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Does ICT boost Dutch productivity growth?

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Preface

This document analyses the effect of ICT on Dutch labour productivity growth. It addresses the question whether ICT has boosted productivity growth across the Dutch economy. As a general purpose technology, ICT can have wide-ranging productivity effects. Already, considerable effects of ICT on labour productivity growth have been seen in many industrialised countries, particularly in the US.

The document is part of an extensive CPB research project on the productivity performance of the Netherlands. One of the major aims of this project is to better understand the sources for the scanty labour productivity growth in the Netherlands, especially in market services. Using the growth accounting framework, the present report focusses on the labour productivity performance at the macro level and the level of industry. Other parts of the productivity project specifically focus on the productivity performance at the firm-level using individual data of firms.

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Henk Don,
Director CPB

Table of content

Executive summary (in Dutch)

De Nederlandse arbeidsproductiviteitsontwikkeling blijft in de jaren negentig achter in historisch en internationaal perspectief. Alhoewel Nederland met haar productiviteitsniveau nog steeds een hoge positie in de wereld inneemt, staat deze positie door de lage groei de laatste jaren onder druk. Ook kan de lage toename van de arbeidsproductiviteit gevolgen hebben voor de toekomstige groeimogelijkheden van de Nederlandse economie. Dat laatste is niet onbelangrijk in het licht van bijvoorbeeld de vergrijzingsproblematiek. Tezamen met de structurele toename van het arbeidsaanbod bepaalt de groei van de arbeidsproductiviteit de groeimogelijkheden van een land op termijn. Omdat de groei van het arbeidsaanbod terugloopt, zal de productiviteitsontwikkeling moeten versnellen om in de komende jaren een economische groei van 2½% per jaar mogelijk te maken. ICT kan hier in belangrijke mate aan bijdragen.

In de jaren negentig van de vorige eeuw nam de arbeidsproductiviteit met circa 1¼% per jaar toe, tegen zo'n 2% in de jaren tachtig. Lange tijd leek de afzwakkende productiviteitsgroei geen Nederlands probleem te zijn, daar ook andere landen –waaronder de VS– kampten met hetzelfde patroon. Bovendien nam het arbeidsaanbod nog sterk toe waardoor de groei van het Nederlandse BBP hoog kon blijven vergeleken met vele andere landen. Recente cijfers geven echter aan dat de Nederlandse productiviteitsgroei achterblijft bij landen van de Europese Unie, maar vooral bij de VS. Mede door de productie en toepassing van informatie- en communicatietechnologie (ICT) in het bedrijfsleven is de Amerikaanse arbeidsproductiviteit sinds 1995 aanzienlijk versneld.

Dit rapport gaat in op de vraag in hoeverre Nederland tot nu toe de vruchten van ICT heeft geplukt. ICT heeft alle kenmerken van een doorbraaktechnologie zoals in het verleden revoluties als stoommachine en elektriciteit dat waren. ICT kan in principe de arbeidsproductiviteit langs drie wegen bevorderen. Ten eerste leiden het zeer efficiënt produceren van ICT-producten en voortdurende technologische ontwikkelingen (o.a. Moore’s Law) in de ICT-sector tot een hogere arbeidsproductiviteitstoename. Ook als een land zelf niet of nauwelijks ICT-producten voortbrengt kan het via invoer profiteren van de potenties van ICT. Het gebruik van ICT in het productieproces kan de productiviteitsgroei van gebruikende bedrijfstakken stimuleren. Daarnaast kan ICT zorgen voor een hogere groei door spill-over effecten en netwerkexternaliteiten. Zo wordt het gebruik van e-mail nuttiger naar mate meer bedrijven dit communicatiemiddel gebruiken. Bovendien kan ICT er voor zorgen dat arbeid en kapitaal efficiënter wordt ingezet, waardoor een hogere productiviteit kan resulteren. Tenslotte kan ICT bijdragen aan het ontwikkelen van nieuwe producten met meer toegevoegde waarde per werknemer.

Het rapport concentreert zich op de productiviteitsprestaties van de Nederlandse marktsector.[1] Overigens is het beeld voor de marktsector in de jaren negentig iets gunstiger dan voor de gehele economie. In de marktsector versnelde de arbeidsproductiviteitstoename in de tweede helft van de jaren negentig enigszins, al bleef deze nog aanzienlijk achter bij die van de jaren tachtig. Dit lichte herstel lijkt te maken te hebben met ICT.

Binnen de marktsector is daarom afzonderlijk gekeken naar de productiviteitsprestaties van drie sectoren: producenten van ICT-producten, ICT-intensieve bedrijfstakken, en de overige bedrijfstakken. De ICT-producenten, waaronder telecom- en computerservicebedrijven, boekten aanzienlijke productiviteitswinsten en droegen sterk bij aan de productiviteitsversnelling in de marktsector in de tweede helft van de jaren negentig. Vooral de telecomsector verhoogde de productiviteit fors mede door de doorbraak van mobiele telefoons en internet. Daarnaast versnelde de arbeidsproductiviteit van ICT-intensieve bedrijfstakken zoals de handel aanzienlijk. Echter, de productiviteitstoename van de overige bedrijfstakken in de marktsector liep verder terug. Het is dus met name deze laatste categorie bedrijfstakken die de gemiddeld nog magere Nederlandse productiviteitsgroei veroorzaken.

De 'growth accounting' methode biedt de mogelijkheid om te kijken hoeveel ICT aan de recente productiviteitsversnelling in de Nederlandse marktsector, en met name in de ICT-gerelateerde bedrijfstakken, heeft bijgedragen. Gebruik makend van een productiefunctie met constante schaalopbrengsten rafelt deze methode de arbeidsproductiviteitsgroei uiteen in een bijdrage van de kapitaalintensiteit – de hoeveelheid kapitaal per werknemer– en de totale factor productiviteit (TFP). De bijdrage van de kapitaalintensiteit is gesplitst in de bijdrage van ICT-kapitaalintensiteit respectievelijk overige kapitaalintensiteit. Een hogere kapitaalintensiteit draagt bij aan een hogere arbeidsproductiviteit. TFP staat voor technologische ontwikkelingen door innovaties die niet verbonden zijn aan nieuwe kapitaalgoederen. Achter de TFP-ontwikkeling gaan meer factoren schuil waaraan ICT ook een bijdrage kan leveren. Een efficiënter gebruik van de factoren kapitaal en arbeid, zoals een betere verdeling en organisatie van taken binnen een bedrijf, leidt bijvoorbeeld ook tot een hogere TFP-groei.

