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Assessing potential output growth in the euro area - a growth accounting perspective

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EUROPEAN CENTRAL BANK

OCCASIONAL PAPER SERIES

NO. 22 / JANUARY 2005

ASSESSING POTENTIAL OUTPUT GROWTH IN THE EURO AREA

A GROWTH ACCOUNTING PERSPECTIVE

by Alberto Musso
and Thomas Westermann



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EXECUTIVE SUMMARY

Growth accounting provides a useful framework for analysing the medium to longer-term developments in real GDP and supply-side factors, and can thus help in assessing potential output growth. Applications of this framework have received increased interest from policy-makers in recent years, reflecting the need to analytically underpin for instance the debate on the so-called new economy and the likely impact of information and communication technologies on productivity, as well as the discussion on the growth and employment objectives for Europe stated in the 2000 Lisbon agenda.

The growth accounting framework is empirically motivated and does not rely on adopting *ex ante* the implications of theoretical frameworks. It does not therefore aim to explain the fundamental underlying forces, such as preferences, institutions and economic policies, that drive the evolution of supply-side factors, nor does it take into account the linkages between developments in these factors. In this respect, growth accounting exercises can be seen as a first step towards understanding the longer-term growth process and as a useful complement to model-based approaches to estimating and assessing potential output. This is particularly true for any production function-based approach.

The growth accounting exercise conducted in this paper decomposes euro area real GDP growth in the period since 1980 into the contributions from total factor productivity, capital and the labour supply. The main findings are as follows.

First, growth in measured total factor productivity has been the single most important contributor to medium to longer-term growth, explaining roughly half of the average rate of growth in real GDP of 2.1%. Developments in the gross capital stock also made a significant contribution to real GDP growth, while the contribution from total hours worked was close to zero. When assessing these quantities, it needs to be borne in mind that growth in total factor productivity is derived as an unexplained

residual and is thus a catch-all for both unobserved technological progress and all problems associated with the measurement of capital and labour inputs. Its contribution to real GDP growth should thus not be interpreted as an invariable number that depends only on random innovations. Nevertheless, for policy-makers this also underlines the important role that structural policies can play in raising overall economic efficiency and thereby fostering medium to longer-term growth.

Second, the decomposition of growth shows that there have been substantial changes in the individual contributions to growth between the 1980s and the 1990s. In the first period more than half of real GDP growth was explained by total factor productivity, while the remainder was accounted for by capital. Labour had a broadly neutral effect on growth due to the fact that the positive contribution from growth in the labour force was offset by a rise in the unemployment rate and a fall in average hours worked. For the 1990s, the results show a clear decline in the contribution to growth from total factor productivity, which then explained less than half of real GDP growth. The contribution from capital was broadly unchanged compared with that in the 1980s, while that from labour increased and explained around one-fifth of real GDP growth. The higher contribution to growth from the labour supply in the 1990s was accounted for by a decrease in the unemployment rate and a slower decline in hours worked. One factor behind this development was the moderation in average real wage growth which, *inter alia*, allowed for an increase in the number of lower-skilled workers. The flip side of this was a decline in average labour productivity growth. On balance, the opposite movements in the contributions to growth implied that average real GDP growth declined only marginally between the 1980s and the 1990s.

Third, the paper shows that the contributions from supply-side factors can exhibit significant fluctuations over relatively short horizons. The rates of growth in total factor productivity and

total hours worked have standard deviations of 1 percentage point or more, and while these numbers reflect to a large extent the impact of business cycle fluctuations, the data suggest that even correcting for these fluctuations would leave considerable variation in the rates of growth of supply-side factors. This suggests that the estimates of potential output growth in individual years that are compiled from the contributions of supply-side factors do not necessarily reflect a sustainable rate of non-inflationary growth. Separating the developments in supply-side factors into sustainable rates of growth on the one hand and more temporary movements on the other is inevitably associated with a number of uncertainties. Therefore, before concluding whether a structural change implying a permanent change in output growth has taken place, it is necessary to examine the source of the change. Growth accounting can provide an important input to such an examination.

Fourth, the paper shows that demographic developments have not been favourable for growth over the past business cycle and are projected to become a major reason for concern with regard to future growth. Forward-looking growth accounting exercises show that these adverse demographic developments would reduce average real GDP growth in the period up to 2010 to below 2% and in the period up to 2020 further to around 1½% if no compensation is achieved through higher contributions from other supply-side factors. There appear to be two main areas where improvements are warranted and where the Lisbon agenda states the relevant objectives. On the one hand, structural reforms in product and labour markets could improve the business environment in a way that allows for more innovation and technical progress. On the other hand, there is considerable potential for increasing the contributions to growth from the labour supply, considering that the (structural) unemployment rate in the euro area is still relatively high by international standards and that the participation rate and average hours worked are relatively low. With appropriate

reforms, there is thus some scope for sustaining or even raising medium to longer-term output growth despite adverse demographic developments.

Growth accounting exercises are surrounded by a number of caveats and policy-makers need to be cautious in drawing policy conclusions based on the *ceteris paribus* scenario analysis conducted on the basis of these exercises. Developments in the individual supply-side factors are intertwined and policy changes directed at a particular factor of growth may have reinforcing or offsetting effects on other factors. This complexity needs to be borne in mind when using growth accounting frameworks for policy advice.

I INTRODUCTION

Notions of the medium and longer-term growth prospects of the economy are central to many policy areas. These prospects are often summarised in an estimate or an assumption concerning potential output growth, which is an unobservable measure of the economy's aggregate supply-side capacity and its scope for sustainable, non-inflationary growth. There are many different statistical and theoretical methods to estimate potential output, each with its specific advantages and disadvantages. On the one hand, policy-makers can draw on a variety of methods and thus build on the information that is gained from evaluating and cross-checking the range of estimates. On the other hand, they may choose a preferred method that is perceived to provide the most relevant information for a specific policy area. Whatever the approach, there is a broad consensus that the uncertainties surrounding the concepts and estimation methods used for potential output growth call for considerable caution to be exercised in drawing policy conclusions.

Most estimated series of potential output growth tend to exhibit fluctuations over relatively short horizons and the estimate at a given point in time does not therefore necessarily reflect a sustainable rate of non-inflationary growth. The reasons for such fluctuations include the presence of temporary supply shocks, the persistence of demand shocks and methodological difficulties in properly separating trends and cycles. For monetary policy purposes, it is useful to apply a concept of potential output growth that looks through these fluctuations and focuses on the more permanent, structural factors of growth. In the monetary policy strategy of the ECB, this concept is reflected in the assumption for trend potential output growth in the euro area, which plays an important role in the derivation of the reference value for monetary growth and thus in the assessment of monetary developments.

This paper views potential output growth in the euro area from the narrow perspective of the information that is incorporated in growth accounting frameworks, largely abstracting

from conceptual and methodological issues. Growth accounting breaks down economic growth into the contributions from supply-side factors that determine the evolution of potential output growth over medium and longer-term horizons. These factors typically include the growth in physical capacity through investment, the rate of technological progress, and the growth in the available supply of labour. Understanding the dynamics of the main factors underlying economic growth helps policy-makers to gauge the impact of growth-enhancing measures. On a more conceptual level, it can also provide them with information on the usefulness that the various measures of potential output growth have for policy analysis and advice.

The increased interest that growth accounting exercises have received from policy-makers in recent years is mostly related to two specific policy issues, to which growth accounting provided a useful analytical underpinning. First, it underpinned the debate on the so-called new economy. Underlying this was the question on the nature of the impact that the large-scale emergence of information and communication technologies (ICT) in the second half of the 1990s had on technical progress, aggregate productivity and long-term growth. Second, growth accounting underpinned the discussion on the growth and employment objectives for Europe stated in the 2000 Lisbon agenda. In both cases, the recourse to growth accounting helped in the international comparison and benchmarking of growth performances, as well as in the identification of structural bottlenecks to stronger long-term growth.

The range assumed for trend potential output growth in the derivation of the ECB's reference value for monetary growth reflects the uncertainties surrounding the impact of structural changes on the future path of long-term growth. Growth accounting provides useful information on the scale and pace of past changes in the dynamics of the factors of growth and thus helps to assess the scope for future changes. In this respect, growth

accounting cannot eliminate the problem inherent in a forward-looking monetary policy that the impact of structural changes typically only becomes visible well after the changes have occurred. However, once the impact of these changes has become visible, it helps the assessment of whether such changes would be large enough to necessitate a revision of the assumption for trend potential growth.

The remainder of this paper is organised as follows. Section 2 describes how the growth accounting framework is constructed and which main factors of growth can be derived from it. It also discusses where important assumptions and measurement issues enter the framework. Section 3 analyses for the euro area the developments in these factors since 1980, grouped into the three broad categories related to capital inputs, labour inputs and total factor productivity. It shows that these developments display considerable variation over the business cycle, emphasising the difficulty in determining underlying trends. Section 4 discusses the decomposition of growth in the 1980s and 1990s, and presents a scenario analysis of the impact that changes in specific factors of growth can have on potential output growth. Such analysis helps to assess the growth-enhancing measures that are necessary to counterbalance the likely negative impact on economic growth from future demographic developments. Section 5 concludes, reiterating that a medium-term concept of potential output growth should take into account the uncertainty related to the underlying trends in growth factors.

2 THE GROWTH ACCOUNTING FRAMEWORK

Growth models typically provide a theoretical framework for understanding the fundamental determinants of economic growth and the consequences of economic policies for long-run growth. Growth accounting may be viewed as a first step towards such an understanding. It essentially implies breaking down observed real GDP growth into the contributions from pertinent factors of growth such as labour, capital and technology. In this respect, the growth accounting framework is empirically motivated and does not rely on adopting *ex ante* the implications of theoretical frameworks. However, it may lay the foundations for a second step, namely the analysis of the relationship that exists between developments in the factors of growth on the one hand, and the fundamental determinants, such as preferences, natural resources and economic policies on the other. Assuming that over medium and longer-term horizons actual and potential output growth move in line with one another, real GDP growth accounting over sufficiently long periods also allows for inferences about the contributions that the various factors of growth make to potential growth.

Growth accounting is an empirical tool, but it is not completely free of theory. In particular, in its basic form it assumes that the factors of growth can be combined in terms of an aggregate production function. Most applications assume that the production function is of the Cobb-Douglas type, with output Y produced by three broad inputs: technological efficiency, labour and capital (see equation (1)).¹

$$Y_t = A_t \cdot K_t^{1-\alpha} \cdot H_t^\alpha = A_t \cdot \left(\frac{K_t}{H_t} \right)^{1-\alpha} \cdot H_t \quad (1)$$

Labour inputs are typically measured in terms of total hours worked H and capital inputs in terms of the stock of physical capital K , where the latter is assumed to be proportional to the flow of services that emanates from it. These inputs are in principle observable in the data available from national statistical offices,

although in practice not all these offices provide them. The parameter α represents the (constant) elasticity of output with respect to labour. Under perfect competition (i.e. when in equilibrium the marginal product of each factor equals its price), this elasticity can be approximated by the labour share in national income. The production function can also be expressed in terms of capital intensity K/H , which measures how much capital is used in the production process per hour worked. The primary use of growth accounting has traditionally been to quantify the rate at which technological efficiency A evolves, which is assumed to improve the productivity of both labour and capital alike and is thus also referred to as total factor productivity (TFP). TFP is unobservable, but with all other elements in (1) known, its rate of increase can be derived from official data as a residual after deducting from real GDP growth the contributions associated with changes in hours worked and the capital stock.

