitigated by at least some track record with respect to the marketing of products to established customers. In addition, as the firms expand, they will achieve production levels which generate more tangible assets, including receivables, inventories and fixed assets, which can all be pledged as collateral. Finally, external corporate control becomes easier to the extent that the management requires less hands-on support and monitoring can increasingly rely on ongoing coverage by stock analysts and credit rating agencies for equity and debt finance respectively. Finally, the increasing size of financing needs makes the fixed costs associated with tapping public markets less significant.

One major presumed difference between established firms in the IT sector and those in other sectors of the economy is the pace of innovation and obsolescence: high-tech firms have shorter product cycles. This line of argument implies that established firms in the tech sector will be viewed as potentially providing high return, with high risk relative to those elsewhere in the economy.[33] Certain types of finance appear better suited for such risk-return profiles, such as equity, both public and private, and near equity in the form of junk bonds. Once access to public equity markets has been gained through initial public offerings (IPOs), secondary offerings will be a possible further source of external finance for established firms. Alternatively, such firms may seek to increase leverage through debt finance.

Empirical evidence suggests that established firms in the high-tech sectors generally have not faced major difficulties in accessing debt finance, and greater "maturity" of firms has been associated with greater reliance on debt finance, in particular through the issuance of bonds. In the *United States*, investment grade telecoms service providers – which as incumbents are at a more mature stage of

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[31] Venture capitalists may also be able to reduce agency conflicts through the provision of quasi-equity, such as convertible and/or preferred stock, rather than full equity finance. Such quasi-equity facilitates a state-contingent allocation of cash flow, voting and control rights, thereby enhancing the management of potential conflicts of interest between the entrepreneur and the venture capitalist and giving the latter active control at an early stage of the corporate life cycle. Empirical evidence suggests that the use of convertible or preferred equity is fairly widespread in venture capital finance.

[32] For France, see Duvivier (2001)*. For the United States, see Antoniewicz (2001)*.

[33] Empirical evidence on the riskiness of tech sector firms as compared to other companies is mixed. Brierley and Kearns (2001)* calculate expected failure probability from characteristics such as profitability and capital gearing. Based on this indicator, expected failure probability was lower for the median IT sector firm than for the median non-IT firm. However, they also note that IT firms on average faced higher debt costs than non-IT firms, an observation consistent with the notion that IT firms bear more risk.

development – leveraged balance sheets in the second half of the 1990s by paying down substantial amounts of equity, while raising sizeable amounts of funds in the bond market. (See Graph 2 on p 13). Speculative grade startup telecoms service providers were net issuers of equity and also fairly large issuers of bonds. In *Europe*, telecoms service providers sharply increased leverage in 1999 and in particular in 2000 in order to finance takeover activities and licences for third-generation mobile phone services.

With respect to the use of equity financing by established firms, major differences are discernible between continental Europe and Japan on the one hand and the United States and United Kingdom on the other. In the former countries, the equity market is basically a "one-way street" for corporations – ie it is used to raise funds. In the United States and (to a lesser extent) the United Kingdom, by contrast, the net redemption of equities by established firms indicates a "two-way" use of equity. Evidently, the most important dimension is related to corporate control mechanisms. First, the link between management compensation and corporate performance through equity options – a feature particularly widespread in innovative firms – may encourage equity buybacks as a means of preventing dilution and maintaining the share price. Second, the possibility of takeover may discipline the behaviour of corporate managers. Another dimension that has been important at times has been the opportunity to raise leverage in order to enhance returns on equity. More generally, an active "two-way" equity market has provided an attractive option for the financing of restructuring or refocusing firms.

3.2 Financing established non-tech sector firms adopting new technologies

For established firms outside the tech sector, adapting to a new technology poses different challenges for financing. The actual financing demands associated with the adoption of a new technology will need to be met. But the availability of funding is probably less of an issue. Information asymmetries are low because the firms tend to have (sometimes very long) track records. This is likely to result in the firms having access to external financing through public markets, or possibly through established banking relationships. Collateral and internally generated funds will generally be available.

However, the adoption of IT-related innovation, and the associated changes in the business model, may tend to increase information asymmetries, and monitoring and agency problems may therefore become, at least temporarily, more relevant for the providers of external financing. The main problem associated with investment by non-tech firms in IT capital goods may be the high degree of uncertainty of the results. Reorganising production activities in a manner designed fully to exploit the possibilities offered by more powerful software and computers can imply huge sunk costs.[34] At the same time, much IT-related innovation provides substantially greater information in usable form about production processes, risks and departures from plan than previous technologies, which could facilitate both internal and external monitoring. To the extent, however, that the benefits of improved monitoring are not passed along to external stakeholders, the combination of uncertainty and information asymmetries can produce inefficient outcomes.

The growing importance of human capital and of complementarities between labour and capital in generating returns also has implications for the financing of established firms outside the tech sector. The risk-reward relationship associated with investment in such firms may become more difficult to assess, given that their value is dependent on the ability to retain human capital in a rapidly changing competitive environment. This raises questions about firm valuation and the usefulness of new methods of credit risk measurement also for firms outside the tech sector.

It is important to note that, besides employee stock options, there exists a broad range of incentive mechanisms related to the performance of firms in various countries. These instruments basically differ with respect to the degree to which they make use of market evaluation when assessing performance.

[34] See Bugamelli et al (2001)*.

Employee stock options

Employee stock options are an increasingly important element of the organisational design through which firms seek to motivate employees to enhance and make use of firm-specific skills. In addition, stock options are used as a substitute for cash compensation by firms that face cash flow constraints. Moreover, younger firms tend to rely more heavily on stock option programmes than older ones. Finally, the practice of repricing options when industry share prices fall supports the view that the use of options is motivated by an interest in restoring the efficacy of incentive effects.[35] However, as to the power of stock option-based incentives, one open question is the extent to which their acceptance as a substitute for cash compensation was boosted by the bull equity market of the late 1990s.[36]

Increasing reliance on stock options as an incentive mechanism may have implications for financial markets.