De belangrijkste drijvende factor achter de productiviteitsversnelling in de marktsector in het tweede deel van de jaren negentig is de bijdrage van de TFP-groei. Met name ontwikkelingen in de ICT-sector bepaalden deze sterkere bijdrage. Daar verdubbelde na 1995 de TFP-groei mede als gevolg van het massale gebruik van nieuwe producten zoals mobiele telefoons en internet door de Nederlandse bevolking. Ook de aantrekkende productiviteitstoename in de sterk ICT gebruikende bedrijfstakken is in grote mate toe te schrijven aan een hogere TFP-groei. Moeilijk

[1] In de marktsector zitten sectoren zoals gezondheidszorg en overheid niet inbegrepen.

is aan te geven in hoeverre ICT daarvoor verantwoordelijk is. Wel is de bijdrage van ICT-kapitaal aan de toename van de arbeidsproductiviteit van de marktsector in de loop der jaren toegenomen, maar deze is nog steeds niet groot. In de overige bedrijfstakken gaat de teruglopende arbeidsproductiviteitsgroei vooral gepaard met een minder sterke TFP-groei. Echter, ook de bijdrage van kapitaalintensiteit is daar de laatste tijd sterk teruggevallen.

Het rapport vergelijkt de Nederlandse resultaten ook met ICT-effecten in andere landen, waaronder de VS. De veel sterkere arbeidsproductiviteitsversnelling in de VS in de tweede helft van de jaren negentig is voor een deel te danken aan hun grotere en productievere ICT-sector. Maar ook de sterk ICT-gebruikende bedrijfstakken maakten het verschil tussen beide landen. In vergelijking met de VS blijven de investeringen in ICT en de productiviteitsontwikkeling in ICT-intensieve dienstverlenende bedrijfstakken in Nederland achter. Overigens waren in de tweede helft van de jaren negentig de productiviteitsprestaties van de Nederlandse ICT-producerende diensten wel beter dan hun Amerikaanse tegenhanger. Dit geldt ook voor sterk ICT-gebruikende industriële bedrijfstakken. De Nederlandse prestaties in de overige dienstverlenende takken steken daarentegen weer schril af tegen die in de VS, maar ook andere OESO-landen.

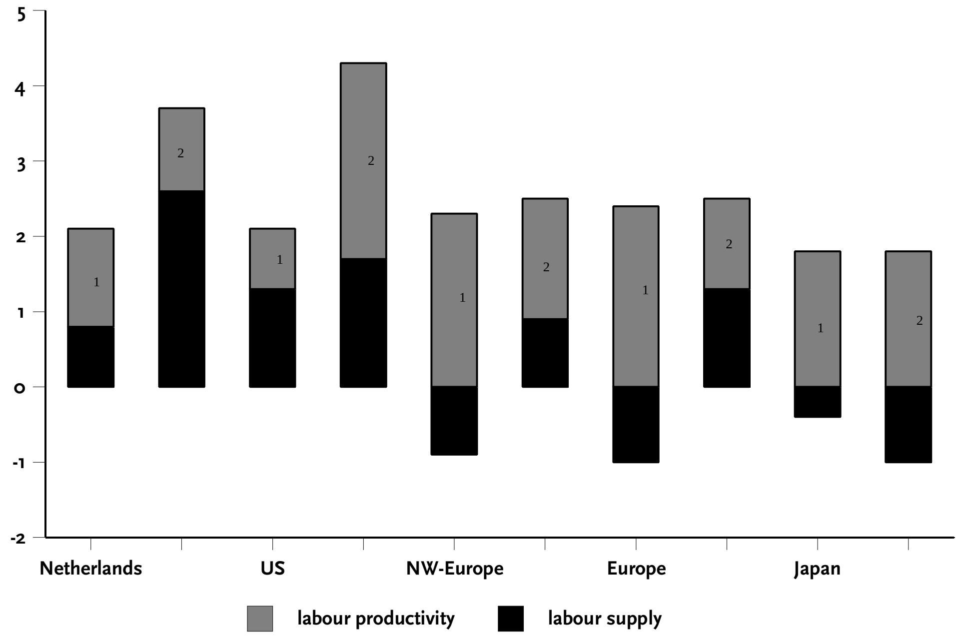
Vooral in bedrijfstakken waar ICT nog relatief weinig wordt toegepast lijkt in Nederland een inhaalslag mogelijk. ICT kan de productiviteitsgroei een duw in de rug geven. Door het lagere groeitempo van het arbeidsaanbod zal de productiviteitsontwikkeling in de komende jaren moeten versnellen om een BBP-groei van 2½% per jaar mogelijk te maken. Voor de overheid is vooral een voorwaarden scheppende rol weggelegd. In een competitieve omgeving waarin er vrije toegang is voor nieuwe, innovatieve, bedrijven worden bedrijven gedwongen tot een efficiëntere bedrijfsvoering, uitmondend in een hoge groei van de arbeidsproductiviteit. Voor minder efficiënte bedrijven wordt het dan moeilijker om te overleven.

1 Introduction

Both labour productivity growth and labour supply growth enhance the economy's potential for long term expansion. Based on the latest population forecasts from Statistics Netherlands for the next five years, demographic factors will further slow down labour supply growth in the Netherlands.[2] In order to achieve a Gross Domestic Product (GDP) growth of 2½%, labour productivity growth has to increase in the coming years. In that respect, information and communication technology (ICT) can induce wide-ranging productivity effects across the economy, in the same way as important other general purpose technologies had their effects in the past.