If the measured changes in factor inputs only reflect changes in the quantities of labour and capital, the estimate of TFP growth derived from equation (1) is a catch-all for both technological progress and all measurement problems related to changes in the quality of factor inputs and in their intensity of use. For example, measures of aggregate hours worked typically do not take into account differences in efficiency that may be associated with education or work experience. Similarly, measures of the capital stock typically do not take into account the degree to which capital is used at a specific point in time. Changes in machine operating hours of the same capital stock would thus be reflected in TFP growth. In addition, TFP growth captures the impact of any erroneous assumption with regard to the factor share α . These caveats need to borne in mind when interpreting estimated TFP growth. This latter factor is generally the single most important

¹ For some evidence supporting the validity of the Cobb-Douglas production function for the euro area, see Willman (2002).

component of long-run growth in advanced economies.

In order to add more detail to the growth accounting framework, the generic factors labour and capital can be broken down into economically meaningful components, as described in Annex 1 and discussed in Section 3. Such a decomposition shows that a lower contribution to output growth from one component can be compensated for by a correspondingly higher contribution from one or several other components.

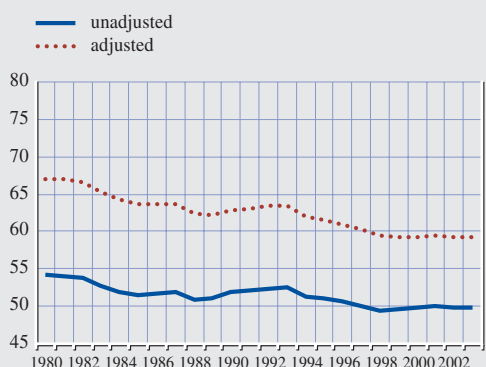
The impact of capital and labour components on output growth is proportional to their respective factor shares. According to national accounts data for the euro area, compensation of employees accounted on average for somewhat more than 50% of GDP in the period since 1980. Adjusted for the imputed labour income of the self-employed, the labour share was on average somewhat higher than 60% (see Chart 1). Changes in the labour input components thus have, a priori, a somewhat bigger impact on output growth than those in the capital components. For instance, if the rate of growth in the labour supply were to increase by 1 percentage point, this would translate into an additional 0.6 percentage point of output growth. If instead the rate of growth in the

capital stock were to increase by 1 percentage point, the effect would just be 0.4 percentage point.

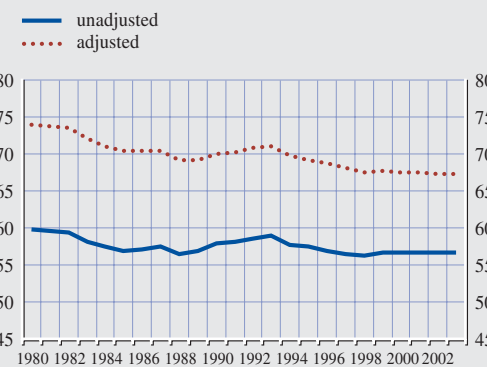
The share of (adjusted) compensation in GDP is the most common measure of the labour share, but it is subject to a number of caveats. In particular, such calculations critically hinge on the assumption that the longer-term average of the labour share reflects factor prices in a long-run competitive equilibrium, and that one minus the labour share reflects the factor share of capital. It is questionable, for instance, to what extent the latter holds in a growing economy where firms typically earn some temporary monopoly rents from innovation. The empirical factor share ($1-\alpha$) based on national accounts data includes these monopoly rents and might thus overstate the contribution to growth from capital and understate that from the residual, i.e. total factor productivity. Moreover, the value of ($1-\alpha$) based on national accounts data includes the share of GDP that is accounted for by indirect taxes (minus subsidies) and the value added used to finance these taxes has partly been generated by labour inputs. Thus, allocating the share of taxes (minus subsidies) proportionately to labour and capital results in a higher adjusted labour share of around 0.7 and consequently in a lower capital share (see right-hand panel of Chart 1).

Chart 1 Labour share in the euro area

(as a percentage of GDP)



(as a percentage of GDP excluding taxes (minus subsidies))



Source: ECB calculations based on Eurostat national accounts data.

Note: The labour share corresponds to the ratio of compensation of employees to GDP. The adjusted labour share takes account of the imputed labour income of the self-employed (assumed to be equivalent to average compensation per employee).

Overall, growth accounting provides a suitable framework for identifying individual factors of growth and summarising them in a convenient way, but the caveats in using the framework need to be borne in mind. These relate both to the empirical derivation of the individual contributions to growth via a production function and to the *ceteris paribus* analysis that is usually conducted on the basis of these contributions. In this respect, it is particularly important to bear in mind that in focusing on the effects that changes in a specific factor may have on growth, knock-on effects on other factors, which can be of an offsetting or amplifying nature, might be neglected. The following analysis should be seen in this light.

3 DISCUSSION OF THE FACTORS OF GROWTH

3.1 GENERAL CONSIDERATIONS

This section discusses the patterns of growth in the individual factors that feature in the growth accounting framework, focusing on the period from 1980 to 2003. The reason for limiting the discussion to only slightly more than the past two decades essentially reflects the constraints imposed by the availability of euro area-wide data. In particular, harmonised national accounts data necessary for the construction of euro area-wide data only date back to 1980. Annex 2 provides more details on the sources and the construction of the data.

The discussion of the historical developments in growth factors helps the assessment of potential output growth in two ways. First, it enables the inherent variation in the growth rates of factors such as the labour force and capital stock to be highlighted. In this paper, no attempt is made to disentangle these variations into temporary and permanent components, as would be the case in model-based production function approaches – for instance with regard to estimates of a structural rate of unemployment such as the NAIRU (non-accelerating inflation rate of unemployment). In the context of the growth accounting framework, this issue is essentially resolved by focusing on average growth rates in the relevant series over horizons such as a decade or a full business cycle. This simplification is less controversial than might appear at first sight as a number of the more sophisticated time series-based methods for extracting the permanent component of output in essence also amount to a somewhat arbitrary averaging of the relevant growth developments. Second, the discussion of the historical developments in growth factors sheds some light on the likely causes and magnitudes of fluctuations in potential output growth. This helps in assessing the plausibility of the range for trend potential output growth assumed in deriving the reference value for monetary growth, as well as the risks of moving outside the range over shorter horizons.

Measured in terms of real GDP developments, there have been two broad economic cycles in the euro area since the early 1980s, extending from 1981 to 1993 and from there to 2003. For simplicity, the two periods will henceforth be referred to as the 1980s and the 1990s. The analysis below uses these periods as benchmarks for the medium to longer-term developments in factors of growth which are reflected in trend potential growth. Annex 3 provides some summary statistics on the factors of growth in the two periods.

3.2 GROWTH IN LABOUR INPUTS

From 1980 to 2003 labour inputs as measured by total hours worked increased at an average annual rate of 0.1% (see left-hand panel of Chart 2). This conceals the fact that employment growth was on average significantly positive, but was largely offset by declines in average hours worked per person employed (see right-hand panel of Chart 2). However, average growth in total hours worked increased between the 1980s and the 1990s, as employment growth became stronger while the decline in average hours worked slowed.

The increase in employment growth during the 1990s compared with the 1980s is due to a large extent to the sustained growth and increased relative importance of part-time employment.² For example, according to Labour Force Survey data, part-time workers accounted for about 17% of total employment in 2003, while the corresponding number was around 13% in 1993 and less than 10% in the early 1980s. Another important determinant of overall employment growth over the same time horizon was substantial temporary job creation (most of which was in the category of full-time jobs) in the 1990s. The almost continuous (although decelerating) decline in average hours worked

2 For evidence on the increasing relative importance of part-time employment in total employment in the euro area, see the article entitled “The composition of employment growth in the euro area in recent years” in the November 2002 issue of the ECB’s Monthly Bulletin.

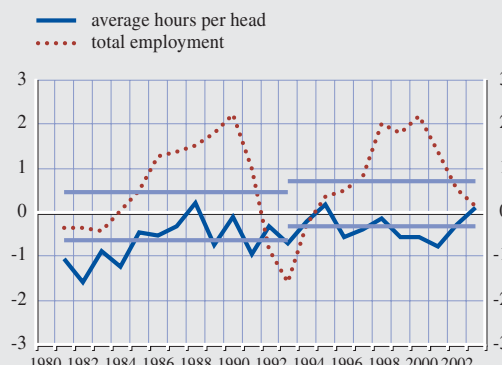


Chart 2 Growth in total hours worked and its components in the euro area

(annual percentage changes)



(annual percentage changes)



Source: ECB calculations based on data from Eurostat, the European Commission and the Groningen Growth and Development Centre.
Note: The horizontal lines show the annual average growth rates in the periods 1981-1993 and 1993-2003 respectively.

since 1980 is also largely explained by the gradual increase in the share of part-time employment observed in the euro area. However, there has also been a gradual decline in the average hours worked of full-time workers since the early 1980s. These labour market developments reflect a number of cultural and economic factors, with a prominent example of the latter being the structural reforms undertaken during the 1990s. In particular, efforts to promote structural reforms in euro area countries gained momentum in the second half of the last decade, with reforms

implemented in the framework of the European Employment Strategy as of 1997.³

In accounting terms, employment growth can be expressed in terms of labour force growth and developments in the unemployment rate (see equation A2 in Annex I). From this perspective, it can be observed that average labour force growth was significantly positive during the past two decades (see left-hand panel of Chart 3) and was also broadly unchanged across

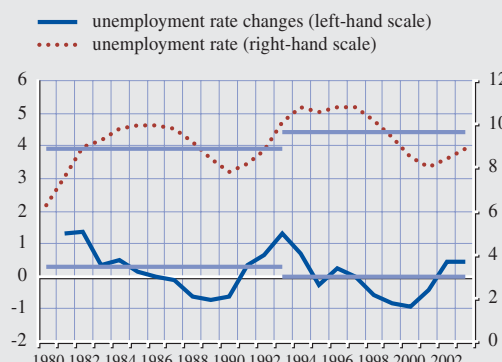
³ See also the Eurosystem report entitled "Labour market mismatches in euro area countries" (March 2002).

Chart 3 Labour force growth and unemployment rate in the euro area

(annual percentage changes)



(percentages and changes in percentages)



Source: ECB calculations based on data from Eurostat and the European Commission.
Note: The horizontal lines show the averages of the various measures in the periods 1981-1993 and 1993-2003 respectively.

the business cycles of the 1980s and the 1990s. At the same time, while the unemployment rate was somewhat higher in the 1990s than in the 1980s its average change was close to zero in the 1990s and thus lower than in the 1980s (see right-hand panel of Chart 3). This implies that, in accounting terms, for a given rate of labour force growth, there was less crowding-out of employment growth in the 1990s through adverse unemployment developments.