- Stock option-based employee compensation may further add to the difficulties that exist with respect to firm valuation. On the one hand, expected returns on equity need to be sufficiently high to provide incentives to beneficiaries of such programmes. On the other hand, the actual performance of firms – and hence equity prices – increasingly relies on the ability of companies to retain and make efficient use of human capital. The effect of this circular relationship – equity prices depend on firm value and vice versa – is difficult to assess, particularly in an environment of generally falling equity prices.
- The widespread granting of stock options to employees might have affected aggregate compensation data. A study considered by the working group found that recalculated US labour compensation data displayed no downturn in growth in the late 1990s. That is, when granted stock options are incorporated into the data series, the adjusted series does not display anomalous negative growth in a period of tightening labour markets.[37]
- Reliance on employee stock options may augment the cyclical effects that firms are facing. Booming equity markets allow firms to substitute options for cash payments, while firms would be forced to come up with more cash payments just when cash flow is deteriorating.

3.3 Issues for public policy and research

IT innovation and longer-term implications for firms' financing needs

It is an open question whether IT innovation changes the overall needs of firms in terms of their *size and time profile of external financing*. It is in particular not clear that the pace of IT investment that drove the funding needs of IT firms will revert to the level experienced in the late 1990s or that some of the funding patterns observed during this period (such as the funding of internet firms in the high-yield bond market) will re-emerge.

However, the introduction of IT-related changes in firm organisation can be facilitated by access to compatible financial contracts. The success of IT innovation is dependent on corporate control mechanisms embedded in financial contracts. Moreover, financing has to reflect the changing risk/reward-relationship underlying such investment. This reality has been recognised in recent years through initiatives to create new equity market segments for innovative firms (such as the Neuer Markt, and TSE Mothers). The difficulties experienced by these initiatives with the plunge in the IT equity market require careful assessment to avoid responses that could undercut the possibility of responsibly "reopening" equity markets to innovative firms.

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[35] See Carter and Lynch (2001).

[36] Liang and Weisbenner (2001)* find that about three quarters of the growth in the use of employee stock options in the United States in the second half of the 1990s has been due to rising stock prices.

[37] See Mehran and Tracy (2001).

How important is the impact of IT innovation outside the tech sector?

Three general observations support the thesis that IT innovation will bring about more substantial changes outside the IT-producing sector than within. One is the sheer size of the non-IT sectors, which widens the potential scope of IT application as a general purpose technology. A second factor is the strong empirical evidence developed by researchers on the role of factor complementarities in realising productivity gains. And finally, firm-level empirical studies confirm that the ability (or inability) of a firm to use IT may strongly influence the likelihood of success.

Sector information on IT use is available for Canada, the Netherlands, the United Kingdom and the United States.[38] Among the areas using IT relatively more than average in the total economy are general services, trade, finance and insurance. On the manufacturing side, electrical and optical equipment and machinery are heavy users of IT. These indications underline the widespread use of IT outside the tech sector. What is not readily discernible from studies to date is the relative contribution of two alternative sources of productivity gains: the combination of IT investment with complementary changes in firm organisation and the role of competitive forces affecting firms regardless of whether they are adapting to new technology or not.

This said, a first challenge is to assess the relevance of IT-related changes for firms' risk-reward profile. Evidence based on interviews carried out by the Working Group suggests that US banks monitor clients' use of IT as part of assessments of firms' future prospects. German banks confirm that when monitoring firms' credit quality, they check on the extent to which the firms are adapting to relevant IT developments. In interviews, Dutch banks commented on their efforts to develop indicators to gauge the adequacy of IT investments in the future. Japanese banks are observing IT-related changes outside the IT sector that may imply lower financing needs, such as the application of supply chain management and the introduction of cash management systems.

4. Financing implications of IT innovation

Given that IT investment has the potential to be an important influence on the risk-reward profile of firms, outside stakeholders have an incentive to seek out information and develop assessments on the implications of IT for their risk exposures. From the financing perspective, the general issue is the extent to which different institutional settings and financial systems address these problems. This section discusses these questions for equity and debt markets and for venture capital.

4.1 Equity markets

Funding in public equity markets has played a major role in the financing of established tech sector firms across most of the G10 countries relative to other sources of funding and relative to the funding of non-financial corporations as a whole. Generally, the size of equity funding of IT sector firms has been influenced by the size of the overall equity market. This suggests that the degree to which equity financing and investment in equity is established in an economy (the "equity culture") may be relevant to the availability of such funds for IT firms.

With the marked correction in tech equity prices since March 2000, equity funding has slowed substantially or even dried up, the most extreme case probably being internet firms. While US internet firms raised $3.2 billion in the first half of 2000, net funding fell back virtually to zero in the second half.[39]

Valuation of IT sector firms and market functioning

The valuation mechanism that open equity markets provide is in general not different for IT sector firms. The prices and market values generated in this process indicate the (expected) profitability of

[38] See Pilat and Lee (2001).

[39] See Antoniewicz (2001)*.

investments. By doing so, market valuation in principle also exerts a disciplining effect on managers. Suboptimal management performance tends to drive a wedge between the potential value of a firm's assets and its market value, creating incentives for outside investors to replace management. However, the actual valuation of IT sector companies differs distinctly from that of other firms (see Table 3).[40]

- Valuation *levels* in the tech sector have been much higher than in the old economy sectors. Indicators such as the market-to-book-value ratio[41] or price-earnings ratios rose to much higher levels in the tech sector than in other segments of the equity market during the bull phase and remain higher even after the marked correction in high-tech equity prices over the past two years.
- Price *volatility* has been persistently high.
- The weight of country-specific or local factors in equity prices is declining relative to sectoral determinants.[42]

From the perspective of market functioning, it is of particular interest whether the price patterns observed for IT equities reflect structural changes in information processing in equity markets or whether such changes are attributable to the specifics of IT firms. Two sets of factors may matter in this respect. One is the character of information available for the valuation of IT firms and the applicability of "traditional" valuation models. The other relates to changes in the market microstructure that might have contributed to the overshooting of equity prices.

The characteristics of the *information available* for the valuation of tech sector firms matter in several respects. Generally, (potential) investors face high uncertainty regarding the equilibrium price levels for inputs and outputs, which makes it very difficult to make longer-term projections of corporate earnings. This uncertainty stems from a number of factors: a high rate of innovation in the sector; uncertainty about future returns; and specifics in the organisation of production processes, involving an increasing role for intangible and firm-specific assets. In the longer run, as IT disperses through the economy, those uncertainties would not necessarily be confined to tech sector companies.

A related problem is greater uncertainty about the appropriate *valuation model*. The valuation of new, innovative firms is difficult, relative both to historical standards and to positioning benchmarks within the industry. This calls into question the reliability of models based on time series data. Moreover, it is frequently difficult to apply "comparable company" analysis or to define the appropriate peer group for innovative firms because such analysis requires, for example, assumptions about future market share. Qualitative techniques and assessments, and hence subjective judgments, are seemingly becoming more important for evaluating tech sector firms.[43] The fact that some IT equity analysts were celebrated as "gurus" during the IT sector bull market may be an (extreme) by-product of the reliance on "soft" information.