This document addresses the question: Does ICT boost Dutch productivity growth? ICT has all the characteristics of a general purpose technology, such as a large variety of applications, a wide range of applications across the economy, and complementarity with existing or potentially new technologies. ICT contributes to the renewing process in the economy, and can be a driver for at least a temporary upturn in economic growth. The diffusion and use of ICT can affect productivity in almost every industry. However, it stands to be seen whether ICT can elevate productivity growth to a trend level permanently above that of previous decades. The effects of general purpose technologies like ICT on productivity often occur with a certain delay. It may

Figure 1.1 Fundamentals of GDP-growth, 1991-2000



Source: Van Ark, B. and R McGuckin (2001); 1= period 1991-1995; 2= period 1996-2000

[2] Don, F.J.H., 2001, Dutch growth potential in the medium term, CPB report 2001/2.

still be too early to see the benefits of ICT on (measured) productivity in the Netherlands. Figure 1.1 summarises the main drivers for GDP-growth in an international perspective in the last decade. The reasonably strong growth of the Dutch economy in output and employment in the 1990s can be regarded as an excellent performance in an international perspective.[3] In the 1990s, Dutch GDP grew at a rate of almost 3 percent per year, whereas the average growth rate in the European Union (EU) was 2 percent. In the period 1996-2000, Dutch GDP growth even averaged 3.7 percent per annum. Growth rates of GDP also accelerated in the US in the second half of the 1990s. So, in terms of GDP-growth, both the Netherlands and the US are front runners. However, the main sources of growth differ between both countries. Accelerating Dutch GDP growth was completely due to the remarkable expansion of the labour force, whereas an acceleration in labour productivity growth almost entirely drove the stronger US growth.[4]

Slow labour productivity improvement, both from a historical and international perspective, has been a salient feature of the Dutch economy. Overall Dutch labour productivity rose by an annual average rate of 2 percent in the 1980s. In the 1990s, it continuously slowed down to an average annual growth rate of about 1 percent. Likewise, in an international perspective, the recent productivity growth performance is disappointing. Although the Dutch productivity level is high compared to most other European countries and on par with the US level, the Dutch productivity growth performance could not match the considerable US productivity gains in the late 1990s. Other European countries also experienced a slowdown in productivity growth in the second part of the 1990s, but their growth rates exceed the Dutch one. The excellent ranking of the Netherlands in terms of productivity level is at stake.

Although the views still differ slightly, a consensus among US economists has emerged that both the production and the use of ICT considerably contributed to the US productivity resurgence in the second half of the 1990s. For the Netherlands, therefore, improving productivity through ICT and its applications across the economy might still occur in the coming years.[5]

[3] Besides the Netherlands, Australia and Ireland registered markedly stronger trend growth of GDP over the past decade than in the 1980s. see OECD, 2001, The new economy: beyond the hype. Final report on the OECD growth project.

[4] Recently, labour productivity growth figures for the US has been revised. Average productivity growth over the past five years has been trimmed to 2.5% from 2.8%. This document uses earlier figures because detailed revised information is not yet available at the level of industry.

[5] Wiel, H.P. van der, 2000, ICT important for growth, CPB report 2000/2.

Earlier studies by Bartelsman and Hinloopen (2000), Van Ark (2001) and Van der Wiel (2000) already analysed the effect of ICT on the Dutch economy.[6] They all primarily focussed on the impact of the ICT-sector at an aggregated level. Van Ark goes a little bit further by making a distinction between the contribution of ICT-producing, ICT-using sectors and non ICT-using sectors to overall productivity growth. This document extends these earlier studies in two ways.[7] First of all, the current report is conducted at lower levels of aggregation with recent data of Statistics Netherlands. Second, using the growth accounting and investment series, this report is able to show the impact of ICT on labour productivity growth in several ways. The growth accounting framework provides a breakdown of output growth into components associated with changes in factor inputs like ICT-capital, other capital, labour and a residual, i.e., total factor productivity (TFP). The residual reflects improvements through technological progress and other elements like economies of scale, spill-overs and improvements in the organisation. All these effects on TFP could be driven by or related to ICT.

This document proceeds as follows. Section 2 sketches the main features of the growth-accounting method, the analytical framework of this paper. Readers familiar with this method can easily skip this section. In section 3, we particularly focus on recent trends in productivity growth in the Netherlands. So far, there has been no productivity miracle in the Netherlands. We investigate whether beneficial effects of ICT are perhaps limited to specific sectors within the Dutch economy, by dividing the economy into the ICT-sector, ICT-intensive industries and other industries. In section 4, we discuss the results of the growth accounting method. This section deals with the direct and indirect effect of ICT on productivity. Did capital deepening through the surge of investment in ICT stimulate increases in productivity? Or, are there improvements in labour productivity that go beyond the direct contribution of more capital per worker? The latter effect points toward spill-over effects or externalities of ICT-capital, generating increases in TFP. Section 5 presents an international comparison of the effect of ICT in other industrialised countries including the US. Moreover, this section touches upon policy issues that can be derived from both the results in section 4 and the international comparison. Section 6 summarises the main conclusions of this document. It also looks forward and argues that there is a strong case for expecting a more robust pick-up in Dutch productivity growth in

[6] Bartelsman, E.J. and J. Hinloopen, 2000, De verzilvering van een groeibelofte (only in Dutch), in *ICT en de economie*, Koninklijke Vereniging voor Staathuishoudkunde, Preadviezen 2000. Ark, B. van, 2001, The renewal of the old economy: an international comparative perspective, OECD, STI Working Papers 2001/5.

[7] The analysis in this document is part of the CPB project on ICT and productivity. One of the major aims of this project is to better understand the specific sources for the scanty productivity growth in the Netherlands, especially in the market services. Other parts of the project specifically focus on productivity performance at the firm-level.

the near term as the effects of ICT investment finally emerge at their full potential across the economy.