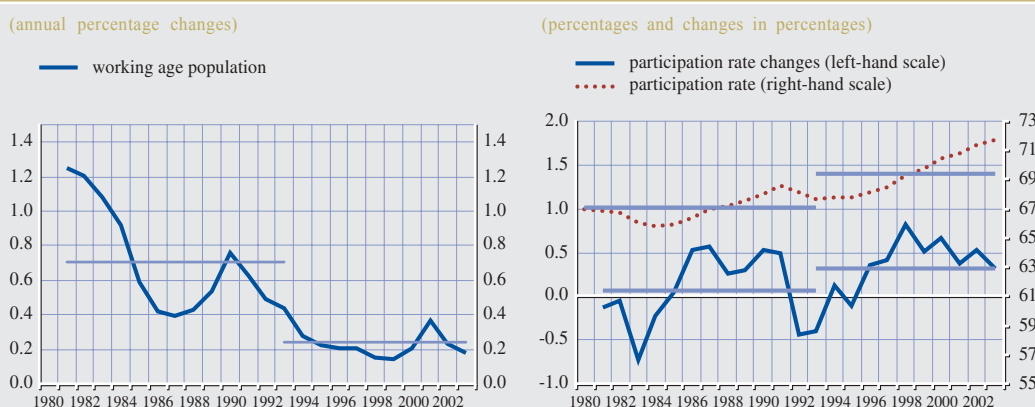
The unemployment rate typically reacts to some extent (and often with a lag) to cyclical conditions, but the fact that average unemployment in the euro area has been relatively high over the past few decades points to an important structural component. One sign for this is that long-term unemployment accounts for a large proportion of total unemployment.⁴ The increase in the average unemployment rate is often explained in terms of labour market rigidities, which transformed temporary increases in unemployment in the aftermath of adverse shocks into persistently higher unemployment rates. Frequently mentioned rigidities include in particular generous unemployment systems with regard to both the duration and the level of benefits, but also higher and less flexible wages, higher payroll taxes, tighter job security legislation and more centralised wage bargaining. Labour market reforms since the mid-1990s seem to be among

the main factors that may have induced a halt in the overall trend. There are some indications that the rising trend in the unemployment rate came to a halt in the mid-1990s, but it is clear that further comprehensive labour market reforms are needed to reduce the structural level of unemployment.

The broadly unchanged annual average growth in the labour force between the 1980s and 1990s conceals diverse developments in the participation rate and the working age population. In particular, annual average growth in the working age population, although significantly positive over the two cycles, exhibits a clear declining trend (see left-hand panel of Chart 4). This was broadly compensated for by a stronger average increase in the participation rate in the 1990s than in the 1980s (see right-hand panel of Chart 4).⁵ To a large extent, this stronger increase reflects developments in the labour force participation of women and is partly related to the stronger creation of part-time jobs.

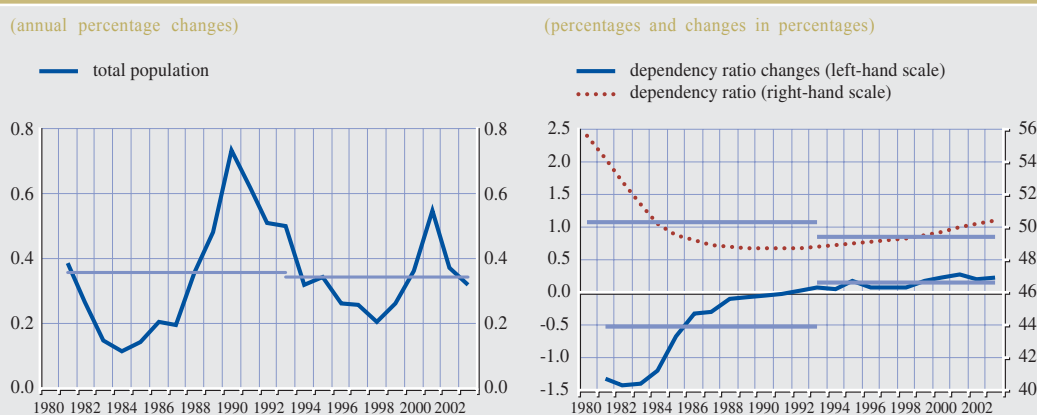
- 4 For a more detailed analysis of the characteristics of euro area unemployment since the early 1980s, see the article entitled "Developments in and structural features of the euro area labour markets" in the May 2000 issue of the ECB's Monthly Bulletin. For an overview of the causes and consequences of long-term unemployment in Europe, see Machin and Manning (1999).
- 5 For a more detailed analysis of developments in the euro area participation rate, see Genre and Gómez-Salvador (2002).

Chart 4 Working age population growth and participation rate in the euro area



Source: ECB calculations based on data from Eurostat and the European Commission.
Note: The horizontal lines show the averages of the various measures in the periods 1981-1993 and 1993-2003 respectively.

Chart 5 Population growth and dependency ratio in the euro area



Source: ECB calculations based on data from Eurostat and the European Commission.
 Note: The horizontal lines show the averages of the various measures in the periods 1981-1993 and 1993-2003 respectively.

The decline in working age population growth can, in turn, be attributed largely to a gradual ageing of the population since the late 1980s, which has reversed the pattern of the dependency ratio (see right-hand panel of Chart 5). By contrast, the average growth of total population over the two cycles was broadly unchanged (see left-hand panel of Chart 5). As will be discussed in Section 4, demographic developments since the 1990s and currently available projections suggest that declining population growth and population ageing are likely to represent a cause for concern with regard to growth prospects in the coming decades.⁶

Overall, the discussion of developments in the labour input and its components shows that it is important to take into account major changes such as labour market reforms which might have induced a structural break. Thus, while comparing developments across cycles or decades is a natural starting-point, occasionally it is also necessary to go beyond this classification of periods to gain an insight into the likely future sources of growth. As regards the variability of growth in labour input factors, there is no clear sign of major changes.

3.3 GROWTH IN CAPITAL INPUTS

This paper measures the economy's productive capacity in terms of the gross capital stock. The results are based on ECB estimates of the euro area capital stock derived from the data that are partly available in the national accounts of individual euro area countries. In the period since 1980 the euro area gross capital stock grew at an annual average rate of 2.6%, with average growth declining by more than $\frac{1}{4}$ percentage point between the 1980s and the 1990s (see left-hand panel of Chart 6).⁷

⁶ See also McMorrow and Roeger (2003) and the chapter entitled "How will demographic change affect the global economy?" in the September 2004 issue of the IMF World Economic Outlook.

⁷ The capital stock data used in this paper refer to the economy as a whole. It may be argued, however, that increases in productive capacity are best measured in terms of business investment only. At the euro area level, buildings account for roughly three-quarters of the capital stock, while equipment and transportation account for the rest. A narrow focus on business investment only may be problematic for two reasons. First, there have been statistical breaks over the past years as formerly state-owned enterprises in the area of public utilities such as telecommunications, electricity and transportation were privatised. Second, public infrastructure investment may have an important bearing on the development and efficiency of private investment, and the availability of housing may be an important aspect with regard to labour mobility and supply. Such considerations suggest that there may be some merit in applying a wider concept of the capital stock.

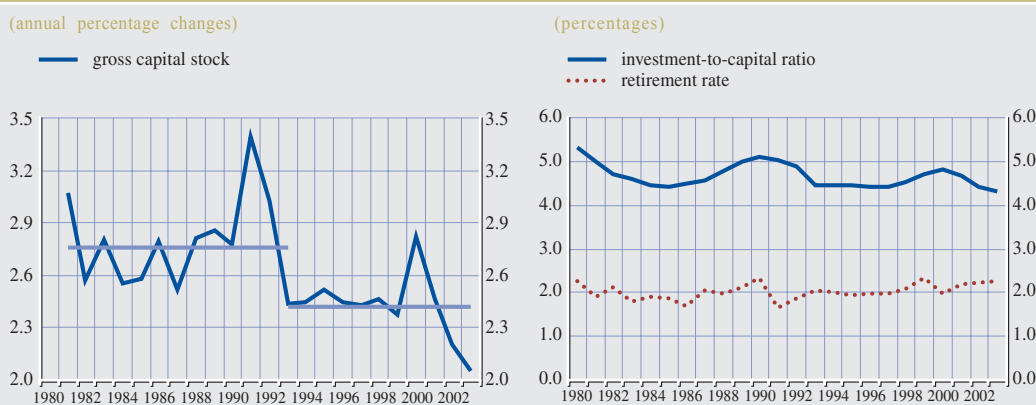
Drawing on the decomposition of capital stock growth in equation A6 of Annex I, this decline reflects essentially a small rise in the average retirement rate and a small decline in the investment-to-capital ratio between the two periods. Variations in these rates (as measured by their standard deviation) tend to be relatively small in absolute terms, given that the level of the capital stock is so much higher than the levels of investment or depreciation flows. The average variation of 0.3 percentage point in capital stock growth in the period since 1980 is for instance only around one-fifth of that in real GDP growth. The largest variation in the rate of growth of the capital stock between individual years was 0.5 percentage point. With a factor weight for capital inputs of 0.4, such a variation would imply an impact on potential output growth in the year in question of less than $\frac{1}{4}$ percentage point.

To assess the likely changes in the rate of growth in the capital stock, it is instructive to review the possible sources of variation in the retirement rate and investment-to-capital ratio. The average variation in these two ratios was more or less of the same magnitude, although the variation was generally somewhat lower in the 1990s than the 1980s. In national accounts the *retirement pattern* of installed capital is mostly estimated under the assumption that the

retirement date of an investment good follows some pre-specified distribution around an average service life. If these assumptions do not change, then the aggregate retirement rate reflects to a large extent the scale of past investment vintages. Investment booms and slumps should then normally imply increases and decreases in the retirement of capital some years on. However, this effect is smoothed out over a number of years due to the assumption that the retirement dates of the capital goods pertaining to a particular vintage are distributed around an average service life. Stronger effects on the retirement rate can arise if service lives decline from vintage to vintage, for instance due to obsolescence as a result of accelerating technical progress.

Moreover, effects on the overall retirement rate may come from a rapid change in the structure of the capital stock, given that the assumptions for the service lives of structures and equipment are different. For instance, while computer equipment is often assumed to have an average service life of below 10 years, the corresponding assumption for other types of equipment is around 20 years, for non-residential buildings around 50 years and for housing even longer. For a given rate of overall investment growth, an increasing share of equipment investment and a decreasing share of

Chart 6 Growth in the euro area gross capital stock and its components



Source: ECB calculations and estimates based on data from Eurostat and the European Commission.