The greater emphasis on incentive structures in executive compensation packages might have influenced the functioning of equity markets. One set of arguments is linked to the fact that during the tech sector boom equities were widely used for financing mergers and takeovers and as compensation for employees. Such use of equities adds to existing incentives for management to influence equity valuations. Sound accounting and internal control practices, backed by external audits, are typical controls for such incentives. But high-tech firms, especially those with substantial intangible assets, pose challenges to traditional accounting frameworks that can provide the opportunity to overstate income and market worth.

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[40] See Fornari and Pericoli (2001b)*.

[41] The MBTV ratio gauges the difference between the value market participants assign to a company and its capital accumulation.

[42] Fornari and Pericoli (2001b)* show a steady increase in the correlation between US and European TMT, but also "traditional" sectors.

[43] For a summary of valuation techniques applied to technology stocks, see Lünnemann (2001)*. The important role of "soft" factors in evaluating firms is also emphasised by Ayrer et al (2001)*.

Table 3

Equity market valuation of TMT[1] equities vis-à-vis total market

		United States	Euro area	Japan	Canada	United Kingdom	Sweden
Price-earnings ratio							
Average 1995–2000:	TMT	32.3	27.9	76.0	30.1	31.3	48.5
	non-TMT[2]	21.1	17.7	54.6	17.7	17.7	15.9
Latest[3]:	TMT	49.9	30.3	87.8	45.9	128.8	21.0
	non-TMT[2]	24.3	14.8	36.0	16.1	16.6	11.8
Volatility[4]							
1995–2000:	TMT	23.7	21.7	23.7	24.3	20.4	38.0
	IT	30.3	29.4	25.0	31.9	22.5	39.8
	Telecom	20.2	23.0	29.8	20.9	26.0	36.8
	non-TMT[5]	17.7	14.9	19.0	16.8	17.0	20.5
Mar 1995–Dec 2001:	TMT	40.2	38.9	36.8	40.8	39.7	56.4
	IT	49.1	51.1	40.0	67.1	53.9	65.0
	Telecom	28.1	38.1	44.4	22.9	44.9	45.7
	non-TMT[5]	23.0	19.6	22.5	20.4	20.9	23.2

[1] Technology, media and telecoms. [2] Datastream calculated series "Market ex TMT". [3] End-December 2001. [4] Historical volatility calculated as standard deviation of annualised daily percentage changes in the price index during calendar months. [5] In order to obtain volatilities for sectors of comparable size, non-TMT volatility is calculated as the weighted average (weights: market capitalisation) of historical volatilities of market subsectors ("FTSE level 3 classification") excluding those containing information technology, media and telecoms.

Sources: Datastream; BIS calculations.

Another line of argument emphasises the potential for conflicts of interest with respect to IPOs of tech sector firms. In general, pre-issue shareholders (in particular venture capitalists and management) retain a portion of the firm after it goes public and this encourages the firm to choose the optimal timing and financial structure for the IPO. When demand for tech sector stocks was high, there was an incentive to bring firms to the market at an early stage of the firm's life, both for management and for underwriters.[44] The former group – as pre-issue shareholders – might have been particularly interested in a public listing as they could expect an increase in their wealth.[45] At times, the information problems and increasing reliance on assessments based on quantitative indicators put greater onus on the valuation process by the financial intermediaries engaged in bringing new firms to the public market. Finally, the relaxation of issuing requirements and the opening of special market segments for tech stocks in recent years has also facilitated the earlier listing of tech firms on public exchanges.[46]

[44] An indicator of the strong demand for IPOs in 1999 and 2000 is the return on the first day of listing. In the United States, the average return on the first trading day reached 70.9% in 1999 and 57.3% in 2000, compared to 24% for the period 1990–2000 (see Ritter (2001). On the Frankfurt stock exchange, the average initial return on IPOs peaked at 78.6% in 1998, remained high in 1999 and 2000 (44.3 and 46.2%), and fell back to 20.8% in the first quarter of 2001 (see Lünnemann (2001)*).

[45] See Loughran and Ritter (2000).

[46] Mouriaux and Verhille (2000)* cite other structural features of equity markets that might help transmit valuation uncertainties into excessive price fluctuations. One set of arguments emphasises factors that potentially contribute to a lack of diversity in opinion, thereby favouring self-sustaining price increases. Index-linked asset management could be such a factor because allocating capital to track a benchmark portfolio requires buying and selling assets in line with the movement of the overall market. Although this phenomenon is not unique to listed companies in the tech sector, it may add to price movements

Relevance of equity market conditions for the availability of other funding

Factors that reduce the efficiency of the price formation process in equity markets also affect the terms of other forms of financing for firms at all stages of their life cycles. As noted above, firms at an early stage of the corporate life cycle are likely to be heavily dependent on the availability of venture capital and private equity. The availability of both kinds of financing is likely to be positively related to a functioning IPO market offering an exit for venture capitalists and private equity investors. Moreover, high stock prices tend to support merger and acquisition activity, offering another exit channel for investors in private equity.

Similar relationships exist in the terms and conditions of bank credit and bond finance. One linkage is through the use of equity market valuations in the assessment of creditworthiness. High equity market capitalisation may indicate high potential value of a company's assets and future strong earnings growth, which would both signal a high future capacity to service debt. These signals have become used in a formulaic manner for the assessment of default risk and the pricing of corporate credit, for example in Merton-type models.[47]

Moreover, the depth and liquidity of both the primary and secondary equity markets may also affect the provision of debt finance to tech firms, inasmuch as banks may be more prepared to extend bridging loans to tech firms, on the presumption that these firms will be able eventually to reduce gearing by issuing new equity or refinancing in the equity market. This linkage has been particularly important in the telecoms sector but has certainly not been confined to it. A major threat to the continued financing of tech firms on existing terms and conditions could arise if the substantial correction in equity values over the past two years fundamentally undermines the validity of earlier assumptions by debt providers about the ease of equity market refinancing of the previous accumulation of debt.

