The significance of information and communication technology

Advances in information and communication technology (ICT) are closely monitored among the research community and in the economic policy debate. Initial hopes of such technologies creating a "New Economy" have proved unrealistic, but the question as to whether there is any correlation between contemporary ICT and economic developments is still no less relevant.

In Germany, ICT has assumed a significantly greater role over the past few years, in terms of both its production and use. At the same time, the prices of ICT products have slumped, triggering a marked reduction in the user cost of capital. ICT expenditure now constitutes more than 40% of total investment in machinery and equipment, just one reason why its economic impact must not be underestimated. Although the results of studies on the influence of ICT on long-term growth are not clear-cut, particularly in comparison with other countries, there are many indications that ICT could potentially generate a sustained increase in productivity and thus boost longer-term growth.

Classification and spread of ICT

Production and use of ICT goods

If the impact of ICT is to be examined in terms of technological progress vis-à-vis the (gross) investment in this sector, it is first of all necessary to more clearly define the group

of ICT goods driving the alleged efficiency gains.[1] It would therefore be useful to distinguish between the domestic manufacture of such goods and their use in the domestic production process. This is particularly significant in the ICT sector as, in the case of computers, for example, the assessment of important facts may depend on whether they are being considered from a production or use point of view.[2]

Production of ICT goods

As regards production, the Federal Statistical Office[3] divides the ICT sector into the following branches[4] according to the international conventions of the OECD.

- Publishing, printing and reproduction of recorded media (22),
- manufacture of office machinery and computers (30),
- manufacture of radio, television and communication equipment and apparatus (32),
- post and telecommunications (64),
- computer and related activities (72) and
- recreational, cultural and sporting activities (92).

The table on page 47 shows the value added of ICT sectors at current prices and at 1995 prices as well as the number of persons employed and labour productivity from 1991 to 2002. Each figure is also compared to that for all sectors together. In both real and nominal terms, there has been a disproportionately sharp increase in value added in the ICT sector. This, however, is not the case for the number of persons employed, the strong growth in the number of persons employed in ICT services not being sufficient to offset the decline in the number of persons employed in the ICT branch of the manufacturing sector. Consequently, the rise in output per person employed in this sector far exceeds that for the economy as a whole, prompting the theory that the contribution of ICT to total productivity gains tends to stem from the production rather than the use of ICT goods.[5]

Use of ICT goods

As regards the use of such goods, it is first of all necessary to find out how much investment is being made in ICT goods. Generally, however, ICT goods that are either produced in Germany or imported may be used not only for investment purposes, but also for private consumption or as intermediate goods. This has already given rise to some conceptual difficulties.[6] For example, according to the convention for the system of national ac-

1 A summary of the important statistical details on ICT is available from the Federal Statistical Office (ed), *Im Blickpunkt: Informationsgesellschaft,* Wiesbaden 2003 (in German only).
2 See, for example, W Roeger (2001), The Contribution of Information and Communication Technologies to Growth in Europe and the US: A Macroecomomic Analysis. *European Commission Economic Papers* No 147, Brussels.
3 See Federal Statistical Office (2003), loc cit, pp 12 ff. See also S Schnorr-Bäcker (2001), *Neue Ökonomie und amtliche Statistik*. *Wirtschaft und Statistik,* 3, pp 165 ff, (in German only).
4 In brackets: description of the economic branches according to the branch classification, WZ 93.
5 This problem is discussed in detail by D Pilat and F C Lee (2001), Productivity Growth in ICT-producing and ICT-using Industries: A Source of Growth Differentials in OECD? SIT Working Paper 2001/4, Paris.
6 See Deutsche Bundesbank, Appendix: Problems of international comparisons of growth – a supplementary analysis, *Monthly Report,* May 2001, p 39.