Note: The horizontal lines in the left-hand chart show the annual average growth rates in the periods 1981-1993 and 1993-2003 respectively. The level of the capital stock is measured at the end of the year, while the left-hand chart shows annual averages.

buildings would shorten the average service life of capital goods and raise the overall retirement rate. This effect has received increased attention in the context of the strong growth in ICT investment that was recorded in the second half of the 1990s.

In pure accounting terms, changes in the *investment-to-capital ratio* can be decomposed into changes in the investment-to-GDP ratio and changes in the ratio of the capital stock to real GDP, where the latter ratio can be seen as a measure of capital productivity (see left-hand panel of Chart 7).⁸ These components may be more prominent in applied economic analysis than the investment-to-capital ratio and have the advantage that they provide more detailed information on the sources of variation in capital stock growth. In the period since 1980 the two components showed clear cyclical movements that offset each other to a large extent, thus explaining the relatively small average variation in the investment-to-capital ratio. Capital productivity declined between the 1980s and the 1990s, while the average investment-to-GDP ratio remained unchanged at 21%. The stability of the investment-to-GDP ratio reflects to a large extent the positive impact in the 1990s that was associated with the decline in capital goods prices relative to the GDP deflator. This relative decline was mainly

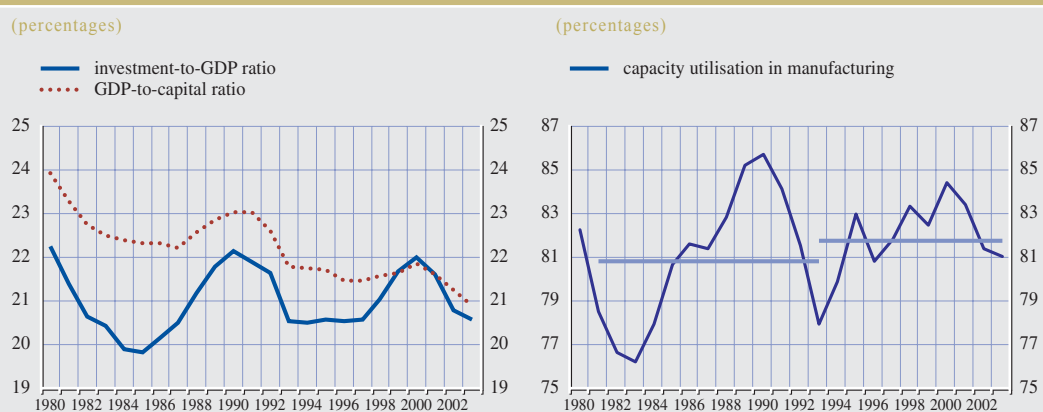
due to a fall in prices for ICT capital goods and the increasing share of these goods in total investment. However, as discussed previously, a rising share of ICT capital most likely also implies a higher average rate of capital retirement, which should have a counterbalancing effect on the falling capital goods prices with regard to capital stock growth.

Depending on the motives for investment, developments in the investment-to-GDP ratio may be associated with different developments in capital productivity. A distinction can be made between investment for expansion, replacement, rationalisation and modernisation purposes. If investment is undertaken with the aim to substitute capital for labour (for instance in response to wage cost pressures), then capital productivity is likely to decline. By contrast, if investment is of the modernisation type, then the higher level of technical progress embodied in the new vintages is likely to raise capital productivity. However, more productive vintages may also have the effect of raising the

8 The investment-to-capital ratio can be decomposed according to the following identity, where CU denotes capital utilisation and K^{actual} the capital stock effectively used at a point in time.

$$\frac{I}{K} = \frac{I}{Y} \cdot \frac{Y}{K^{actual}} \cdot \frac{K^{actual}}{K} = \frac{I}{Y} \cdot \frac{Y}{K^{actual}} \cdot CU$$

Chart 7 Determinants of the investment-to-capital ratio in the euro area



Source: ECB calculations based on data from Eurostat and the European Commission.

Note: The horizontal lines in the right-hand chart show the annual average growth rates in the periods 1981-1993 and 1993-2003 respectively.

rate of economic obsolescence amongst older vintages, thus increasing the retirement rate. Moreover, if capital goods are bought and installed because of subsidies or tax exemption, or if they reflect so-called gold-plating, i.e. investment expenditure not strictly relevant for the production of output, this may involve some degree of inefficiency and thereby imply a lower increase in capital productivity than would otherwise be associated with newly installed capital vintages.

A higher productivity of the installed capital can reflect a higher average rate of capital utilisation. More permanent changes in this rate reflect, for instance, changes in the operating hours of equipment and structures through changes in individual working hours or in the number of shifts. More flexibility through an adjustment of the working hours of employees can reduce the premia that are otherwise paid for overtime work or shift work and can lower the cost of capital. However, a higher rate of capital utilisation may also imply increased wear and tear of the capital stock and may then be associated with shorter service lives and a higher rate of retirement. Some information on capital utilisation may be inferred from survey data on capacity utilisation in the manufacturing sector. These data suggest that average utilisation increased between the 1980s and the 1990s (see right-hand panel of Chart 7).

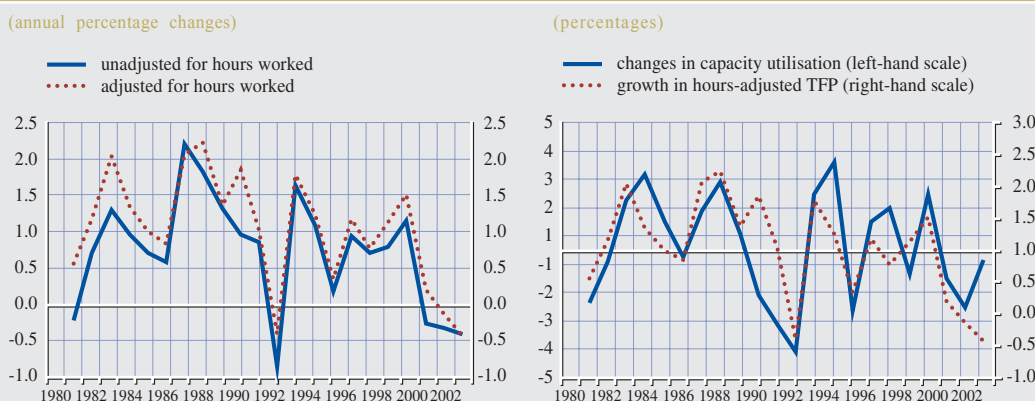
However, given that the manufacturing sector only accounts for a small fraction of the total capital stock, no strong conclusions can be drawn about the impact of capital utilisation on aggregate capital productivity.

The discussion in this section shows that any *ceteris paribus* analysis to account for changes in capital stock growth needs to bear in mind the possible interrelationships between the underlying components such as the investment-to-GDP ratio, capital productivity and the retirement rate. Moreover, when assessing the relatively low variability of capital stock growth over time, it should be kept in mind that measures of the capital stock based on the so-called perpetual inventory method do not take into account the degree to which the existing capital stock is actually used. Growth in actual capital services is thus likely to be considerably more volatile, but in conventional growth accounting frameworks this effect typically only shows up in the residual, i.e. total factor productivity.

3.4 GROWTH IN TOTAL FACTOR PRODUCTIVITY

Estimating TFP growth as a residual implies that it captures the part of real GDP growth which is unexplained by the contributions from

Chart 8 Growth in euro area total factor productivity



Source: ECB calculations based on data from Eurostat, the European Commission and the Groningen Growth and Development Centre.
Note: Capacity utilisation refers to the manufacturing sector.

labour and capital inputs. Depending on the specific measures used for these inputs, TFP growth thus typically reflects much more than pure technical progress. In particular, if labour inputs are measured in terms of employed persons, then estimated TFP growth will pick up the effect of changes in average hours worked per person employed. Considering that in the period since 1980 there has been a gradual decline in average hours worked, an adjustment for hours worked results in a somewhat higher average rate of growth in TFP (see left-hand panel of Chart 8). Similarly, if capital inputs are measured by the available capital stock, TFP growth will pick up the effect of changes in capital utilisation. As capital utilisation is a highly cyclical variable that should not display a longer-term trend, adjusting for short-term changes in utilisation will essentially reduce the variability of TFP growth (see right-hand panel of Chart 8). Nevertheless, any smoothing of the growth accounting residual in order to derive a figure for trend TFP growth that is relevant for potential output growth necessarily entails assumptions about the developments in the normal level of capital utilisation.

Table A3.4 in Annex 3 shows the outcomes for TFP growth that result from the different measures of labour and capital inputs. If labour inputs are measured in terms of total hours worked and capital inputs by the gross capital stock, then average TFP growth in the period since 1980 is estimated to have been 1.0% per annum, with a standard deviation in the annual growth rates of 0.8 percentage point. Incorporating also the information on capacity utilisation has no impact on the average rate of growth in TFP, but clearly reduces the variability of TFP growth. This reduction in variability might facilitate the detection of changes in underlying TFP growth and thus in trend potential output growth (the box examines the possibility of breaks in trend TFP growth).

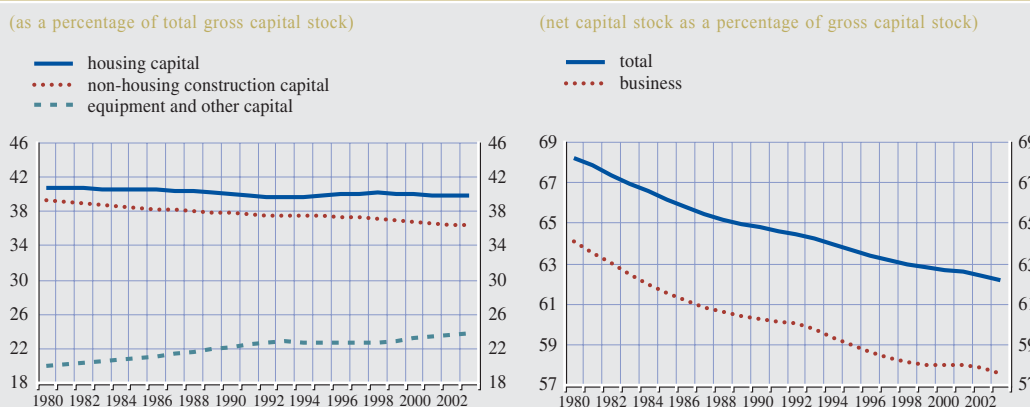
Adjusting for the impact from hours worked and capacity utilisation implies a better measurement of the quantity dimension of

factor inputs. However, estimated TFP growth still includes any likely quality changes of labour and capital inputs and can thus not be associated with pure technical progress or innovation discussed later in this section. The quality aspect is likely to be reflected in the composition of the labour force and the capital stock. For instance, an additional working hour by an experienced worker is likely to account for a larger increase in output than would an extra hour by an inexperienced worker. This implies that for a given rate of growth in overall output and a given rate of growth in total hours worked, the contribution from labour inputs would be larger if at the same time the share of experienced workers were to have increased. Similar considerations can be made for categories like education or gender. It is usually very difficult to aggregate the various categories into a meaningful overall labour quality indicator, but quantitative estimates – to the extent that they are available – suggest that labour quality in the euro area has increased over time. Growth accounting exercises that do not take into account changes in labour quality thus tend to understate the contribution to growth from labour and overstate that from TFP.