4.2 Debt markets

Financing the IT boom has involved the creation of considerable amounts of debt. Taken together, gross issuance in the bond market and syndicated loan arrangements for IT firms amounted to $1.6 trillion from 1998 to 2001 (see Table 4). Within the IT sector, telecom firms have relied most heavily on debt financing (about $1.3 trillion from 1998 to 2001). This reflects high financing needs of telecoms operators arising from massive infrastructure investments and buoyant takeover activity. Other established tech sector firms have also relied on the debt markets (although in some countries tech sector firms faced higher credit costs than companies in other sectors). Lending to firms in the IT sector has been subject to increasing credit risk differentiation, particularly visible in the credit spreads for telecom bonds.

While the debt financing of large and more established tech sector firms is basically consistent with the theoretical considerations discussed above, two other observations are rather surprising. One is that banks have provided unsecured debt financing to new, innovative firms in some countries.[48] Although it is not clear whether such lending is widespread – when it does occur it is probably on a small scale – *any* interest by banks in exploring such financing opportunities seems surprising given the perceived riskiness of such lending.

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resulting from the valuation uncertainties mentioned above. The emergence of electronic trading platforms and the associated decline in transaction costs has been cited as another factor possibly working in the same direction, because such changes facilitate market access for uninformed investors.

[47] Such a link can be established by viewing a firm's debt as a short put option, with the strike price equal to the debt's face value. The valuation of this option – ie the debt – reflects uncertainty about the future value of the underlying asset. If increasing equity market volatility is interpreted as higher uncertainty, it should lead to a decline in the value of the debt (see Cohen (2000)).

[48] See eg Pozzolo (2001)*.

Table 4

Debt financing of IT sector firms (in billions of US dollars)[1]

		Computers/software		Electronic equipment		Telecommunications	
		bonds	**loans**	**bonds**	**loans**	**bonds**	**loans**
1998		1.2	11.6	4.0	18.5	52.7	138.7
1999		7.5	25.5	5.9	36.0	83.6	167.8
2000		12.3	22.4	14.3	37.8	119.4	333.8
2001		11.6	28.5	22.4	37.0	145.4	215.3
Total		32.6	88.1	46.6	129.3	401.1	855.6
of which	US	23.8	55.6	6.5	84.6	99.1	411.3
	EU 15	2.6	9.5	23.7	13.5	227.2	275.4
	Japan	3.4	11.5	6.2	9.9	11.4	37.1

[1] Announced international and domestic issues/loan facilities.

Source: Dealogic Capital Data.

The other observation is that, overall, tech sector borrowers do seem thus far to have been able to access increased bank finance when funding in securities markets became more difficult in the second half of 2000. For example, while bond issuance halved between the second and fourth quarters of 2000, the amount of syndicated loans doubled. To the extent that this reflects increased usage of loan facilities arranged earlier and the rollover of credits, the question is whether banks have appropriately priced these facilities. Against the background of these developments, concerns have been raised that lending to tech sector firms may be inappropriate for banks and that there may be a concentration of related credit risks, particularly exposures to the telecoms industry, in the banking sector (see box).

Bank lending

IT-related changes may influence the effectiveness of the different mechanisms and methods that banks use for screening, contracting and monitoring borrowers. The most important methods utilised by banks to reduce information and incentive problems are relationship lending (where information is gathered through continuous contact with firms and is used to determine contract terms and monitoring strategies) and the taking of collateral. The lack of collateral in the early stages of the tech firm life cycle places the onus on the screening of borrowers, that is identifying potentially successful business strategies, and the monitoring of the investment process.

Whether banks are in an advantageous position compared to other financiers with respect to access to information and the ability to assess such information crucially depends on the origins of information asymmetries and uncertainties. Banks may, for example, have superior information regarding conditions in local or regional markets where they may possess particular knowledge. However, a lack of technical expertise may be a negative factor in financing tech firms, which is generally not offset by greater familiarity with traditional businesses. This increases the risk of technology-related misjudgments and may also create incentives for borrowers to engage in riskier projects than contracted.

In later stages of firm development, information problems are less relevant because creditors can more readily employ the usual risk mitigation techniques. However, this does not preclude the fact that modifications may be necessary compared to the standards traditionally applied. A greater importance of non-tangible assets may either require adjustments in collateral practices or, again, more emphasis on the monitoring of borrowers. Similarly, changes in the business model of established firms may call for a more intense monitoring of customers.

In addition to intensified monitoring, other adjustment mechanisms within the banking sector are conceivable. One possibility is specialisation with respect to the financing of specific projects. As such strategies probably involve significant economies of scale, they might create additional incentives for concentration in the banking industry or for (narrow) sectoral specialisation of smaller banks. Specialisation in the origination of loans could be facilitated by the use of credit risk transfer tools, which would allow both the originating banks and the purchasers to construct diversified loan portfolios of many small loan positions and thus avoid portfolio risks that reflect any possible sectoral concentration in loan origination.

Debt financing of the telecoms sector

Increasing attention has been paid to bank exposures to telecoms. Gross lending to the sector exceeded US$ 1 trillion from 1998 to 2001. As external funding has become increasingly difficult amid deteriorating earnings prospects and the ongoing need to finance investment in new networks, the issues of the transparency of financing relationships and the opacity of exposures to telecoms-related sectors, such as telecoms equipment providers, have loomed large. Vendor finance for telecoms equipment providers or leasing arrangements may add to the riskiness of these related sectors in the case of difficulties of a telecoms service provider, without necessarily being transparent.[49] Although corporate credit exposure arising from business activities is nothing unusual, the amounts accumulated by several telecoms equipment manufacturers with exposures to telecoms service providers as Ericsson, Nokia or Siemens were apparently much higher than that of the average firm.[50]

With respect to possible general issues for debt financing of IT-related innovation, two observations seem to be of particular interest.

- The business risks that became apparent in the financing of telecoms operators combine several features characteristic of IT innovation. The first is technological uncertainty related to the development and marketability of new technologies. Such risk has materialised from the need to postpone the introduction of 3G mobile phone technology. The second relates to network effects and increasing economies of scale that are partly reflected in aggressive takeover strategies and have also contributed to high debt levels. Third, in the case of incumbents in the European market, the change in business plans within an "old economy" firm (and substantive cash generation from "old" activities) has raised questions about the implications of such repositioning on the long-term creditworthiness of established firms.
- The speed of deterioration in credit quality even of the European "national champions" among the providers of telecoms services highlights the uncertainties surrounding risk assessment and management for firms exposed to such IT-related business risks (see Graph 3).