Information and communication technology (ICT) in the national accounts from 1991 to 2002

%

Sector	Gross value added at current prices		Gross value added at constant prices		Employed persons		Labour productivity	
	Share 1	Change 3	Share 1	Change 3	Share 1	Change 3	Index 2	Change 3
Total	100	+ 13.9	100	+ 13.1	100	+ 3.7	100	+ 7.7
ICT sector	8.3	+ 31.1	10.6	+ 66.6	5.6	+ 2.7	176.7	+ 53.8
Manufacturing	1.8	+ 5.1	1.7	+ 2.8	1.8	– 14.9	124.8	+ 41.7
Services	6.5	+ 40.5	8.9	+ 89.7	3.9	+ 3.7	197.6	+ 53.2

Source: Federal Statistical Office (2003), *Fachserie 18, Volkswirtschaftliche Gesamtrechnungen – Hauptbericht 2002,* Wiesbaden. — **1** Share in 2002. — **2** Index for 2002, total = 100. — **3** Measured over the entire period.

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counts, which was common practice until 1998, software tended to be listed under intermediate goods and therefore not as having an impact on GDP. The new European System of Accounts (ESA 95), however, introduced intangible fixed asset investment as a new final demand category, and this also includes software expenditure. Therefore, according to this system, an increase in software expenditure may boost GDP.

Foreign trade in ICT goods

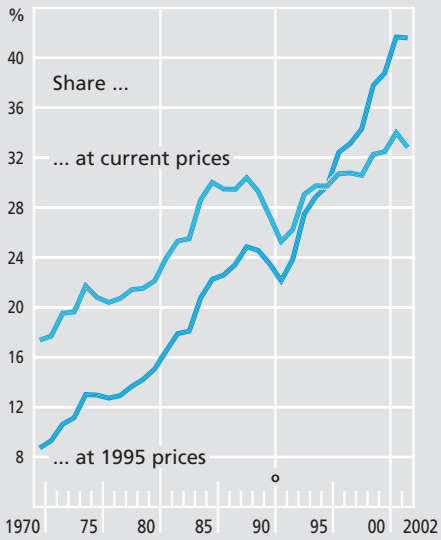
As far as foreign trade in ICT goods is concerned, it should be noted that German net exports of ICT goods are negative, whereas net exports of all goods and services taken together are positive. In itself, this could suggest that ICT goods are not a key focus of the German economy. It could also be an indication of weaker technological competitiveness among German enterprises since it is often asserted that ICT goods have seen particularly rapid technological progress. However, such a broad interpretation of this situation is somewhat premature, especially as it is not substantiated by detailed studies on German technological efficiency.[7]

ICT goods in the household sector

ICT goods have also gained considerable importance for households and their consumption habits. Among other things, this is highlighted by the number of selected ICT goods owned by households.[8] For example, in

7 See, for example, H Belitz (2004), *Forschung und Entwicklung in multinationalen Unternehmen. Studien zum deutschen Innovationssystem* No 8-2004, Berlin (in German only).
8 See S Deckl et al (2003), *Zur Ausstattung privater Haushalte mit Informations- und Kommunikationstechnologie – Ergebnisse der Wirtschaftsrechnungen privater Haushalte. Wirtschaft und Statistik,* 4, pp 354–367 (in German only).

Relationship between ICT goods and investment *



* Share of information and communication technology investment in machinery and equipment investment as a whole.— o Up to 1990 West Germany, from 1991 Germany as a whole.

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2002, over one in two households had a PC, over 40% had internet access and approximately 70% of households used a mobile telephone. Any measurement of the strength of the development must take into account the fact that between 1998 and 2002 household ownership of ICT goods rocketed by an annual average of 8% for PCs, 50% for internet access and 67% for mobile telephones. These figures also show that ICT is a major driving force behind the structural changes within the economy as a whole. Demand for new products is also an important factor in the growth process.

ICT in the corporate sector

As regards the contribution of ICT to overall growth in the corporate sector, the Federal Statistical Office divides ICT investment into the following classifications of "fixed asset investment by type of product".[9]

– Investment in office machinery and computers,

– investment in radio, television and communication equipment and apparatus and

– intangible fixed asset investment, which primarily includes software investment.[10]

A major practical advantage in classifying ICT investment according to goods is that they are then more easily identified with the help of data from the national accounts. Other – possibly more precise – classifications, by contrast, often require additional information.[11]

According to the above definition, ICT investment constitutes a significant and relatively fast-moving part of overall investment in machinery and equipment, rising, in real terms, from around 34% to almost 42% between 1998 and 2002. In comparison with other countries, this puts Germany at a mid-scale position.