In parallel to the above, quality changes in the capital stock may reflect shifts between different categories of capital. In this respect, a distinction can be made between the more productive machinery and equipment capital on the one hand and less productive buildings and structures on the other.⁹ In the euro area, the share of equipment in the total capital stock has risen somewhat since the 1980s and that of construction capital has declined, suggesting that growth in the total capital stock might understate the contribution from capital inputs, and that estimated TFP growth should be correspondingly lower (see left-hand panel of Chart 9). A quantitative measure of quality-adjusted capital inputs can be derived by aggregating the different categories of the

⁹ For a more detailed discussion of the role of capital quality improvement with regard to growth and some evidence for the euro area, see Sakellaris and Vijselaar (2004).

Chart 9 Indicators of the quality of the capital stock in the euro area



Source: ECB calculations and estimates based on data from Eurostat and the European Commission.

Note: The gross capital stock discounts for the retirement of capital goods, while the net capital stock takes into account the depreciation of capital goods.

capital stock according to their relative user costs. In this respect, it should be noted that the relative user cost is inversely related to the relative depreciation rate of a capital good. The shift towards ICT capital, for which the depreciation rate is higher than for other types of capital, would thus show up as an improvement in quality and would increase the contribution to growth from a quality-adjusted measure of capital inputs.

A crude approximation of the modernity and thus the quality of the capital stock is the ratio of the net capital stock to the gross capital stock. Measures of the gross capital stock, which typically feature in growth accounting exercises, implicitly assume that capital goods provide a constant flow of services over their entire life. By contrast, the net capital stock adjusts for depreciation over the service life and thus takes into account the ageing and possible quality losses of the capital good. In the euro area, the ratio of the net capital stock to the gross capital stock has decreased over time (see right-hand panel of Chart 9). This would suggest that the rate of increase in the gross capital stock overstates the contribution to growth from capital inputs and that estimated TFP growth is held down by a loss in quality of the capital stock. At the same time, the rate of

decline in this modernity ratio was smaller in the 1990s than in the 1980s, implying that developments in the quality of capital contributed to a rise in measured TFP growth in the 1990s.

The previous considerations highlight that there are a number of factors that can explain why the average contribution to growth from estimated TFP growth may be smaller or larger than suggested by basic growth accounting exercises based on quantity measures of labour and capital inputs. The balance of these factors, and thus the part of TFP growth that can be more closely associated with pure technical progress or innovations, is essentially an empirical question. Further attempts to endogenise this “genuine” TFP growth residual have typically focused on the role of research and development (R&D) expenditure. The payoffs from R&D are inherently random and difficult to predict, but it is likely that more technological progress will be made if the efforts directed at achieving it become greater. In this respect, a cyclical pattern of R&D, for instance in response to the availability of internally generated funds, could account for some correlation between the rate of pure technical progress and the business cycle. This would also imply some variation in the rate of growth of potential output.

In the context of the debate on the new economy, there have been several studies aimed at explaining the technical progress in measured TFP growth in terms of the spillover effects that the use of ICT investment has on the general efficiency of the economy.¹⁰ However, empirical studies based on sectoral patterns of labour productivity have failed to produce convincing evidence for such an effect, both in the euro area and in economies with a higher ICT penetration such as the US economy.¹¹ It appears that ICT-related increases in labour productivity have thus far been confined to industries that produce ICT and to some extent to industries that actually use ICT. In the former industries the positive impact on labour productivity would also work through TFP growth, while in the latter industries it would work through capital accumulation and capital deepening.

Nevertheless, ICT is a useful and germane example that technological progress remains mostly unpredictable, also after the basic technical discoveries that underlie it have been made. Even today, when the use of ICT is common, the exact extent to which it helped raise TFP growth is still under debate and its contribution to future TFP growth is not known with any degree of accuracy. This limits the possibility in forward-looking growth accounting exercises of deviating in the assumptions for TFP growth from the average rates that have been observed in the past. This aspect will be discussed in the next section.

¹⁰ For a review of the literature, see for example the contributions to the symposium on "Computers and Productivity" in the Fall 2000 issue (vol. 14, no. 4) of the *Journal of Economic Perspectives*.

¹¹ See the evidence provided by Vijselaar and Albers (2002).

Box

HAVE THERE BEEN BREAKS IN THE MEAN AND VOLATILITY OF GROWTH OF REAL OUTPUT AND THE MAIN INPUTS OVER THE LONGER TERM?

Assessing average developments in factor inputs over the full length of a business cycle can provide useful information on trend potential growth. However, it has to be borne in mind that under such an approach gauging future developments in trend potential growth depends on the assumption that the average developments observed in the most recent cycle can be carried forward. This assumption may not be innocuous, as structural breaks can occur within a business cycle. Against this background, the objective of this box is to examine whether there is any evidence of structural breaks in the mean and the volatility of the growth rates of real GDP and the input factors (labour, capital and total factor productivity) over the longer term.

As already discussed in the main text, harmonised national accounts data for the euro area are only available from 1980. On an annual basis, estimates are available from the European Commission starting from 1960. These data must be interpreted with the necessary caution for the years before 1980, but they should provide a general picture regarding the longer-term trends. Tests for structural breaks are conducted using the method of Bai and Perron.¹ Compared with alternative tests in the literature, the Bai-Perron test has several advantages, including the possibility to test for multiple breaks within a unified framework and to take into account serial correlation and heteroskedasticity in the data.

¹ See Bai and Perron (1998) for details on the test and Bai and Perron (2003) for the corresponding critical values.

Longer-term trends and breaks in mean growth rates

Over the past four and a half decades, euro area real GDP growth has been on average markedly positive (see Table 1). However, there is evidence of a break around 1973, after which growth has been on average less than half that during the preceding period. This evidence is consistent with the studies on European economic history which refer to the period from 1950 to 1973 as the Golden Age of European economic growth.² After 1973 average growth seems to have been broadly stable between 2.0% and 2.5%.

As for most advanced economic areas, there is also evidence of a productivity slowdown in the euro area, represented by the clear abrupt decline in average TFP growth after 1973. After the mid-1970s, average growth in euro area TFP was about one-third of that during the preceding period. Moreover, there is some evidence of a slight declining trend in TFP growth since 1974. By contrast, no evidence can yet be found of new economy effects for the euro area around the mid-1990s, as concluded also in other studies.³

No evidence of structural breaks is detected for total employment growth from 1960 onwards, although trend growth has been increasing during this period. Thus, while no abrupt change can be identified, a more gradual structural change cannot be excluded over the longer term. As regards the capital stock, some evidence for two breaks in the pattern of growth can be found, in the middle and at the end of the 1970s. After 1980, capital stock growth seems to have been significantly lower compared with the previous two decades, but broadly constant on average up to 2003. However, since measurement problems are particularly acute for the capital stock, this evidence should be interpreted with much caution.

Table 1 Breaks in long-term mean growth rates

Variable	Mean 1960-2003	Breaks ¹⁾	Mean			Trend 1960-2003 ²⁾
			Before first break	In between	After last break	
Real GDP	3.1	1973	5.1		2.2	broadly constant
TFP	1.6	1973	3.2		1.0	decreasing
Employment	0.5	—				increasing
Capital stock ³⁾	3.2	1974, 1980	4.8	3.3	2.3	broadly constant

Source: ECB calculations based on data from the European Commission.

1) Break tests are carried out using the test of Bai and Perron (1998) on the growth rate of the series specified. The test options were chosen such that the first possible break is in 1966 and the last is in 1998.

2) In case of breaks, the reference is to the trend after the (most recent) break found.

3) Capital stock refers to the net capital stock.

Longer-term trends and breaks in volatility

A number of recent empirical studies have found that there is clear evidence of a reduced volatility of growth in several macroeconomic variables starting from the early 1980s, especially for the United States.⁴ As regards the economies of the euro area, the evidence is

² See for example Temin (1997).

³ See for example Visselaar and Albers (2002).

⁴ See for example the evidence and the references reported by Stock and Watson (2002).

more mixed, as breaks in volatility can be found but seem to be more dispersed in time.⁵ Thus, it is not surprising that very limited evidence of breaks in the volatility of growth of some basic euro area macroeconomic variables can be found. In particular, from 1960 onwards some evidence of a break in volatility can be detected but only for growth in euro real GDP and TFP (see Table 2). After the mid-1970s average volatility of growth in these two variables decreased, remaining broadly stable thereafter for output growth but exhibiting an increasing trend for TFP.

With regard to the volatility of growth in employment and the capital stock, no clear breaks can be detected. However, for both employment and TFP growth, volatility seems to have been increasing from 1960 onwards. By contrast, for the capital stock, the volatility of growth appears to have been decreasing, compensating for the increased volatility of the other factors of production.

Table 2 Breaks in long term volatility

Variable	Standard Deviation 1960-2003	Standard Deviation			Trend 1960-2003 ²⁾
		Breaks ¹⁾	Before break	After break	
Real GDP	1.8	1976	1.8	1.2	broadly constant
TFP	1.4	1976	1.4	0.8	increasing
Employment	0.9	–			increasing
Capital stock ³⁾	1.2	–			decreasing

Source: ECB calculations based on data from the European Commission.

1) Break tests are carried out using the test of Bai and Perron (1998) to unconditional volatility measured following Stock and Watson (2002) as the absolute value of the deviation of the quarter-on-quarter growth rate from the average. The test options were chosen such that the first possible break is in 1966 and the last is in 1998.

2) In case of breaks, the reference is to the trend after the (most recent) break found.

3) Capital stock refers to the net capital stock.

Overall, the evidence reported indicates that a number of structural breaks took place during the 1970s in both the mean growth rate and the volatility of growth of real GDP and some of the input factors. It is beyond the scope of this paper to review exhaustively the causes and consequences of these breaks, but it is likely that most of them are related to the structural change induced by the oil shocks of the 1970s. This evidence provides further reasons for focusing the growth accounting analyses of the euro area on the period starting from 1980, as well as for the lack of harmonised data before that year.

⁵ For the largest euro area economies, see for example the evidence reported by Van Dijk et al. (2002).

4 THE GROWTH ACCOUNTING EXERCISE IN PRACTICE

4 THE GROWTH ACCOUNTING EXERCISE IN PRACTICE

This section brings together the developments in the factors of growth discussed in the previous sections in terms of the actual contributions to real GDP growth. The decompositions are based on an average labour share of 0.6 and an average capital share of 0.4. The analysis includes a backward-looking part, decomposing growth for the past two decades, as well as a forward-looking part that uses the growth accounting framework for a scenario analysis over the horizon up to 2020. The periods considered in the analysis are sufficiently long to allow for an interpretation of the average real GDP growth rates as indicators of trend potential growth.