The ability to absorb shocks also depends on the liability structure. One adjustment here could be a shift from (protected) deposits to liabilities participating in losses (such as subordinated debt), thus better matching equity-like products created on the asset side of the balance sheet.

Specific issues may arise with respect to loan commitments. Such arrangements are presumably particularly relevant to the intertemporal smoothing of external financing for firms largely relying on funding in open markets.[51] However, they involve additional risks. As firms are likely to draw on such

[49] Issues related to vendor finance are, for example, the conditions under which such finance is granted and the ability of the providers of vendor finance to monitor exposures.

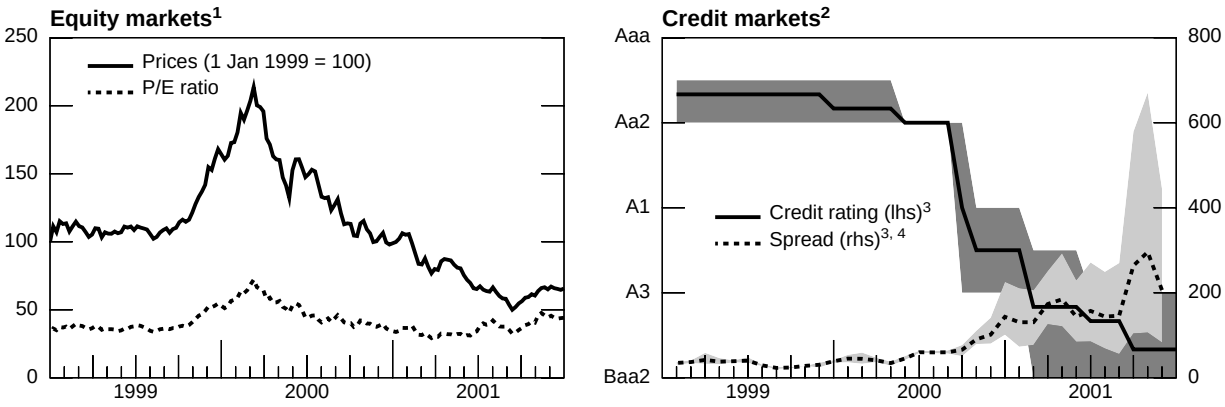
[50] The corporate credit exposure of Ericsson amounted to 52% of corporate assets, and that of Nokia and Siemens to 40% and 39% by the end of 2000, compared to 20% on average Europe's 50 largest public companies (see Peterson (2001)).

[51] This argument would be consistent with research findings that market (and international) financing are positively correlated with overall economic performance, and that the diversity of types of external financing is associated with lower GDP volatility (see Davies and Smith (2001)*.

lines when other sources of funding dry up, risk assessment requires careful analysis of the prospective ability of the borrower to service debt when making use of the loan commitment. And banks might attempt to take a greater role as arrangers and underwriters of loans and standby facilities in order to compensate for firms' declining reliance on "traditional" lending.

Graph 3

Financial market indicators for European telecoms firms



[1] Euro area telecoms service providers. [2] Unweighted average of Deutsche Telekom, France Telecom and KPN. [3] The shaded area represents the range around the average. [4] Bond yields of euro area telecoms against euro swap rate, in basis points.

Sources: Bloomberg; Datastream; BIS calculations.

Public debt markets

In recent years, public bond markets have addressed the uncertainty about the future creditworthiness of tech sector borrowers (as mentioned above, mainly telecoms firms) in two different ways. One is issuance in the high-yield segment of the markets, implying that the bonds have – in terms of risk premia and ex ante returns – the character of quasi-equity investment. The high-yield market has been an important source of funding, mainly for US speculative grade telecoms firms, but also for internet firms. The other development has been an increasing reliance on bonds that include convertibility features and coupon step-up clauses. Large European investment grade telecoms borrowers in particular have used these types of finance.

The two approaches have in common that they take into account the specific risks of tech sector firms by means of structures incorporating equity-like characteristics. The state-contingent nature of returns raises the issue of monitoring mechanisms. For example, coupon step-up clauses rely on the exercise of rating agency judgment. From the perspective of investors, bonds with step-up clauses provide a kind of "automatic" compensation for declining credit quality and hence reduce the need for ongoing monitoring. From the perspective of borrowers, rating changes immediately affect financing costs not only at the margin, but also for outstanding debt if a downgrading triggers higher coupon payments.

Credit derivatives markets have probably facilitated debt financing, in particular of telecoms firms. The use of instruments such as credit default swaps has allowed banks to reduce exposures by transferring credit risk to other institutions and to diversify portfolios.

4.3 Venture capital

As noted earlier, the provision of venture capital enables financiers to manage the monitoring and agency problems associated with the financing of high-tech firms through customised financial contracting. In venture capital arrangements, control rights, cash flow rights and liquidation rights can

be allocated separately and their potential exercise can be linked to the performance of the firm being financed.[52]

Contractual incentives linking the compensation of the venture capitalist to business success encourage more informed analysis of the commercial possibilities of new technologies.[53] Lenders interested solely in securing sufficient cash flow to service debt do not normally have such incentives. The close involvement in the business activity implied by such contracts provides venture capitalists with superior information to banks and investors in public security markets, particularly with respect to the marketability of specific projects and their operational implementation. As a consequence, venture capitalists may be better able to assess the risk-reward relationship than debt providers, especially if they can mitigate information asymmetries through reliance on particular types of equity finance such as preferred and/or convertible stock.[54]

Venture capital combines elements also found in other financial contracts in a flexible way and requires transfer into other forms of finance as firms mature and financing needs increase. Hence, open "exit" channels to other forms of finance are important complementary elements of a functioning venture capital market. In turn, as mentioned earlier, reliance on public equity markets as an exit mechanism makes the supply of venture capital sensitive to conditions prevailing in the equity market.

Overall, there is a divergence in the relative importance of venture capital (as a percentage of GDP, see Table 5) in 2000 between the United States, the United Kingdom and Canada on the one hand and continental Europe on the other (although venture capital grew rapidly in many European countries in the second half of the 1990s). The concrete form of venture capital financing differs markedly between different countries, potentially having a significant impact on the projects actually financed.