9 See Federal Statistical Office (2002), *Fachserie 18, Volkswirtschaftliche Gesamtrechnungen – Hauptbericht 2002,* Table 3.3.7 (in German only).
10 However, this category also covers the costs of ownership transfer for undeveloped land. The Federal Statistical Office does not list software separately. According to the German Council of Economic Experts in 2000/01, an estimated three-quarters of this aggregate could be attributed to software.
11 See B v Ark, R Inklaar and R H McGuckin (2003), ICT and Productivity in Europe and the United States), *CESifo Economic Studies* 49, 3, 295-318. ICT investment may also be classified according to the "market volume" of the ICT sector, which according to the umbrella organisation BITKOM totalled €131 billion in 2003.

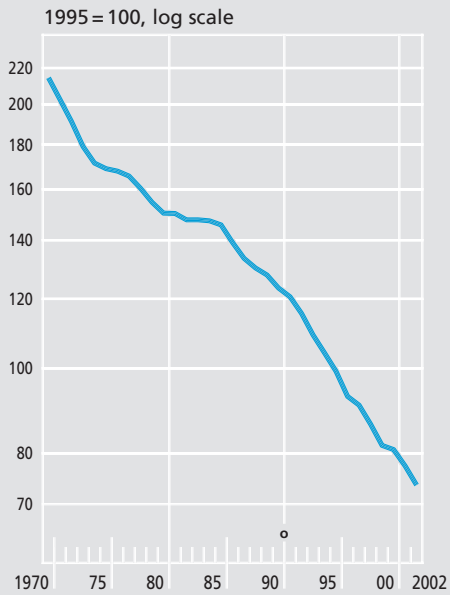
Prices and user costs of ICT investment

Price developments in the ICT sector

As already mentioned, ICT goods have experienced major price reductions both in absolute terms and in relation to the overall price level, measured in this case by the change in the corresponding index for GDP. Such price reductions are part of a long-term trend that began as early as the mid-1980s, but even this may have been underestimated – or at least this is the theory put forward in the discussion about changes in quality being reflected in price adjustments. Problems with the measurement of prices and thus the deflation of production values and investment occur because, over the years, ICT products have not only become cheaper but also significantly more efficient. For example, the processors and memory capacities of PCs today are much larger than 10 years ago.

The Federal Statistical Office, however, has made considerable efforts to improve methods for taking into account changes in quality when measuring the prices of ICT goods. In this regard, hedonic price indices could initially only be calculated for a few years. An interim solution had to be applied to older data,[12] which raises the question as to what extent these data are already an accurate reflection of the reduction in prices. In view of this problem, the Bundesbank at the time suggested[13] comparing the German indices with those in the United States as it seems unlikely that there will be any notable differences in the price reductions of goods that are in essence very similar from a technical point of view. Such a comparison still reveals major discrepancies in the price curves,

Movements in the price of ICT investment relative to the GDP deflator



o Up to 1990 West Germany, from 1991 Gemany as a whole.

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implying a significant underestimation of the price-adjusted development of ICT investment, at least insofar as the US index is a true reflection of the development. This does not mean, however, that one can simply assume this will result in a corresponding underestimation of overall economic production – something that is unlikely to happen given that a large number of ICT goods are also imported, for instance. Should the import deflator be fraught with the same problems as those affecting investment, the result would

12 See, for example, S Linz and G Eckert (2002), *Zur Einführung hedonischer Methoden in die Preisstatistik, Wirtschaft und Statistik,* 10, pp 857-863 (in German only).

13 See Deutsche Bundesbank, Problems of international comparisons of growth caused by dissimilar methods of deflation – with IT equipment in Germany and the United States as a case in point, *Monthly Report,* August 2000, p 8.

be an underestimation of real imports and thus (viewed in isolation) an overestimation of GDP.