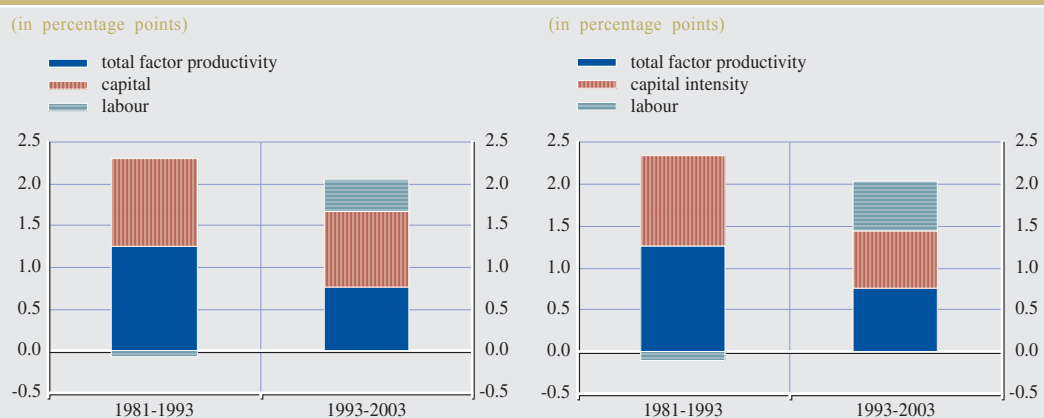
4.1 THE DECOMPOSITION OF GROWTH IN THE PERIOD 1981-2003

Chart 10 reports the sources of real GDP growth in terms of the contributions from labour, capital and total factor productivity. The left-hand and right-hand panels of the chart refer to the alternative representations of the production function as described in equation (1). In the right-hand panel, the sum of the contributions from TFP and capital intensity reflects the contribution to growth from labour productivity. The results confirm the usual

finding in growth accounting exercises that TFP growth accounts for most of real GDP growth or is at least the single most important component. In the 1980s somewhat more than 50% or 1.3 percentage points of real GDP growth was explained by TFP. The remainder (slightly less than 50% or 1.0 percentage point) was accounted for by capital, while labour had a broadly neutral effect on growth due to the offsetting effects from increases in employment and decreases in average hours worked. For the 1990s, the results show a small decline in average real GDP growth, which essentially reflects a decline in the contribution from TFP by around one-third to 0.8 percentage point. By contrast, the contribution from capital was broadly unchanged compared with that in the 1980s and labour made a positive contribution of around 0.4 percentage point or almost 20% of real GDP growth. More detailed results can be found in Annex 4.

Capital deepening, i.e. a rise in capital intensity, is a prevalent feature of the growth process in industrialised economies. In the 1980s capital deepening explained half of euro area real GDP growth, while the contribution declined to one-third in the 1990s. Together with lower TFP growth, the slower capital deepening had a negative impact on growth in labour

Chart 10 Contributions to real GDP growth in the euro area



Source: ECB calculations based on data from Eurostat, the European Commission and the Groningen Growth and Development Centre. Note: Labour is defined in terms of total hours worked, while capital refers to the gross capital stock in 1995 prices. Capital intensity denotes the ratio of the capital stock to total hours worked. In the right-hand panel labour thus contributes to real GDP growth both directly (via hours worked) and indirectly (via its impact on capital intensity).

productivity. However, some caution is warranted when interpreting this development, as it essentially reflects a reversal of the unfavourable labour market trends that started before the 1980s. Relatively strong real wage growth and inflexible labour markets had fostered the substitution of capital for labour and led to a rise in the unemployment rate. In the 1990s, real wages grew more moderately on average and labour market reforms led to some improvement in terms of flexibility. This slowed the substitution of capital for labour and allowed for higher employment growth.

Moreover, at the macroeconomic level capital deepening does not only reflect shifts towards less labour-intensive production, but also changes in the employment composition of industrial sectors. The decline in the rate of capital deepening between the 1980s and 1990s thus also reflects a rise in the share of total employment in particular for those industries that are characterised by relatively slow capital deepening. These industries belong to a large extent to the services sector and may also have absorbed relatively low-skilled and inexperienced workers, many of them re-integrated from unemployment. This may also partly explain the slowdown in TFP growth, considering that the estimate of the latter includes the impact of unmeasured changes in labour quality. In this respect, the lower TFP growth may to some extent be interpreted positively in the sense that it reflects an increased capacity of the economy to absorb a previously unused supply of labour.

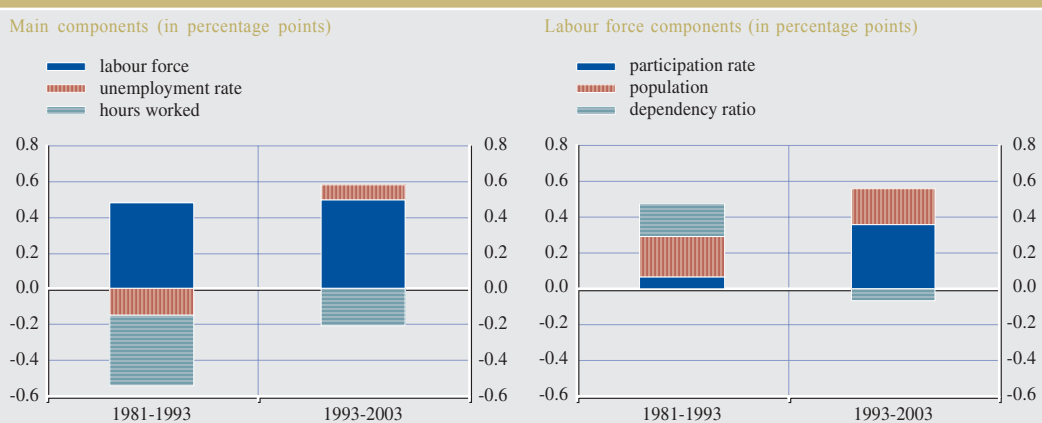
Nevertheless, assuming for simplicity that measured TFP growth reflects something like a natural rate of technological progress, sustaining real GDP growth in the 1990s would have required a stronger increase in the quantity of labour and/or capital inputs. More specifically, average real GDP growth declined by 0.2 percentage point and with factor shares of 0.6 (0.4), growth in total hours worked (gross capital stock) would need to have been $\frac{1}{3}$ ($\frac{1}{2}$) percentage point higher than it actually was in order to sustain real GDP growth. These

magnitudes should be put into perspective with regard to the underlying components. In the case of capital, the requirement to stabilise average real GDP growth would, *ceteris paribus*, have implied an average investment-to-GDP ratio in the 1990s of 22½% and thus a higher level than was reached during business cycle peaks. Similarly, in the case of labour it would for instance have been necessary for average hours worked to have more or less stabilised at a level of somewhat more than 1,600 hours per year in the mid-1990s, while up to 2003 they actually declined further by around 50 hours.

While the contributions to growth from the individual components of capital stock growth have been more or less unchanged between the 1980s and the 1990s, those from the labour supply components have in some cases changed substantially. Chart 11 shows that the contribution from labour force growth was 0.5 percentage point in both the 1980s and the 1990s. However, in the 1980s most of this contribution was offset by a rise in the unemployment rate and a decline in average hours worked. In the same vein, the higher contribution to growth from the labour supply in the 1990s reflects a decrease in the unemployment rate and a slower decline in hours worked (see the left-hand panel of Chart 11). These different developments are likely to be related first of all to the negative consequences that the oil shocks of the 1970s had on developments in the 1980s and second to the positive impact that partial labour market reforms had on developments in the 1990s.

The unchanged contribution to real GDP growth from labour force developments between the 1980s and 1990s reflects *inter alia* an unchanged contribution of 0.2 percentage point from population growth. At the same time, it conceals the fact that the contributions associated with changes in the dependency ratio and participation rate moved in opposite directions. While declines in the dependency ratio made a positive contribution in the 1980s, subsequent increases implied a negative

Chart 11 Contributions from labour components to real GDP growth in the euro area



Source: ECB calculations based on data from Eurostat, the European Commission and the Groningen Growth and Development Centre.
Note: Labour is defined in terms of total hours worked, while capital refers to the gross capital stock in 1995 prices.

contribution in the 1990s. However, this effect was counteracted by a rise in the contribution from changes in the participation rate. Thus, while demographic developments have not been favourable in more recent periods and, as discussed in the next section, are projected to become a major factor of concern for future growth, the experience of the 1990s shows that the negative impact of demographic developments on medium to longer-term growth can be compensated for by other components of the labour supply.

Two general points can be made about such accounting exercises. First, they show that counterbalancing the impact of a strong decline in TFP growth, as was observed between the 1980s and 1990s, implies a considerable strengthening in the labour supply and/or fixed capital formation in order to sustain growth. Second, given the large magnitudes of the required change that is, *ceteris paribus*, implied for the individual components of labour and capital, only a combination of different growth-enhancing measures may realistically lead to the desired results. More generally, however, the developments in the United States have shown that a decline in TFP growth is not an iron law of economic developments. In this respect, the Lisbon agenda also calls for reform policies that lead to a business environment that is more

conducive to innovation and thus higher TFP growth. The section below highlights these points in the context of a forward-looking growth accounting exercise.

4.2 THE DECOMPOSITION OF GROWTH IN FORWARD-LOOKING SCENARIOS

The historical evaluation of growth developments in output and factor inputs is important for assessing the current evolution of the economy's supply-side potential. However, it is also important for assessing the assumptions underlying forward-looking growth scenarios. Such scenarios can be important to provide policy-makers with quantitative information on policy requirements or options. This section develops three types of assumption-based scenarios. The first type examines the consequences for economic growth under the assumption that the developments in factor inputs essentially follow past patterns. The second type derives the growth in factor inputs that would be necessary if real GDP growth were to be sustained at past levels. Finally, the third type sketches the impact on economic growth that may be associated with reaching the employment targets stated in the Lisbon agenda. All of these scenarios are of a purely illustrative nature and

should not be confused with projections of trend potential growth.

The three scenarios share some common assumptions. In particular, given the unpredictable nature of technical progress it appears appropriate to conduct the scenarios under the assumption of an unchanged average rate of TFP growth. In this respect, it needs to be borne in mind that the possible role of ICT in raising TFP growth is still under debate. Scenarios could thus be envisaged where average TFP growth in the euro area increases to similar magnitudes as those currently recorded for the United States, depending on how quickly the production and use of ICT gain further importance in the overall economic process. There is some consensus that the successful introduction of new technologies, in turn, depends on how quickly the economy can be made flexible through structural reforms. A technology shock of the same size as in the United States should thus not be expected to lead to a similar rise in average TFP growth as long as there are institutional differences with regard to labour market rigidities and capital adjustment costs. Obviously, the objectives stated in the Lisbon agenda address a number of these institutional differences and might thus also imply a case for different assumptions with regard to average TFP growth.