Table 5

Venture capital in the G10 countries

	BE	CA	DE	FR	GB	IT	JP	NL	US
VC invested in 2000 (bn US$)[1]	0.5	4.2	4.4	4.9	12.3	2.8	7.1[2]	1.2	102.6
VC/GDP	0.2	0.6	0.2	0.4	0.9	0.3	0.2	0.3	1.0
Number of VC firms	102	110	229	83	135	82	190	52	5,506
Share of VC invested in tech sector (%)[3]	57	85	53	51	36	23	–	38	84

[1] Total gross investment, US dollar figures calculated at end-of-year exchange rates. [2] 1999. [3] Including IT, biotechnology and life sciences. Definitions may differ as figures are based on national statistics.

Source: National statistics and BIS calculations.

One factor is the structure of capital providers. Channelling the funds of institutional investors to venture capitalists is an important step towards meeting the financing needs of firms of a non-traditional and innovative nature. For example, the share of venture capital invested in IT and other high tech sectors tends to be higher in countries where investment funds are a major source of funding for venture capital firms as opposed to countries where banks were the main providers of funds.

[52] For a discussion of the role of venture capital finance, see eg Cayen (2001)*.

[53] In the United States, incentive problems related to venture capital finance are addressed though the compensation of the general partner as the specialist who finds, structures and manages investments. The bulk of the general partner's compensation comes from sharing the profits of portfolio investments. This construction protects the limited partners, who provide capital but enjoy extensive oversight of the general partners' activities (see Covitz and Liang (2001)*).

[54] See Brierley and Kearns (2001)*.

4.4 Issues for public policy and research

Does the structure of the financial system matter for exploiting the benefits of IT innovation?

There is no general answer on the extent to which financial constraints matter for the dissemination of new technologies through the economy. The existence of financiers willing to assume business risk has to be complemented by many other factors, such as – perhaps most importantly – Schumpeter-type entrepreneurs able to identify new business ideas and willing to realise them. Many other "real" factors, such as an entrepreneur-friendly tax system, are important as well. In addition, funding investment in IT and complementary human and organisational capital by established firms should generally not pose an obstacle to the spread of IT innovation through the economy.[55] On these grounds, finance may in general represent less of a problem than sometimes assumed.

However, there are two possible caveats to this view. One is that countries with more market-oriented financial systems and in particular with larger venture capital markets have generally experienced a greater contribution of the IT sector to economic growth.[56] This would be consistent with the observation that venture capital is of particular importance for the development of new, knowledge-based industries and that a developed equity market is required as an exit route for venture capital investments and for the provision of sufficient risk capital in later stages of the corporate life cycle. Generally, an underdeveloped venture capital market warrants the attention of public policy, including issues such as investment opportunities for institutional investors and the existence of market segments complementary to a functioning venture capital market.[57]

The second is related to the capacity of different financial structures to deal with higher idiosyncratic risks of established firms adapting to new technologies. 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.

The financing of IT-related change and the risk of "excesses"

With past boom-cycles going hand in hand with technological innovation, it may be argued that the IT sector exuberance was not the last episode of overshooting expectations and swings in sentiment. And with hindsight, the capacity of the financial system to generate funds for investment in new technologies (in particular through venture capital and equity) has seemingly been associated with the risk of overinvestment.

Against this background, one issue is the appropriate specialisation in processing information across the financial system. Given the increasing importance of the price formation process in the equity market, mechanisms and structures that may support efficient equity valuation need to be identified. In a global context, the general convergence of accounting standards should enhance the transparency and comparability of corporate accounts and hence support efficient valuation. Regulatory initiatives to promote transparency should also work in this direction. However, addressing issues specifically related to new technology – such as the valuation of non-standard and intangible assets – in a way that anticipates valuation problems that may occur in the next technological cycle is a challenging task.

Another issue is how the resilience of the financial system against (unavoidable) "errors" in the process of technological progress can be strengthened. The fact that the collapse of tech sector equities has not led to any major failures of financial institutions is a reassuring sign as regards the allocation of financial risks through reliance on market mechanisms. One interesting question for future

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[55] See Bugamelli et al (2001)*.

[56] See Houben and Kakes (2001)*.

[57] Examples of initiatives addressing these issues are the European Community's Financial Services Action Plan and the Risk Capital Action Plan. These plans have been adopted to remove barriers to pan-European financial market integration in general and to foster venture capital funding for innovative businesses in particular.

research is how and to what extent specific regulations and incentive mechanisms for institutional investors and banks have influenced their actual performance during the boom and bust of the tech equity market.

5. Implications for financial stability and public policy

Risk management and risk allocation

Greater relevance of firm-specific risks and difficulties in evaluating them is likely to affect the volatility pattern in *financial markets,* particularly equity markets. While market volatility need not necessarily be higher, greater price volatility of individual stocks could become a more frequent or even persistent phenomenon. Shifts in the structure of price co-movements across firms and sectors are reflected in reconfigurations of volatility clusters.

As equity market valuation is likely to become more central, such price movements would be easily transmitted to other markets. One channel of transmission that may involve particular risks is the reliance on the equity market capitalisation of a firm as an indicator for its capacity to service debt. Using market capitalisation as "implicit" collateral may create incentives for the firm's management to increase leverage at times of buoyant equity markets. Declining equity value could then confront creditors with – possibly very rapidly – deteriorating credit quality, and actual losses. Beyond this negative impact on the profitability of creditors, their likely reaction – a tightening of credit standards – would add to deteriorating financing terms in equity markets. The future relevance of such effects would, however, depend on how quickly and in which way market participants adjusted to the shortcomings of specific valuation techniques.

Another channel involves the transmission of price volatility both to real investment through greater reliance on equity finance and to consumption through equities forming a larger part of household financial assets and remuneration being linked to equity performance. Possible repercussions on the financial system, eg in the form of an increased vulnerability of the household sector, would crucially depend on the distribution of such losses.

The risk management of *financial institutions* would also have to address the negative consequences of higher idiosyncratic risks and uncertainties regarding firm valuation. In particular, this would affect the capacity to employ credit histories to generate debt default estimates confidently. Intensified monitoring would not be limited to IT and other high-tech sectors since borrowers in "traditional" sectors have become more vulnerable to mistakes related to the choice of technology. Creditors would need to be realistic and vigilant about the constantly evolving credit risk environment. At the portfolio level, similar problems would occur if the business links, and hence the correlation of default risk between sectors, changed. Moreover, risk mitigation techniques would have to be adjusted, for example with respect to the valuation of collateral. If idiosyncratic risk is rising, then portfolio diversification may require larger portfolios and more exposure to generate desired levels of risk than before.