Falling user costs

Viewed in isolation, an absolute or relative decline in the prices of capital goods will cause the user cost of capital to fall, with the result that, at a specified level of capital productivity, additional capital input will generate profits. This basic principle may also be applied to ICT investment, albeit with one significant modification. It must also be taken into consideration that the economic rate of depreciation for ICT goods is on average higher than for total investment, which, viewed in isolation, pushes up the user cost of capital. The national accounts, however, only record depreciations according to the type of product in relatively broad classification groups, which means that only certain quantitative conclusions on the impact of this effect may be drawn. Given the marked drop in the prices of ICT goods, which, for the selected classification, averaged 4.5% per year between 1991 to 2002, the cost-reducing impact of this price effect was probably not offset by higher rates of depreciation. The fall in relative prices is indeed one of the main reasons for the strong performance of ICT investment.

ICT investment, growth and productivity

ICT investment more volatile?

Over the years, there has been a sharp increase in the direct contribution of ICT investment to economic growth, which was always positive until 2000. Only once the "New Economy" bubble had burst on the stock markets was there a negative growth contribution from the demand side – yet this contribution was very large.[14] In an ailing economy, purchases of relatively non-durable ICT capital goods may be put on hold. In many cases, the technical life of ICT goods may indeed exceed their economic life cycle. The latter is an endogenous variable, which means that enterprises try to reach the optimum reinvestment time. Furthermore, the fact that hardware and software are often complementary means that any new software requires matching investment in hardware. It is therefore conceivable that an increase in ICT investment will precipitate a higher level of cyclical sensitivity in the economy. This is also indicated by a comparison of the cyclical volatility of ICT investment with the corresponding figure for investment in machinery and equipment, which has risen sharply over the years.

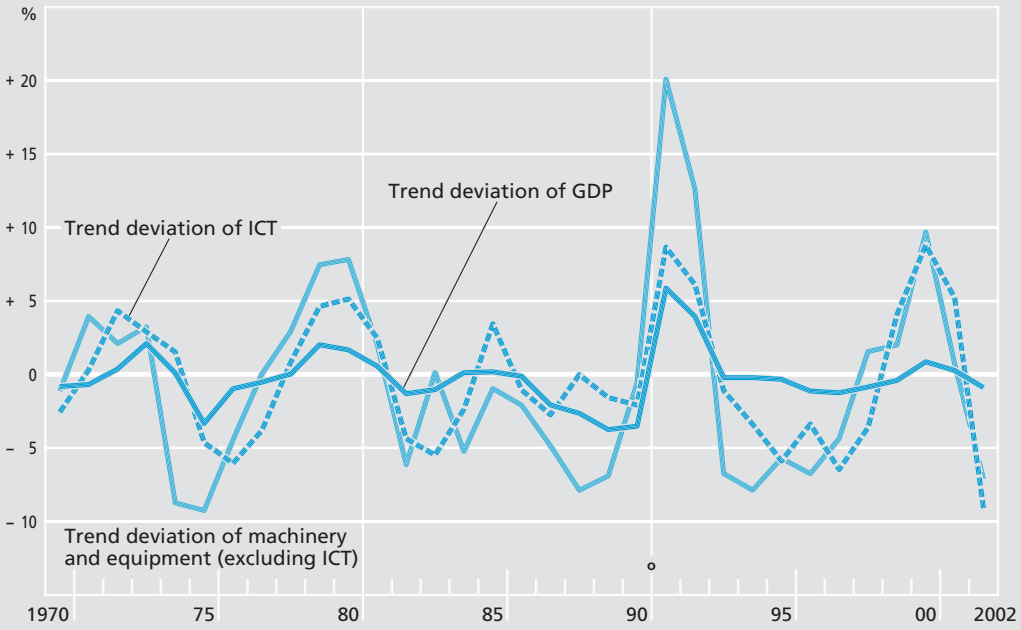
From this, however, it must not be inferred that the economy as a whole has become subject to more fluctuation as the volatility-multiplying effect of an increase in ICT investment may be offset by other factors, such as less fluctuation in inventory investment. Empirical analyses, for example, show that, in general, total economic output is now more stable.[15]