In addition to unchanged TFP growth, all the scenarios below also assume an unchanged rate of capital deepening. According to equation (1), this implies unchanged growth in labour productivity. This assumption is naturally more difficult to justify than that of unchanged TFP growth alone. Changes in the capital-to-labour ratio depend on developments in relative factor prices and on sectoral shifts within the overall economy. Moreover, the analysis of historical data suggests that for the euro area there have typically been trade-offs between higher labour productivity growth and lower employment growth, and vice versa. Bearing in mind this caveat, the assumption makes it possible to focus exclusively on the contribution to real GDP growth from the labour supply and thus

on one of the prominent policy issues in the context of the Lisbon agenda.

In the medium to longer term, the labour supply will to a large extent be determined by demographic developments. The available long-term projections by national statistical institutes suggest that population growth in the euro area will decline over the period up to 2020 and that after this point the population will shrink in absolute terms. Moreover, the negative impact that this would have on the potential labour supply is reinforced by the fact that the share of older persons is expected to rise and lead to a concomitant increase in the dependency ratio. As a result, the working age population is expected to shrink before 2020. More specifically, following an average rate of growth of 0.2% in the 1990s, the working age population is projected to stagnate on average in the period up to 2010 and to decline by 0.2% per annum in the further period up to 2020. The equivalent projections by the United Nations imply very similar demographic developments. When taking these projections as a given, it needs to be borne in mind that they are exclusively based on assumptions about fertility, life expectancy and migration and thus do not take into account a number of socio-economic factors that may be relevant but cannot be properly measured.

Given the constant features in the three scenarios, the analysis is effectively limited to different assumptions for the developments in labour utilisation, which in the present growth accounting framework is expressed as a function of the participation rate, the unemployment rate and average hours worked per person employed.

The first scenario considers the case where developments in labour utilisation maintain unchanged dynamics compared with those in the 1990s (see Table 1). In this case, the adverse demographic developments would reduce average real GDP growth in the period up to 2010 to below 2% and in the period up to 2020 further to around 1½%. The unchanged

Table 1 Scenario for real GDP growth if factor inputs were to grow in line with past patterns

	Constant features		Variable features			Real GDP
	Labour productivity	Working age population	Participation rate	Unemployment rate	Hours worked per person	
Percentages						
1993-2003	1.4	0.2	0.6	-0.1	-0.3	2.0
2003-2010	1.4	0.0	0.6	-0.1	-0.3	1.8
2010-2020	1.4	-0.2	0.6	-0.1	-0.3	1.6
End-of-period levels						
2003			71.7	8.9	1,557	
2010			74.6	8.0	1,521	
2020			79.0	6.7	1,471	

Source: ECB calculations based on equation A7 in Annex I.

dynamics would imply that the participation rate reaches levels comparable to those in the United States by 2020, while the unemployment rate would still be somewhat above the longer-term average in the United States and above levels prevailing in the euro area before 1980. Finally, hours worked would decline further, reflecting to a large extent the extrapolation of the picture in the 1990s, when the strong increases in participation were associated with a rising share of part-time employment.

The second scenario considers the requirements in terms of growth rates of the individual labour input components if real GDP growth were to be sustained at the level of 2%. *Ceteris paribus*, this would for instance require growth in the participation rate of around 0.8% per annum,

considerably stronger than in any period of the past (see Table 2). Under this scenario, the participation rate would need to reach a level of around 75% by 2010 and of almost 85% by 2020. In Europe, such high participation rates have only been observed in smaller economies such as Iceland or Switzerland. Sustaining real GDP growth through stronger growth in the labour supply could also be achieved through a faster decline in the unemployment rate or a stabilisation in average hours worked. *Ceteris paribus*, the unemployment rate would have to decline to 6½% by 2010 and to below 1% by 2020. In the case of average hours worked, a small further decline of around 10 hours by 2010 and a similar increase by 2020 would be sufficient. This implies that the ratio of part-time employment should more or less stabilise,

Table 2 Scenario for labour input growth if real GDP growth were to be sustained

(percentages)

	Constant features		Variable features			Real GDP
	Labour productivity	Working age population	Participation rate	Unemployment rate	Hours worked per person	
1993-2003	1.4	0.2	0.6	-0.1	-0.3	2.0
2003-2010	1.4	0.0	0.8	-0.1	-0.3	2.0
2010-2020	1.4	-0.2	1.0	-0.1	-0.3	2.0
2003-2010	1.4	0.0	0.6	-0.3	-0.3	2.0
2010-2020	1.4	-0.2	0.6	-0.6	-0.3	2.0
2003-2010	1.4	0.0	0.6	-0.1	-0.1	2.0
2010-2020	1.4	-0.2	0.6	-0.1	0.1	2.0

Source: ECB calculations based on equation A7 in Annex I.

Table 3 Scenario for real GDP growth if Lisbon employment target were to be reached by 2010

(percentages)

	Constant features		Variable features			Real GDP
	Labour productivity	Working age population	Participation rate	Unemployment rate	Hours worked per person	
1993-2003	1.4	0.2	0.6	-0.1	-0.3	2.0
2003-2010	1.4	0.0	0.9	-0.1	-0.3	2.1
2010-2020	1.4	-0.2	0.6	-0.1	-0.3	1.6
2003-2010	1.4	0.0	0.6	-0.4	-0.3	2.1
2010-2020	1.4	-0.2	0.6	-0.1	-0.3	1.6

Source: ECB calculations based on equation A7 in Annex I.

or that with unchanged part-time dynamics a longer average working week would generate the additional labour supply.

Finally, the third scenario assumes that the employment rate (as a percentage of the working age population) reaches 70% in 2010, as stated in the targets set in the Lisbon agenda for Europe. Applying this target also to the euro area and considering that some countries have already achieved relatively high employment rates, the target implies considerable adjustment pressure on the remaining countries. For the period after 2010, the scenario assumes that labour supply dynamics return to the pace observed in the 1990s, as was already assumed in the first scenario. The mechanics of the growth accounting framework suggest that the Lisbon employment target can be achieved by more quickly raising participation or by more quickly reducing the unemployment rate. *Ceteris paribus*, the participation rate would need to increase by 0.9% per annum, reaching a level of 76% in 2010, while the unemployment rate would have to decline by 0.4 percentage point per annum to a level of 6¼% in 2010 (see Table 3). In each case the associated increase in labour supply growth would raise average real GDP growth to 2.1%, slightly higher than in the 1990s but still slightly lower than in the 1980s. It should be noted, however, that the employment target is only one of the targets in the Lisbon agenda related to labour supply. Achieving in addition the target of raising the effective retirement age by five years by

2010 would obviously also generate a further potential supply of labour.

The scenario analysis above shows that there is some scope for sustaining or even raising medium to longer-term output growth by accelerating growth in the labour supply. The *ceteris paribus* nature of the analysis emphasises that a focus on individual components of the labour supply may imply dynamics that significantly exceed those observed in past periods. However, addressing several components at the same time will reduce the requirements of each individual component and may also be necessary in the light of the interrelationships that exist between the dynamics of the individual growth components. Policy-makers thus need to exercise the necessary caution in using the information from growth accounting exercises.

5 CONCLUSIONS

5 CONCLUSIONS

Growth accounting provides a useful framework for analysing medium to longer-term developments in real GDP and can thus help in assessing potential output growth. In particular, it allows the relative importance and quantitative contribution of the individual supply-side factors of growth to be identified and summarised. In this respect, the results from growth accounting exercises crucially depend on the availability of data on the quantity and quality of labour and capital inputs. Data limitations will inevitably show up in the rate of growth in total factor productivity, which is derived as a residual and, in growth accounting exercises, usually emerges as the single most important driving force of longer-term growth. The results of this paper are no exception: over the past two decades, estimated total factor productivity has accounted for more than half of real GDP growth in the euro area.

Growth accounting does not aim to explain the underlying forces of economic growth such as institutions and economic policies, or the behavioural relationships that ultimately drive technological progress, physical capital accumulation or the labour supply and the linkages between the developments in these individual factors. In this respect, growth accounting exercises can only be a useful complement to model-based approaches to estimating and assessing potential output. This is particularly true for the production function approach to potential output estimation.¹² Nevertheless, analyses based on average contributions to growth over sufficiently long time periods such as a full economic cycle may be useful for gauging the sustainable rates of economic growth and thus, for instance, underpin the ECB's assumption for trend potential growth.

This paper shows that the developments in supply-side factors are subject to considerable variation over the economic cycle. Given the various underlying driving forces, it can thus be difficult to separate the more temporary movements from the sustainable rates of growth by means of economic models or to arbitrarily

smooth out such variations using statistical filters. As a result, estimates of potential output growth will usually inevitably display some variation characterising unsustainable developments. Moreover, when assessing potential output growth, the properties of the data, including possible breaks related to structural reforms, need to be taken into account in order to avoid misleading results. The discussion of the labour input components shows that the detection of breaks, for example resulting from the gradual impact of successive labour market reforms, may require a long time. The problem of timely detection of structural change is very difficult to deal with in both the purely data-based growth accounting exercises and the model-based approaches to estimating potential output. By exploiting all relevant sources of information, including for instance timely business surveys, and cross-checking this information with the results from the analysis of growth developments, this problem can be mitigated to some extent.

The forward-looking growth accounting exercises conducted in this paper have shown that there is some scope for sustaining or even raising medium to longer-term output growth despite the adverse demographic developments expected in the years ahead. There appear to be two main areas where improvements are warranted and where the Lisbon agenda states the relevant objectives. First, structural reform in product and labour markets could improve the business environment in a way that allows for more innovation and technical progress. Second, there is a considerable potential for increasing the contributions to growth from the labour supply, considering that the (structural) unemployment rate in the euro area is still relatively high by international standards and that the participation rate and average hours worked are relatively low. This requires further labour market reforms, which can be seen as an essential part of any strategy aimed at raising trend potential output growth.

¹² See for example Proietti et al. (2002).

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ANNEX I DECOMPOSITION OF THE BROAD FACTORS OF GROWTH

Starting from equation (1) in the main text, this annex decomposes the generic factors labour and capital into economically meaningful components.