2 An analytical framework

2.1 A growth accounting framework

Labour productivity is an interesting variable for entrepreneurs, policymakers and economists, because gains in labour productivity are linked to rising standards of living. Labour productivity growth contributes to an increase in GDP per capita, one indicator of economic welfare. Moreover, the level of labour productivity indicates the international competitiveness and applied technology of firms, industries and countries.

This section elaborates on the way we analyse the Dutch productivity performance in more detail in this document. In general, in the short and medium term, labour productivity growth stems from two main sources: capital deepening and technical progress. Labour productivity gains can be the result of increases in the capital-labour intensity without changes in underlying technology or inefficiency. This happens when employees have more machines and equipment at their disposal. Additionally, labour productivity growth rises due to technological progress.

Sources of growth: Neoclassical growth theory versus new growth theories

There are two main strands for explaining output and productivity growth. According to the neoclassical view technological progress is exogenous. It drives long-run labour productivity growth since capital suffers from diminishing returns. This assumption holds even if capital is broadly defined including human capital, R&D etc. In fact, modern growth accounting is more about measuring technical change than explaining it.
In contrast, the new growth theory argues that productivity growth is endogenous. This strand assumes either constant (or increasing) returns to capital or explains technical change as the result of specific actions of economic agents. Romer (1986) and Lucas (1988) have brought externalities to the forefront of the discussion. Today, this strand exists of a vast literature on many factors like production spillovers, increasing returns, competition and innovation.

We employ the extended growth accounting framework for measuring the contribution of different inputs to the growth process.[8] This framework is based on the neoclassical model of Solow (1957). It assumes that at the level of industry (=i) there exists a (value added[9]) production function relating output to labour, capital, and time:

$$y_t = F_y(l,k,t) = A(t) f_y(l_t, k_t)$$

[8] See e.g. Jorgenson, D.W., F.M. Gollop and B.M. Fraumeni, 1987, Productivity and US economic growth, Cambridge, MA, Harvard University Press.

[9] As labour productivity growth is defined as value added per hour worked in this document, intermediate inputs are not seen as sources for productivity growth.

Where y denotes value added, k is capital input, l represents labour input, A is Hicks-neutral technical progress and t is time. In a Cobb-Douglas function this becomes:

$$y = e^{\rho t} l^{\alpha} k^{\beta}$$

So, the amount of available factor inputs determines labour productivity, i.e. labour (including human capital), capital and technological progress (= ρ).

The production function is characterised by constant returns to scale, neutral technological progress, and producers are price takers in both output and input markets. If firms maximise profits and act as price takers in both output and input markets, then the elasticity of output with respect to labour or capital is equal to, respectively, the share of labour cost in the value of total output and the share of capital cost in the value of total output. Both shares are directly observable. Moreover, constant returns to scale imply that the elasticities of the input factors add up to one. So, the labour share (or capital income share) can replace the production elasticity of labour (capital):

$$\varepsilon_l = \frac{\partial y}{\partial l}\frac{l}{y} = \frac{Pl}{Py}\frac{l}{y} = \alpha \; ; \; \varepsilon_k = \frac{\partial y}{\partial k}\frac{k}{y} = \frac{Pk}{Py}\frac{k}{y} = \beta$$

$$\varepsilon_l + \varepsilon_k = 1$$

Where α denotes the share of labour income in total income, β is capital income share. p_l is the wage rate of employees, p_k is user cost of capital and p_y represents the price of output. Now, if we assume that the production function is translog, then the contribution of factor inputs to output growth can be computed as their own growth rate weighted by their (mean) value share in total factor input.[10]

$$d \ln y = d \ln TFP + \varepsilon_l d \ln l + \varepsilon_k d \ln k$$

Where TFP equals ρ. Rearranging this equation enables us to disentangle the proximate sources of labour productivity growth:

$$d\ln y - d\ln l = \beta [d\ln k - d\ln l] + d\ln TFP$$

[10] In order to obtain a discrete Törnqvist index to measure growth in output and inputs, the income shares of inputs are measured as the average shares of two subsequent periods.

Here, Total Factor Productivity (TFP) growth is a residual. TFP measures the rate at which output increases if not attributable to increased factor inputs such as labour and capital. Given data on output, capital, labour and the share of labour in total factor inputs, TFP growth can easily be computed. TFP is a catch-all term that captures unmeasured factors such as disembodied technological progress, economies of scale, economies of scope, organisational improvements and other deviations from the assumptions mentioned above. Moreover, cyclical demand factors changes the growth rates of TFP because productivity growth is pro cyclical. Finally, TFP-growth also reflects changes in measurement errors that may arise due to measurement problems in output and input.

The assumption of neutral technological progress means that technological progress is independent of the size of capital and labour inputs. According to the neoclassical theory, the marginal product of capital is equal to zero in the long run. Then, labour productivity growth stems entirely from TFP growth. The latter rains down from heaven as manna, or is 'a measure of our ignorance', as Abramovitz (1956)[11] called it, since TFP growth largely dominated among sources of growth in growth accounting studies at that time. In this theoretical neoclassical framework, labour (supply) as well as technological progress are exogenous.

Jorgenson and Griliches (1967) considerably broadened the idea of substitution in Solow's growth accounting framework.[12] The original framework does not incorporate substitution among different types of capital inputs, nor does it incorporate substitution among different types of labour input. Solow only modelled substitution between capital and labour inputs. However, as Jorgenson and Griliches showed, investment can be made endogenous within a neoclassical growth model, while TFP is still exogenous, since capital goods and labour inputs differ substantially in marginal productivity.

The specific feature of investments in physical capital and human capital as a source of economic growth is that the investor can internalise the returns to these investments. Jorgenson and Griliches introduced constant quality indices of capital and labour inputs and a constant quality measure of capital goods output in allocating the sources of economic growth between investment and productivity. Their approach recognised that investments have different services lives, tax treatments, depreciation rates, and different marginal products.