It is unclear (and perhaps unlikely) that these issues would surface simultaneously and immediately cause a concentration of loan problems. However, a deterioration could occur quite abruptly (as the rapid downgrading of telecoms firms has demonstrated) and reinforce problems, in particular in an economic downturn when credit conditions are perceived to be worsening.

IT innovation may also *shift the sectoral allocation* of business-related risks. One dimension of this is an increasing reliance on compensation that is more variable over the cycle. Rather indirectly, heightened competition in goods markets and the erosion of producer rents would be beneficial for individual consumers, but may expose individuals to higher risk as suppliers of labour and capital. A related dimension of risk transfer would be the shift from financial intermediaries to investors in financial markets through the increasing reliance of firms on market-based financing. Business-related risks would be dispersed more widely across the economy, probably reducing the overall vulnerability of the system. However, the issue of risk diversification would gain in importance. It is important to see this development in conjunction with other trends such as the secular shift to private sector management of savings in CGFS member countries. And for banks, the question arises of whether exposures to the household sector would have to be reconsidered.

Banks could also become increasingly exposed to market risk with a larger component of basis risk (both through direct holdings of securities and through their increasing use as collateral). Assuming such exposures would be a natural by-product of their monitoring efforts aimed at assessing idiosyncratic risks. Again, a greater onus would have to be placed on risk diversification, perhaps reinforced by business strategies aiming at more specialisation in credit business. As a consequence, issues related to sectoral exposures or a growing reliance on credit risk transfer tools would become increasingly relevant.

What does the rise and fall of IT equity markets say about these risks?

The boom and bust in the IT segment of equity markets and their impact on the financial system provide some insight into the relevance of the issues outlined above and the risks that may be important when going forward. The following points can be highlighted:

- On the positive side, the huge loss in equity wealth has not triggered any major default among financial intermediaries. This suggests that markets have provided for an allocation of risks to those sectors that have been able to bear them, possibly including the diffusion of IT sector-related credit exposures through credit risk transfer markets.
- Valuation problems have been substantial and were probably exacerbated by market practices that might not have dealt appropriately with the specific information and valuation problems that characterise new and innovative firms. One example may be the incentives to bring firms to the public equity market at a very early stage of the corporate life cycle.
- Equity market conditions had considerable knock-on effects for other segments of the financial system. They impacted adversely on the provision of venture capital and private equity to high-tech firms. The drop in equity market capitalisation 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.
- The difficulties associated with using equity valuations and market capitalisation of high-tech firms to signal the ability of those firms to service debt obligations became apparent. A case in point is the telecoms sector. The inability of some telecoms companies to arrange equity market takeouts of bank debt and rising defaults left banks with unanticipated exposures.

In a longer-term perspective, these experiences can be seen as part of a learning process for all participants, which may have led to significant improvements in risk management and valuation capabilities. However, the tentative nature of these arguments should be recognised, as it is still too early to draw final conclusions about the implications of the tech sector exuberance. This is all the more important as the IT sector boom and bust may well have some lasting impact. For example, the evolving equity culture (in particular in Europe) may have slowed as a consequence of the disappointment of expectations. The sharp decline witnessed in the amount of equity capital raised by IT firms supports such a view. However, it is reassuring that the extent of equity business, for example investment in equities by households, remains considerably higher than before. And past mistakes and losses should help to limit the extent of future problems. Reconsidering and reassessing these implications should be the subject of future investigations.

Implications for public policy and central banks

The general challenge for public policy in the face of a technological shock is to strike the right balance between exploiting potential gains and avoiding risks that could threaten the overall system.

Regarding the exploitation of investment opportunities, empirical evidence supports the view that other policy areas – such as labour market policy or taxation – have been more important in defining the cost of risk-taking and hence the set of attractive investment opportunities. But financing clearly plays a role in supporting the reorganisation of the corporate sector and in allocating the risks associated with this process. And this role is likely to increase as market-based incentive mechanisms gain in importance and the management of financial risks becomes more complex.

The main risks involved in the financing of new technologies are large-scale failures of investment projects that may damage the financial institutions providing funding and excessive price movements in financial markets resulting from unrealistic expectations. Against this background, the task of

financial policy is to set a framework of regulation and standards that allows for market-driven adjustment of financing mechanisms and encourages ongoing improvement in risk management techniques. Central banks can play an active role in this process.

One aspect of this role is employing the research capabilities and the knowledge of the financial system combined in central banks to improve the understanding of the financial impact of technological change. This could include, for example, identifying mechanisms that potentially amplify swings in expectations, or exploring the implications of changes in idiosyncratic risk for volatility and portfolio diversification. Another area would be risk management issues involved in the provision of equity-like finance by financial intermediaries and the redistribution of risks within the financial sector and to non-banks. Interviews by the Working Group indicate that further adjusting the risk management of financial institutions in the light of a changing corporate sector is an issue receiving the attention of banks.[58]

The other aspect is active monitoring of the financial system by the central banks. Changing linkages between the real and the financial sphere and across the different segments of the financial system, and in particular the reallocation of risks across the financial system, underline the need for systemic monitoring. Enhancing this function would probably involve closer cooperation with supervisors, in particular as the value of firm-specific information (including the relevance of "soft" information) increases as idiosyncratic risks become more important.

[58] Notwithstanding this, central banks would probably have an interest in the issues that changing financing patterns raise for monetary policy, namely possible changes in the monetary transmission mechanism.

Bibliography

Central bank papers submitted by Working Group members

Papers marked by an asterisk can be accessed on the BIS website.

Ayrer, B, C Upper and T Werner (2001): "Stock market valuation of old and new economy firms", *Deutsche Bundesbank paper*.*

Antoniewicz, R L (2001): "Financing of publicly-traded 'new economy' firms in the United States", *Federal Reserve Board paper*.*

Bakhshi, H and J Larsen (2001): "Investment-specific technological progress in the United Kingdom", *Bank of England working paper*.*

Berk, J M (2001): "New economy, old central banks? Monetary transmission in a new economic environment", *Netherlands Bank paper*.