Determining growth contributions

One of the main issues at the heart of the "New Economy" debate was the question as to how ICT can help sustainably boost prod-

14 Owing to the Y2K problem, the subject of heated debate, ICT investment was brought forward to 1999, which may also have contributed to the weakening of ICT investment after 2000. However, no reliable quantification of this effect is available.
15 See C Buch, J Döpke and C Pierdzioch, Business Cycle Volatility in Germany; forthcoming in: *German Economic Review.*

Fluctuation intensity* of ICT investments



* Deviations from a specific trend calculated using a Hodrick-Prescott (100) filter. — o Up to 1990 West Germany, from 1991 Germany as a whole.

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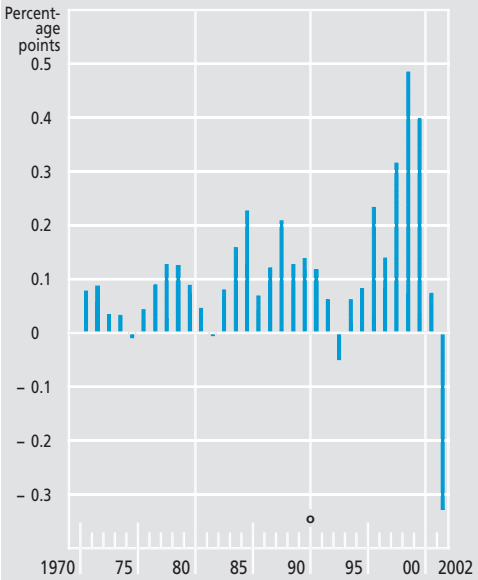
uctivity growth and labour productivity. In this regard, two factors must be taken into account. First, a reduction in the useful life of a product generally leads to a rejuvenation of the capital stock, with new expertise being more rapidly absorbed into the production process. Second, it must be noted that the increase in efficiency per newly installed unit of capital goods becomes more crucial and the supply effect is expected to be more pronounced as the pace of technological progress increases. In times of rapid technological progress, shifts in the composition of gross investment as well as a generally high or rising investment ratio play a particularly important role.

In most cases, growth decompositions constitute the methodological basis of an empirical analysis. The rate of change in real GDP (Y) may be expressed as the sum of the rate of change in the factors of production labour (L), non-ICT capital (K^{other}), the stock of ICT goods (K^{ICT}) and total factor productivity (A), each weighted with the income share (α).

$$\Delta \ln Y_t = \Delta \ln A_t + \alpha_L \Delta \ln L_t + \alpha_{K,other} \Delta \ln K_t^{other} + \alpha_{K,ICT} \Delta \ln K_t^{ICT}$$

The decomposition of growth rates of labour productivity is an equally common procedure. In this way, the change in labour productivity may be traced back to capital deepening and the change in total factor productivity. A major problem with this approach, however, is the fact that the income share of ICT capital cannot be observed directly but must instead be estimated. As a rule, the income share in

Contribution of ICT investment to change in GDP*



* Contribution also known as Lundberg components. — o Up to 1990 West Germany, from 1991 Germany as a whole.

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such cases is determined via the user costs of capital. The latter, however, are calculated from a number of variables that likewise may only be quantified with certain restrictions or under the assumption of additional conditions.[16] Besides the interest rate on an alternative investment (eg on the capital market), which can still be determined to some degree, these include, for example, the rate of depreciation for ICT capital goods, the rate of change in ICT capital goods prices and the value of ICT capital stock. It is therefore not surprising that empirical analyses result in very different assessments of the significance of ICT goods.