In order to account properly for substitution among different types of capital inputs, this document also measures capital inputs as a flow of services (=KS). Using the perpetual-inventory method and investment series over longer periods, we have constructed capital stocks (=K) for several types of assets at the level of industry (=i).[13] Then, each type of

[11] Abramovitz, M. ,1956, Resource and output trends in the United States since 1870, American Economic Review, vol. 46, pp. 5-23.

[12] Jorgenson, D.W., and Z. Griliches, 1967, The explanation of productivity change, Review of Economic Studies, volume 34, no. 99, July, pp. 249-280.

[13] See appendix A for more information on this issue.

asset is separately weighted with a capital cost of services, since each type of capital (=j) input must be weighted by the corresponding marginal product.

$$KS_i = \sum_j W_{ij} K_{ij}$$

$$W_{ij} = \frac{P^k_{ij} \cdot K_{ij}}{\sum_j P^k_{ij} \cdot K_{ij}}$$

Where KS is capital services, K represents capital stock. Differences between the pace of growth of capital stock and capital services point towards compositional changes in the capital stock. In fact, the growth in capital services can be separated into two effects:

- Quantity changes of the capital stock
- Changes in the composition (e.g. vintage and quality).

For instance, a shift in the capital stock toward ICT-investments with large marginal products leads capital services to grow faster than capital stock.

With regard to labour input, a similar issue as for capital substitution arises. Investments in human capital through education and training add to the supply of people with higher qualifications or skills. Therefore, labour inputs differ in marginal productivity. As a result, a rise in the supply of labour contributes to output growth in proportion to the marginal product of the added labour volume. Due to a lack of data at lower levels of aggregation, we are not able to adjust labour inputs for changes in labour quality or composition effects. Instead, labour input is measured only by annual hours (i.e. full-time equivalents times annual contractual hours).[14]

Caveats in the growth-accounting framework

Despite its transparency and simplicity, the growth accounting framework includes some caveats that should be borne in mind when reading this document. It assumes constant returns to scale, positive and diminishing returns with respect to each input: marginal products of each input approach zero as each input goes to infinity. TFP can be seen as a proxy for technology progress, i.e. the Solow residual. If the neoclassical assumptions fail to hold, TFP contains the

[14] Labour quality improvements are disregarded. This implicates that TFP growth rates will be understated if labour quality raises.

effect of externalities, non-constant returns to scale and mark-ups. Moreover, the growth accounting framework provides information on what happened to productivity growth, but it provides no explanation why something happened.[15] In other words, the growth accounting framework presents the proximate sources and not the ultimate sources of productivity growth. To address the latter sources one needs another sort of analysis such as firm-level studies or case studies.

2.2 The potential effect of ICT on productivity

ICT has all the characteristics of a general purpose technology and it could at least temporarily produce higher productivity growth rates. ICT can affect the economy, and, more specifically, labour productivity through three channels:

- production of the (domestic) ICT-sector;
- use of ICT as an input in the production process;
- spill-over effects of ICT.

First, the domestic production of ICT can contribute directly to overall TFP and labour productivity growth. Technological progress in the production of ICT-products can generate huge productivity growth in the ICT-sector itself and falling prices of ICT. These developments will stimulate firms (and consumers) to invest in ICT. As a result, the demand for ICT-products will increase, pushing up GDP and labour productivity to rapid growth rates at the macro level. If ICT makes the innovation process itself more productive than productivity growth rates could be permanent faster over the long term.

Second, a country or firm can also profit indirectly from ICT applications in the production process by capital deepening. Firms themselves can raise their productivity by the adoption and use of ICT. More and better ICT per worker contributes to higher productivity. This does not require a domestic ICT-sector, since ICT-products can often be imported quite easily. In fact, in this view, ICT is just one of the investment goods among bunches of other investments goods. Firms substitute between inputs along a given production function in response to relative price changes. As the price of ICT, in particular the price of computers, fell dramatically in the 1980s and 1990s, firms substituted ICT for other inputs.

The third channel is that ICT also has the potential to generate TFP-growth due to spill-over effects and externalities beyond the ICT-sector itself. In fact, it assumes a shift of the production function of ICT-using industries not attributable to either labour or capital. This effect is

[15] Stiroh, K.J., 2001, What drives productivity growth? Federal Reserve Bank of New York, Economic Policy Review/March 2001.

controversial in literature. ICT can induce higher TFP-growth because savings in transport and searching costs can be made at all points along the production chain. Foremostly, it can do so because of positive network effects among firms. An investment in communication equipment such as e-mail may have a positive impact not only for the investor but also for all the other users. These network externalities are larger as the level of standardisation rises. On the other hand, because of high switching costs, firms can get locked into certain technologies. This can create negative effects. ICT can also promote the creation of new goods among both producers and customers. Finally, in combination with other changes in the organisation, ICT enhances a firm's efficiency.

Each of the three aforementioned channels through which ICT affects productivity growth easily fits into the growth accounting framework by adding ICT as a separate input factor:

$$d\ln y_i - d\ln l_i = \beta_{o,i}[d\ln k_{o,i} - d\ln l_i] + \beta_{c,i}[d\ln k_{c,i} - d\ln l_i] + d\ln TFP_i$$

in which the term on the left-hand side of the equation is labour productivity, k capital, with o and c other capital goods and ICT respectively, and β_o and β_c the income shares of other capital goods and ICT respectively.