Boisvert, S and C Gaa (2001): "Innovation and competition in Canadian equity markets", *Bank of Canada paper*.*

Bosomworth, A and S Grittini (2001): "New economy, the equity premium and stock valuation", *European Central Bank paper*.*

Brandolini, A and P Cipollone (2001): "Multifactor productivity and labour quality in Italy, 1983-1999", *Banca d'Italia Temi di Discussione* n 422.*

Brayton, F and D Reifschneider (2001): "US macroeconomic performance since the mid-1990s, the FRB/US view", *Federal Reserve Board paper*.*

Brierley, P G and A Kearns (2001): "The financing patterns of new and old economy firms in the UK", *Bank of England paper*.*

Bugamelli, M and P Pagano (2001): "Barriers to investment in ICT", *Banca d'Italia Temi di Discussione* n 420.*

Bugamelli, M, P Pagano, F Paternò, A F Pozzolo, S Rossi and F Schivardi (2001): "Ingredients for the new economy: How much does finance matter?" *Banca d'Italia Temi di Discussione* n 418.*

Casolaro, L and G Gobbi (2001): "Information technology and productivity change in the banking industry", *Bank of Italy paper*.*

Cayen, J-P (2001): "Venture capital in Canada", *Bank of Canada paper*.*

Cette, G, J Mairesse and Y Kocoglu (2001): "The contribution of information and communication technology to French economic growth", *Bank of France and Université de la Méditerranée paper*.*

Covitz, D and N Liang (2001): "Recent developments in the private equity market and the role of preferred returns", *Federal Reserve Board paper*.*

Crawford A (2001): "Productivity growth in Canada – stylised facts and research issues." *Bank of Canada paper*.*

Davies, S M and D C Smith (2001): "Trends in external corporate financing", *Federal Reserve Board paper*.*

Duvivier, A (2001): "Financing and risks of internet startups: A preliminary assessment", *Bank of France paper*.*

Fornari, F and M Pericoli (2001a): "A macro-sector perspective of TMT and traditional stock prices", *Bank of Italy paper*.*

Fornari, F and M Pericoli (2001b): "Characteristics of stock prices in TMT and traditional sectors", *Bank of Italy paper*.*

Frankel, A (2001): "The new firm", *BIS background note*.*

Fujita, K and T Matsuno (2001): "Financing the 'new economy' firms in today's Japan", *Bank of Japan paper*.*

Houben, A and J Kakes (2001): "Fostering the 'new economy: The role of financial intermediation", *De Nederlandsche Bank Meb series paper*.*

Kahn, J, M M McConnell and G Perez-Quiros (2001): "Inventories and the information revolution: implications for output volatility", *Federal Reserve Bank of New York paper*.*

Lalonde, R and D Lecavalier (2001): "The US miracle", *Bank of Canada paper*.*

Liang, N and S Weisbenner (2001): "Who benefits from a bull market? An analysis of employee stock option grants and stock prices", *Federal Reserve Board Finance and Economics Discussion Series*.*

Liu, Y (2000): "An overview of angel investors in Canada", *Bank of Canada paper*.*

Lünnemann, P (2001): "Stock market valuation of old and new economy firms," *Bank of Luxembourg Cahier d'études* No 2.*

Macklem, T and J Yetman (2001): "Productivity growth and prices in Canada: What can we learn from the US experience?" *Bank of Canada paper*.*

Mehran, H and J Tracy (2001): "The impact of employee stock options on the evolution of compensation in the 1990s", *Federal Reserve Bank of New York paper*.*

Mouriaux, F and F Verhille (2000): "The difficulty of pricing 'new economy' stocks", *Bank of France paper*.*

Osler, C L (2001): "Corporate governance and the market for corporate control: Lessons from the US", *Federal Reserve Bank of New York paper*.*

Oulton, N (2001): "ICT and productivity growth in the UK", *Bank of England paper*.*

Planès, B M Bardos, P Sevestre and S Avouyi-Dovi (2001): "Innovation, financing and financing constraints", *Bank of France paper*.*

Pozzolo, A F (2001): "An empirical investigation of bank secured lending", *Bank of Italy paper*.*

Scheuer, M (2001): "Measurement and statistical issues related to the 'new economy' with IT equipment and software in Germany and the United States as a case in point", *Deutsche Bundesbank paper*.*

Other literature

Baldwin, F and D Sabourin (2001): "Impact of the adoption of advance information and communication technologies on firm performance in the Canadian manufacturing sector", *Statistics Canada Research Paper Series* No 174.

Bessen, J (2000): "The skills of the unskilled in the American industrial revolution", *Research on innovation Working Paper*.

Black, S E and L M Lynch (1999): What's driving the new economy: the benefits of workplace innovation, *NBER Working Paper* 7479, revised October 2000.

Breshanan, T F and M Trajtenberg (1992): "General purpose technologies: engines of growth?'" *NBER Working Paper* no 4148, Cambridge, MA.

Brynjolfsson, E, L M Hitt and S Yang (2000): "Intangible assets: how the interaction of computers and organizational structure affects stock market valuations", *MIT Sloan School of Management Working Paper*.

Campbell, J Y, M Lettan, B G Malkiel and Y Xu (2001): "Have individual stocks become more volatile? An empirical exploration of idiosyncratic risk," *Journal of Finance*, vol LVI, no 1, February.

Carter, M E and L J Lynch (2001): "An examination of executive stock option repricing", in *Journal of Financial Economics*.

Cohen, B (2000): "Credit spreads and equity market volatility", *BIS Quarterly Review*, November, p 10.

DeLong, J B and L H Summers (2001): The "new economy": background, questions and speculations, proceedings of a symposium sponsored by the Federal Reserve Bank of Kansas City, August.

Goldin, C and L F Katz (1998): “The origins of technology-skill complementarity”, *Quarterly Journal of Economics*, vol 1B (June), pp 683-732.

IMF (2001): *World Economic Outlook*, October, Washington.

Loughran, T and J R Ritter: “Why don’t issuers get upset about leaving money on the table in IPOs?” *University of Notre Dame and University of Florida Working Paper*, 2000.

McKinsey Global Institute (2001): *US productivity growth 1995-2000.*

OECD (2001): “Measuring the ICT sector”, Paris.

Peterson, M (2001): “The accidental credit investors”, *Euromoney*, August, pp 28-35.

Pilat, D and F C Lee (2001): Productivity growth in ICT producing and ICT using industries: a source of growth differentials in the OECD? *OECD/STI Working Papers* 2001/4, Paris.

Ritter, J R (2001): *Some factoids about the 2000 IPO market*, http://bear.cba.ufl.edu/ritter.

Terlin, S and K Whelan (2000): “Explaining the investment boom of the 1990s”, *Federal Reserve Board Finance and Economics Discussion Series*.

Varian H R (2001): “High-technology industries and market structure”, paper presented at the Jackson Hole Symposium of the Federal Reserve Bank of Kansas City, August.