Decomposition of growth in Germany

Several studies have been carried out on the components of change in labour productivity in Germany. According to the results of a study carried out by the RWI (*Rheinisch-Westfälisches Institut*), ICT makes a positive, non-negligible contribution to economic growth in Germany.[17] Furthermore, as most other research papers suggest, its contribution to growth rose in the second half of the 1990s. It therefore cannot be said that Germany missed out on the "New Economy". Instead, the results of the decompositions of growth indicate the inadequate contribution of labour as the main reason behind Germany's sluggish economic growth.

International comparison of contributions to growth

In addition, a comparison with developments in the USA and other European countries clearly shows that the lower level of economic growth is only tentatively linked to ICT investment, if at all. There is little difference in the growth contributions among the various states under review. However, it may not be possible to allocate contributions with absolute precision, and some growth effects resulting from ICT investment may be reflected in the residual variable, ie total factor productivity. The fact that total factor productivity has also increased in sectors that do not manufacture ICT goods may serve as evidence of this. However, a significant portion of international productivity differentials is attributable to differences in total factor productivity growth. It is also easily conceivable that ICT is a sort of "general-purpose" technology, the use of which boosts productivity in all sectors of the economy. This hypothesis

16 See, for example, S Oliner und D E Sichel (2002), Information Technology and Productivity: Where Are We Now and Where Are We Going? *Federal Reserve Bank of Atlanta Economic Review 3rd Quarter,* pp 15-43.
17 See J Dehio et al (2003), New Economy – The German Perspective, in: *RWI: Schriften,* No 70.

is substantiated by the fact that, in both a sectoral and an international comparison, the use of ICT is positively correlated with total factor productivity growth.[18]

However, none of the above considerations make any major difference to the overall conclusion to be drawn, which is that the relative weakness of growth in Germany between 1995 and 2001 is primarily not the result of inadequate provision of ICT investment, but insufficient labour input. It must nevertheless be stressed that the importance of this finding is easily tempered by the prolonged weakness in investment over the past few years. Furthermore, it should be noted that the growth differential between Germany and the USA, for example, can be attributed in part to the share of ICT-producing sectors.

International comparison of contributions to growth

1995 to 2001

Country	GDP growth	Contribution of ICT 1 capital	Contribution of non-ICT 1	Total factor productivity	Contribution of labour
USA	3.5	0.8	0.8	0.8	1.1
EU	2.5	0.5	0.8	0.5	0.7
Ireland	8.9	0.8	2.6	3.6	1.9
Finland	4.5	0.7	0.2	2.7	1.0
Greece	3.6	0.5	1.2	1.7	0.3
Spain	3.7	0.3	1.2	– 0.6	2.8
Portugal	3.4	0.4	1.6	0.5	0.9
Netherlands	3.3	0.6	0.9	– 0.1	2.0
Sweden	2.8	0.8	0.7	0.7	0.6
United Kingdom	2.8	0.7	0.9	0.5	0.8
France	2.6	0.3	0.8	0.9	0.5
Belgium	2.5	0.7	0.6	1.1	0.1
Denmark	2.5	0.7	1.1	0.3	0.4
Austria	2.4	0.4	0.9	1.3	– 0.2
Italy	1.9	0.4	0.9	0.1	0.5
Germany	1.5	0.4	0.4	0.9	– 0.1

Source: Timmer, Ypma and van Ark (2003). — 1 Information and communication technology.

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Economic policy consequences

ICT and monetary transmission channels

Changes in the composition of the demand for capital goods could also have a certain influence on the monetary transmission mechanism. As already mentioned, ICT investment primarily consists of goods that can be depreciated quickly. In line with the growing share of ICT goods in the capital stock, the macroeconomic depreciation rate, and consequently its importance in the calculation of the user cost of capital, are mounting.[19] One corollary of the typically shorter commitment period for capital input is the correspondingly higher rate of gross investment necessary to maintain the capital stock. Where the reinvestment cycle is abbreviated, however, the real sector adjusts to changing conditions more quickly.[20] For this reason, different types of changes may occur in the importance of the interest rate channel in monetary policy, for

18 In connection with the USA, doubt is cast on this theory by R J Gordon (2000), Does the New Economy Measure up to the Great Innovations of the Past?, *Journal of Economic Perspectives 14,* pp 49-74. Meanwhile, in the USA too, there have been growing signs of productivity increases in ICT-using branches, too. For an interpretation of current productivity developments in the USA, see R J Gordon (2004), Exploding Productivity Growth: Context, Causes and Implications, *Brookings Papers on Economic Activity,* pp 1-73.