2.3 Data and measurement issues

To decompose labour productivity growth into the contributions of inputs like ICT, we rely heavily on the sectoral database from the CPB. This database includes data of Dutch industries supplied by and collected by Statistics Netherlands, and in particular data from the National Accounts. CPB's database covers the entire Dutch economy divided into roughly 17 industries for the period 1950-2000.[16]

As indicator for output, this document uses gross value added in constant prices 1990. The labour input is defined as contractual working hours. The capital services are inferred from a constructed capital stock. We can distinguish 8 types of assets for each industry. For the purpose of presentation, these types of assets are aggregated into two types of capital: ICT-capital and other capital. ICT consists of computer hardware and communication equipment. Other capital

[16] Due to several comprehensive revisions of the Dutch National Accounts, it is very hard to distinguish more industries. Moreover, the revisions caused several breaks in the time series which had to be restored for the analysis in this report.

includes all other types of tangible assets. Software is not included in the main analysis of this document.[17]

Treating software (including software developed on own account) and other immaterial assets as (ICT) investments was recommended in the 1993 System of National Accounts. From the year 1995 onwards, Statistics Netherlands started to extend the asset boundary to include produced intangible assets, computer software and large databases as gross fixed capital formation. Hitherto, software was treated as an intermediate input. Consequently, for the period before 1995, valued added per industry has to be corrected for purchased software and intangible assets.[18] Unfortunately, at the moment, detailed information for adjusting industry's value added is missing for this period. Moreover, Statistics Netherlands encounters severe problems in constructing real volumes of software investment series.[19] Therefore, we were forced to exclude software investments and other intangible investments from the main calculations of the capital stock.

The level of sectoral data availability in US statistics puts the level of Dutch sectoral detail in the shade. For instance, databases of BEA differentiate more than 60 industries. Moreover, data on the capital stock includes almost 60 categories of fixed reproducible assets. TFP-estimates are, however, only available for broad sectors, and mostly for US manufacturing industries in more detail. Moreover, in the US, several institutes (e.g. BEA and BLS) are collecting data for the US economy. Their results can differ due to differences in methodology (e.g. income-side versus production-side approaches). In contrast, Statistics Netherlands is the only institute that government has officially charged to provide economic integrated data for the Netherlands. [20]

Other data problems hinder the analysis in this report as well. Measurement problems in output, including new products and quality changes, attract many attention these days. It was the late Griliches who suggested that the measurement issue could be an important source of the differential in productivity growth between 'measurable sectors' and 'unmeasurable sectors' of the US economy.[21] In particular, the productivity performance of services could be underestimated. It is even argued that measurement problems in services have aggravated over time because of the increased use of ICT. The argument is partly related to the long-lasting unmeasured effect of ICT on the productivity performance, particularly in ICT-using services like banking and finance.

However, at the moment, it remains unanswered whether labour productivity growth in Dutch services has been increasingly underestimated due to an increase in the measurement

[17] However, a box in section 4 presents the effect of software on the productivity performance in the 1990s based on calculations at the back of the envelope.

[18] Due to this revision, value added will be higher in terms of value because intermediate inputs are lower.

[19] Ende, K. van der, and P. Verbiest, 1999, Software estimate in the Netherlands 1985-1997.

[20] The Dutch Central Bank, however, also collects financial data.

[21] Griliches, Z (ed),1992, Output measurement in the Services Sectors. Chicago: University of Chicago Press.

error. Partly to overcome measurement problems, this document focusses on the market sector instead of the total economy, leaving out the non-market services where real output and labour productivity are hard to measure. Moreover, measurement errors in services evaporate to a great extent on an aggregated level, because huge parts of services are delivered to other industries as intermediate products. If real output of services is understated due to measurement errors, then the input of industries using these services is also understated and therefore their value added is overstated. The aggregate picture remains unchanged unless the services are supplied as final goods to consumers or are exported.

Another problem related to measurement issues is the use of hedonics in statistics, especially in an international comparison. Differences in recent labour productivity performance between the US and European countries could be due to measurement of price indices for ICT.[22] US methods of hedonic price indexing, in particular for ICT-products, could exaggerate labour productivity growth compared with European countries because prices of ICT-products tend to drop more rapidly if they apply hedonic methods than other methods.[23]

Besides the US, other countries like France, Sweden, Denmark, and Germany employ some form of hedonic pricing in their statistics. Statistics Netherlands does not use hedonics in its statistics yet. Recently, Schreyer (2001) analysed the effect of differences in computer price indices on growth and productivity in an international setting.[24] He concludes that the impact on aggregate measures of labour productivity growth of replacing one set of ICT deflators by another one like hedonics is likely to be small across countries. However, disaggregated measurement of output, inputs and productivity are apparently to be much more affected.

[22] See e.g. Grant, J, 2000, America's hedonism leaves Germany cold, Financial Times. Monday September 4 2000.
[23] In the hedonic method, a price is assigned not to a specific product but to a bunch of characteristics of that product using regression analysis. Each characteristic is weighted by its coefficient representing marginal prices. For instance, in the case of computers, changes in computer prices are related to product characteristics such as processor speed and memory. This choice of characteristics is essentially a subjective one. Moreover, it relies on the premises that products can be compared in terms of (same) characteristics.
[24] Schreyer, P. ,2001, Computer price indices and international growth and productivity comparison. OECD Statistics Directorate.

3 Recent productivity trends in the Netherlands

3.1 Introduction

In this section, we focus on recent trends in productivity growth in the Netherlands. In contrast with the US, so far, there has been no productivity miracle in the Dutch economy as a whole.

The pickup of labour productivity growth in the US in the second half of the 1990s has induced a hot debate in economics upon how much of this productivity acceleration was structural and how much of it was cyclical. Usually, productivity growth is procyclical, i.e. during an upswing of the economy productivity growth is higher due to, among others, labour hoarding and increasing returns. Conversely, labour productivity growth is lower in a downswing.

Gordon (2000) states that outside the computer and durable goods industries there has been no improvement in US labour productivity growth after adjusting the productivity figures for cyclical effects and the effect of data revision.[25] He states that ICT do not measure up to great inventions earlier in the twentieth century like electricity. Others, like Oliner and Sichel (2000), Jorgenson and Stiroh (2000) emphasised the importance of the production and use of ICT for the US productivity revival.[26] Although their figures have not been adjusted for cyclical effects, they think that the US productivity revival is not limited to the ICT-sector since most intensive users of ICT also experience productivity gains. They claim that the rebound of the US productivity growth is a real phenomenon, not just a cyclical one. Why should cyclical forces be highly concentrated in precisely those industries that are ICT-intensive?