As regards labour, total hours worked H reflects the product of employment E and average hours worked per person employed h . Employment, in turn, is defined as the difference between the labour force N and total unemployment U and can be expressed as a function of the unemployment rate ur . The labour force is the product of the participation rate pr and the working age population P^{WA} (i.e. the number of persons aged 15 to 64). Finally, the working age population is a function of total population P and the dependency ratio dr , where the latter is defined as the number of persons below 15 and above 64 as a ratio of the working age population. These identities are summarised in equations A1-A4 below.

$$H_t \equiv \frac{H_t}{E_t} \cdot E_t \equiv h_t \cdot E_t \quad (A1)$$

$$E_t \equiv N_t - U_t \equiv N_t \cdot (1 - ur_t) \quad (A2)$$

$$N_t \equiv pr_t \cdot P_t^{WA} \quad (A3)$$

$$P_t^{WA} \equiv P_t \cdot \frac{1}{1 + dr_t} \quad (A4)$$

As regards capital, measures of the capital stock are typically compiled on the basis of the perpetual inventory method, i.e. accumulating gross investment I and at the same time allowing for retirement D of existing capital (see equation A5). Retirement captures the physical removal and scrapping of capital goods from the capital stock due to technical or economic obsolescence. The capital stock in the period ahead thus consists of the capital stock available at the beginning of the current period plus the net additions made during the current period. This implies that the rate of growth in the capital stock can be expressed as the sum of the investment-to-capital ratio i and the retirement rate d (see equation A6). It should be noted that this measure of the capital stock does not take into account the degree of utilisation of the capital stock through time and, in principle,

thus captures capital inputs to potential rather than actual output growth.

$$K_{t+1} \equiv K_t - D_t + I_t \quad (A5)$$

$$\frac{K_{t+1} - K_t}{K_t} = \frac{I_t}{K_t} - \frac{D_t}{K_t} \equiv i - d \quad (A6)$$

Putting all these identities into the production function and expressing the latter in terms of rates of growth (denoted by g) shows that real GDP growth can be decomposed into the contributions from total factor productivity A , investment and depreciation rates, hours worked per person, population, the unemployment rate, the participation rate and the dependency ratio. It should be noted that increases in the capital retirement rate, the unemployment rate and the dependency ratio have a negative impact on real GDP growth.

$$g_Y = g_A + (1 - \alpha) \cdot (i - d) + \alpha \cdot$$

$$(g_h - \frac{ur}{1 - ur} \cdot g_{ur} + g_{pr} - \frac{dr}{1 + dr} \cdot g_{dr} + g_P) \quad (A7)$$

ANNEX 2 GLOSSARY AND DATA SOURCES

ANNEX 2

GLOSSARY

Variable	Definition
Population:	Number of people living in the euro area.
Working age population:	Population aged between 15 and 64 years.
Dependency ratio:	Number of persons in the population that are not of working age as a percentage of the working age population.
Labour force:	Sum of employed and unemployed persons. The number of unemployed persons is calculated on the basis of data for employment and the unemployment rate. The figure may be different from that in the Labour Force Survey as the latter includes only employed persons aged between 15 and 64 years.
Participation rate:	Number of persons in the labour force as a percentage of the working age population.
Unemployment rate:	Number of unemployed persons (defined according to ILO recommendations) as a percentage of the labour force.
Employment:	Sum of employees and self-employed persons.
Hours worked:	Number of paid hours worked per year and per person employed. This includes the hours of persons that have several jobs at the same time. The estimates used in this paper include paid overtime but exclude paid hours that are not worked due to annual leave, sick leave, parental leave, etc.
Capital stock:	Sum of produced fixed assets that provide ongoing services by being used repeatedly or continuously in production processes for more than one year. In the national accounts, capital includes tangible as well as intangible assets.
Labour share:	Compensation of employees as a percentage of GDP. The adjusted share takes into account the fact that part of the mixed income of the self-employed is essentially labour income. The adjustment is based on the assumption that the average compensation of a self-employed person equals that of an employee.

DATA SOURCES

The euro area-wide data used in this paper come from different sources. Eurostat provides official euro area-wide data for real GDP, fixed capital formation, unemployment and population for the period from 1991. Data for the period 1980-1990 are ECB calculations based on the harmonised national accounts data for the individual Member States and compiled according to the same methodology as that applied by Eurostat. For the number of employed persons, the calculations cover the whole period since 1980 as Eurostat thus far only publishes an index of employment. The few gaps in the data for individual years in individual countries were filled on the basis of data from the European Commission's AMECO database. In the case of Germany, data prior to 1991 have been obtained on the basis of developments in West Germany.

Data on annual hours worked for the individual Member States were taken from the Total Economy Database of the Groningen Growth and Development Centre and The Conference Board (February 2004, <http://www.ggdcc.net>). The euro area-wide series was calculated on the basis of the countries' employment shares.

Data on the working age population are calculated on the basis of data taken from the European Commission's AMECO database. More precisely, the working age population has been calculated as the product of Eurostat population data and the dependency ratio implied by the AMECO database.

Data on the euro area capital stock are ECB estimates, produced in the Directorate General Statistics and compiled according to the perpetual inventory method. The estimates for the various categories of the capital stock are based on three components: (i) estimates of the starting values for the respective capital stock series in 1980; (ii) Eurostat data for gross fixed capital formation in the euro area; (iii) and estimates of the retirement and depreciation rates pertaining to the respective capital stock

series. The estimates of the starting values are deducted from a GDP-to-capital ratio in 1980 that is based on national data covering more than 80% of the euro area GDP weight. Similarly, the euro area-wide retirement and depreciation rates are compiled from national data for the capital stock and gross fixed capital formation covering more than 80% of the euro area.

Population projections over the period 2003-2020 are based on Eurostat's demographic scenarios, which were compiled in 1995 and revised in 1999 with the assistance of national statistical offices. The paper uses the medium variant of these projections.

ANNEX 3 DESCRIPTIVE STATISTICS ON FACTORS OF GROWTH

Table A3.1 Growth in the labour input and its components

	Growth in labour supply (total hours worked)	Demographic components		Labour utilisation components		
		Total population growth	Changes in the dependency ratio	Participation rate growth	Changes in the per unemployment rate	Growth in hours worked per person
Percentages						
1981-1993	-0.2	0.4	-0.5	0.1	0.3	-0.6
1993-2003	0.6	0.3	0.2	0.6	0.0	-0.3
1981-2003	0.1	0.3	-0.2	0.3	0.1	-0.5
Standard deviation						
1981-1993	1.4	0.2	0.6	0.6	0.7	0.5
1993-2003	1.1	0.1	0.1	0.5	0.7	0.3
1981-2003	1.2	0.2	0.6	0.6	0.7	0.4

Source: ECB calculations based on data from Eurostat, the European Commission and the Groningen Growth and Development Centre.

Table A3.2 Growth in the labour force and its components

	Labour force growth	Demographic perspective		Composition		Memo items	
		Working age population growth	Participation rate	Employment growth	Unemployment rate	Dependency ratio	Employment rate
Percentages							
1981-1993	0.8	0.7	67.1	0.5	9.0	50.3	61.1
1993-2003	0.7	0.2	69.4	0.9	9.7	49.4	62.7
1981-2003	0.8	0.5	68.1	0.7	9.3	50.0	61.9
Standard deviation							
1981-1993	0.5	0.3	0.8	1.2	0.9	2.3	1.3
1993-2003	0.4	0.1	1.5	1.1	1.1	0.5	2.1
1981-2003	0.5	0.3	1.7	1.0	1.0	1.8	1.8

Source: ECB calculations based on data from Eurostat and the European Commission.

Table A3.3 Growth in the capital stock and its components

	Capital stock growth	Investment-to-capital ratio			Retirement rate	Memo item: capacity utilisation in manufacturing
		Total	Investment-to GDP ratio	GDP-to-capital ratio (capital productivity)		
Percentages						
1981-1993	2.8	4.7	20.9	22.6	1.9	80.8
1993-2003	2.4	4.5	20.9	21.5	2.1	81.8
1981-2003	2.6	4.6	21.0	22.1	2.0	81.4
Standard deviation						
1981-1993	0.2	0.2	0.8	0.4	0.2	3.1
1993-2003	0.2	0.1	0.6	0.3	0.1	1.8
1981-2003	0.3	0.2	0.7	0.6	0.2	2.6

Source: ECB calculations based on data from Eurostat and the European Commission.

Note: Figures may not add up due to rounding.

Table A3.4 Growth in total factor productivity

	Not adjusted for hours		Adjusted for hours worked		Memo items	
	Not adjusted for capacity utilisation	Adjusted for capacity utilisation	Not adjusted for capacity utilisation	Adjusted for capacity utilisation	Changes in capacity utilisation in manufacturing	Growth in average hours worked per employed person
Percentages						
1981-1993	0.9	0.9	1.3	1.3	0.0	-0.6
1993-2003	0.5	0.5	0.8	0.7	0.3	-0.3
1981-2003	0.7	0.7	1.0	1.0	0.1	-0.5
Standard deviation						
1981-1993	0.9	0.6	0.8	0.5	2.2	0.5
1993-2003	0.8	0.5	0.8	0.5	2.1	0.3
1981-2003	0.8	0.6	0.8	0.6	2.0	0.4

Source: ECB calculations based on data from Eurostat, the European Commission and the Groningen Growth and Development Centre.

Note: The adjustment for capacity utilisation assumes that the business sector has the same rate of capacity utilisation and that the business sector's share of the total capital stock is around 42%.

ANNEX 4 DETAILED DECOMPOSITION OF CONTRIBUTIONS TO REAL GDP GROWTH

Table A4.1 Contributions to real GDP growth in the euro area

(percentages)

	Real GDP growth	Contribution from growth in:		
		TFP	Labour	Capital
1981-2003	2.1	1.0 48%	0.1 6%	1.0 46%
1981-1993	2.2	1.3 56%	-0.1 -3%	1.0 47%
1993-2003	2.0	0.8 37%	0.4 18%	0.9 45%

Source: ECB calculations based on data from Eurostat, the European Commission and the Groningen Growth and Development Centre.
Note: Figures may not add up due to rounding.

Table A4.2 Contributions to growth from the labour supply and its main components

(percentages)

	Real GDP growth	Labour supply (total hours worked) $a=b+c$	Main labour components		Main employment components	
			Hours worked per person b	Employment $c=d+e$	Labour force d	Unemployment rate e
1981-2003	2.1	0.1 6%	-0.3 -15%	0.4 21%	0.5 23%	0.0 -2%
1981-1993	2.2	-0.1 -3%	-0.4 -18%	0.3 15%	0.5 22%	-0.1 -6%
1993-2003	2.0	0.4 18%	-0.2 -10%	0.6 28%	0.5 22%	0.1 3%

Source: ECB calculations based on data from Eurostat, the European Commission and the Groningen Growth and Development Centre.
Note: Figures may not add up due to rounding.

Table A4.3 Contributions to growth from the labour force and its components

(percentages)

	Real GDP growth	Labour force $a=b+c$	Demographic components		Working age population components	
			Participation rate	Working age population	Total population	Dependency ratio
			b	$c=d+e$	d	e
1981-2003	2.1	0.5 23%	0.2 9%	0.3 14%	0.2 10%	0.1 3%
1981-1993	2.2	0.5 22%	0.1 3%	0.4 20%	0.2 10%	0.2 8%
1993-2003	2.0	0.5 22%	0.4 18%	0.1 7%	0.2 10%	-0.1 -3%

Source: ECB calculations based on data from Eurostat and the European Commission.

Note: Figures may not add up due to rounding.

Table A4.4 Contributions to growth from the capital stock and its components

(percentages)

	Real GDP growth	Capital stock growth	Investment-to-capital ratio	Retirement rate
		$a=b+c$	b	c
1981-2003	2.1	1.0 46%	1.7 81%	-0.8 -35%
1981-1993	2.2	1.0 47%	1.8 80%	-0.7 -33%
1993-2003	2.0	0.9 45%	1.7 83%	-0.8 -38%

Source: ECB calculations based on data from Eurostat and the European Commission.

Note: Figures may not add up due to rounding.

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