19 See G Ziebarth (2002), *Abschreibungen im Spiegel der Volkswirtschaftlichen Gesamtrechnungen: Ökonomische Relevanz und analytischer Gehalt. Wirtschaft und Statistik,* 12, pp 1119-1127 (in German only).

20 For a theoretical analysis, see U von Kalckreuth and J Schröder (2002), Monetary Transmission in the New Economy: Accelerated Technical Progress, Financial Stability and the Speed of Adjustment in the New Economy, *Jahrbuch für Wirtschaftswissenschaften (Review of Economics)* 53, pp 125-141. For more information on adjusting the capital stock to take account of changing conditions, see also Deutsche Bundesbank, Trends in and structure of the overall capital stock, *Monthly Report,* November 1998, pp 25-37.

which it is used, in particular, to influence demand for capital goods. The interest rate factor becomes less significant than the depreciation factor and the relative prices of capital goods; in the case of maturity-appropriate financing, the interest rates on medium-term investments tend to be more relevant. This means there is less leverage for monetary policy measures on private demand for capital goods, while the impact on interest rates is more direct.

Taking advantage of growth potential through…

If ICT investment can boost economic growth and thus improve social welfare, this above all raises the question as to how Germany can reap the full benefits of its ICT potential. To achieve this, efforts must be made to enhance the productivity-increasing effects generated by the use of ICT goods. Economic policy may also be instrumental in fulfilling this aim.

… favourable investment conditions, …

In this regard, the primary focus should be on improving the overall conditions for investment, as the majority of technical progress is only achieved through fresh injections of capital stock in the production process. Although the marked decline in investment activity since autumn 2000 has finally come to a halt, there is likely to be a turnaround in capital stock growth only once the investment ratio has gone back up to a considerably higher and sustainable level.

… deregulation on the goods and labour market…

It would appear that the speed of diffusion of new technologies varies from country to country. An OECD study[21] reveals a negative, albeit weak, correlation between the regulatory burden and the share of ICT investment in GDP. *Ceteris paribus,* the more heavily the goods markets are regulated, the lower the investment in ICT. Furthermore, such analyses substantiate the relevance of the regulatory burden on the labour markets in this context. The greater the regulatory burden, the lower the volume of investment in ICT. This second finding is particularly significant for Germany because, while the regulations on Germany's goods markets are more or less on a par with the OECD average, its labour market is still heavily regulated relative to other countries. Large-scale deregulation could also promote the distribution of new technologies, thereby making a welcome contribution to growth.

Technical progress is closely linked to structural change, which, as experience shows, has a varying impact on each sector of the economy, professions and jobs. Labour has to migrate from obsolete industries into new fields, and relative demand for specific services shifts in all manner of ways. In order to reap the full economic benefits of the new products and procedures, these changes in conditions must be reflected in the willingness to relocate, skills profiles and salary structures.

… and complementary human and venture capital

Another means of exerting influence indirectly would be through complementary investment, particularly in education. The training system could, in particular, be more geared towards imparting the knowledge required to foster the acceptance and provision of new technologies and boost human capital. The promotion of basic research and the expan-

21 See OECD (2003), ICT and Economic Growth, Paris.

sion of an efficient venture capital market are also effective means of enhancing innovative capacity and the speed of diffusion. However, more direct technology policy instruments should be viewed with caution for the sole reason that it is inconceivable how the government can be expected to have superior information on futuristic products or procedures.

All in all, there is no reason to suspect that Germany has generally lost its technological footing. However, there are many indications that there is still considerable potential for Germany to improve its position in this field. The extent to which these opportunities can be exploited in the medium term, though, also depends on the economic policy moves made.