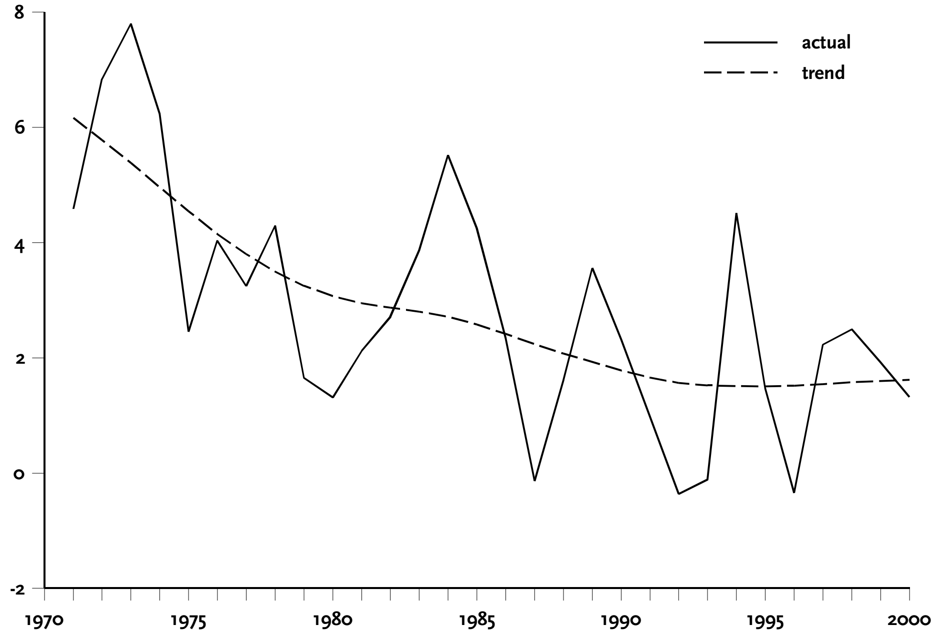
Figure 3.1 presents the results for the Dutch market sector if productivity growth is adjusted for cyclical factors.[27] It shows that a slight change in the growth rate of the labour productivity trend occurs after 1995. The structural trend in labour productivity growth steadily declined from an annual rate of 6 percent in the early 1970s to less than 1½ percent per year in the mid 1990s. From 1995 onwards, the trend in labour productivity growth has been picking-up slightly.

[25] Gordon, R.J, 2000, Does the 'New Economy' measure up to the great inventions of the past?, Journal of Economic Perspectives, Vol. 14, no.4, pp. 49-77.

[26] Oliner, S.D. and D.E. Sichel, 2000, The resurgence of growth in the late 1990s: Is information technology the story? Journal of Economic Perspectives, Vol. 14, no. 4. pp. 3-22. Jorgenson, D.W. and K.J. Stiroh, 2000, Raising the speed limit: U.S. economic growth in the information age, Brookings Papers on Economic Activity, Vol.2.

[27] We used a Hodrick-Prescott filter (HP-filter) to estimate a smooth trend. HP-filter has a parameter to control the relative weights of fit and smoothness. Here, the parameter was set on λ=100. The HP-filter is seriously hampered by a number of drawbacks. The extrapolation results, for instance, are very sensitive to the last few observations. To counter this drawback to some extent, we applied an arima model to construct estimates for the coming years.

Figure 3.1 Trends in Dutch labour productivity growth market sector, 1970-2000



Productivity growth beyond September 11, 2001 [a]

Discussions about whether economies like the US and the Netherlands are experiencing a temporarily or prolonged slowdown are at the top of the agenda of policymakers since the tragedy of September 11, 2001. Although both countries' GDP growth had already started to grow less fast before this catastrophe, uncertainty among entrepreneurs and consumers has intensified the current slowdown.

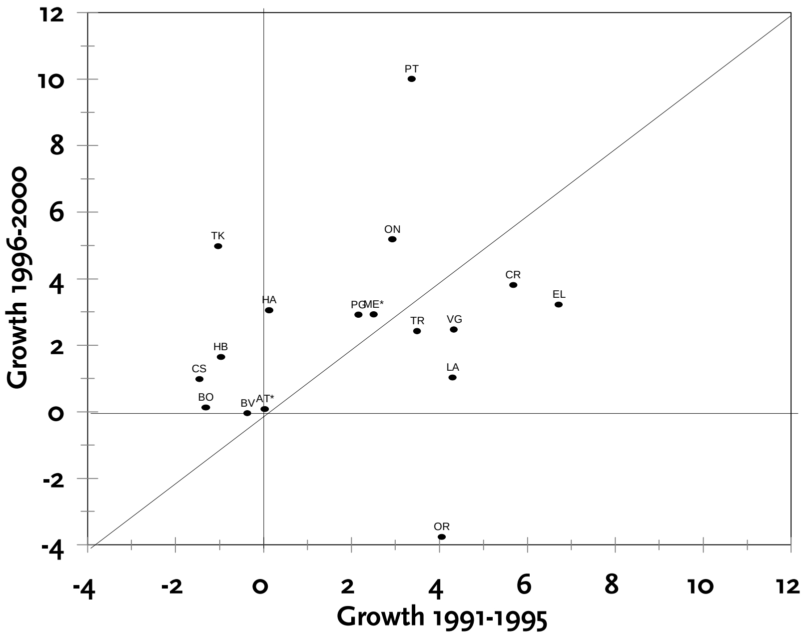
Although both US' monetary and fiscal policies aim to restore confidence and avoid a deep recession, these actions are not able to prevent a further slowdown of US economic growth and labour productivity growth in this year and in 2002. In addition, already before September 11, the Bureau of Economic Analysis released revised estimates of GDP that reduced GDP-growth and the rate of labour productivity growth in 1999 and 2000. Together, it implicates that the US structural labour productivity growth is lower than thought earlier.

The developments worldwide, and in particular in the US, affect the economic performance of the Netherlands as well. The current projection for the Dutch economy points to GDP growth of 1% this year and 1¼% in 2002. The effect on the economic performance of the Dutch market sector is even more profound. This year, labour productivity growth in Dutch market sector will be negative and reach a post-1945 low. Due to the tensed labour market, firms are not eager to fire people immediately. Labour productivity growth is already expected to recover next year. Notice that these forecasts are not included in the estimation of the productivity trend in figure 3.1.

[a] See www.cpb.nl for the latest economic forecasts of the CPB for the period 2001-2002.

Figure 3.2 provides insight into the productivity performance at the industry level in the last decade. The figure affirms the huge heterogeneity across industries that is kept concealed at the aggregated level. The productivity growth rates gap between the fastest and slowest growing industry averaged more than 10 percentage points per year in selected periods. Figure 3.2 also shows which industries registered a speeding up of labour productivity growth in the second half of the 1990s; they are positioned above the diagonal. Ten out of 17 industries within the market sector experienced an acceleration of labour productivity growth in the second part of the 1990s compared with the first part of the 1990s. Noticeably, among these better-performing industries, several industries are to some extent linked with ICT like telecommunication (=PT) and computer services (CS).[28] Still, the productivity performance of the latter is relatively modest compared to other industries in the late 1990s.

Figure 3.2 Changes in labour productivity growth per industry, 1996-2000 versus 1991-1995



3.2 The Dutch ICT-sector

The definition of the Dutch ICT-sector in this document is almost in line with the current OECD-definition and Statistics Netherlands (see the box).[29]

[28] LA= agriculture, VG=food, TK= textile, HB= wood, PG= paper, CR= chemicals, ME*= metals excluding electronic equipment, EL= electronic equipment, OR= oil-industry; BO= construction, ON=utility, HA= wholesale and retail trade, TR= transport, PT= telecommunication, BV= banking and finance, AT*= other market services (excluding computer services), CS= computer services.

[29] OECD, 2000, Measuring the ICT sector.

Measuring the ICT-sector

The Dutch ICT-sector in this document includes industries that manufacture ICT goods and it also consists of services industries. The ICT-manufacturing industry includes firms which produce goods that contribute to the infrastructure for information provision and communication (office equipment and computers, other electronic equipment, audio, video and telecommunications equipment, medical, measuring and regulating equipment). The ICT-services provide telecommunication services and computer services. The table reports the composition of the ICT-sector in more detail. Some pitfalls must be kept into mind.

The definition of the ICT-sector corresponds to a great extent to the definition of the OECD. Due to lack of data, it is not possible to include wholesale of machinery and equipment, and the renting of office machinery and equipment. Both (sub)industries are taken into account in the OECD-definition of the ICT-sector. Furthermore, telecommunication includes postal services. Another problem of demarcation of industries is that the ICT-sector itself produces more than only ICT-products. Non-ICT-industries, in turn, can also produce ICT products. Information is lacking to adjust for these demarcation problems.

Composition of Dutch ICT-sector

Sector	Industry	Branches	SBI-1993	Turnover 2000 (euro, mld)
ICT	ICT-industry	Office machine and computers	30	1.8
		Other elektronic equipment	31	3.4
		Audio, video en telecom equipment	32	10.7
		Medical-, measure- equipment	33	3.4
	ICT-services	Telecommunication (including Post)	64	17.4
		Computerservices	72	11.4

Although, the Dutch ICT-sector has already been active for decades, recent developments seriously affected the size of this sector. The first computer already dates from the early 1950s, but the real emergence of the ‘computer age’ started in the 1970s. Nevertheless, the real productivity effects of ICT were kept concealed until the last decade. Explosive growth in mobile telephony and internet usage, and the issues surrounding the ‘millennium problem’ boosted turnover of the Dutch ICT sector, especially that of telecom. Consequently, the sector expanded enormously in the second half of the 1990s (see table 3.1). With an output growth rate of 12% per year on average, the sector quadrupled the growth rate achieved by other sectors of the Dutch economy.

This boost in turn over was accompanied with faster labour productivity growth rates as well. Huge investments in R&D, fierce competition in (parts of the) ICT markets and increasing returns to scale in production could have caused these high figures. Moreover, the ICT-sector showed strong productivity growth without detriment to its labour input. In fact, the employment substantially expanded in the period 1996-2000. The economic performance, however, remarkably differs within the ICT-sector (see the box *The performance of the Dutch ICT-sector in more detail*)

Table 3.1 Performance of the Dutch ICT-sector, 1980-2000

	1980-1990	1991-1995	1996-2000
	annual percentages changes		
Value added	4.0	2.9	11.6
Employment	0.7	– 1.0	6.5
Labour productivity	3.2	3.9	4.7
	1980	1990	2000
	%		
Share in GDP (nominal terms)	4.3	5.0	6.2
Share in GDP (real terms, 1990)	4.2	5.0	7.2

The increasing share of Dutch producers of ICT in GDP reflects the growing significance of ICT for the Dutch economy. In 1980, the share of the ICT-sector in total GDP was approximately 4 percent. At the end of the last decade, the share was higher. In real terms, the

The performance of the Dutch ICT-sector in more detail

The Dutch ICT-sector documented an enormous acceleration in terms of growth rates of real value added in the second half of the 1990s. The acceleration in labour productivity growth of almost 1%-point was considerably smaller in that period.
Moving beyond the aggregated picture for the ICT-sector reveals that the huge pickup of real value added in the latter part of the 1990s was mainly due to the performance of all ICT-services, particularly telecom. The slight improvement in labour productivity growth rates mainly stemmed from the considerable productivity gains in the telecom sector. Although the productivity performance of the computer services improved in the period 1996-2000, its performance could not match the performance of the other ICT-producing industries. Labour productivity growth of the ICT-manufacturing considerably slackened in the second half of the 1990s due to cyclical factors in 1996 and 1997. Thereafter, industries' labour productivity growth rates recovered to earlier levels.

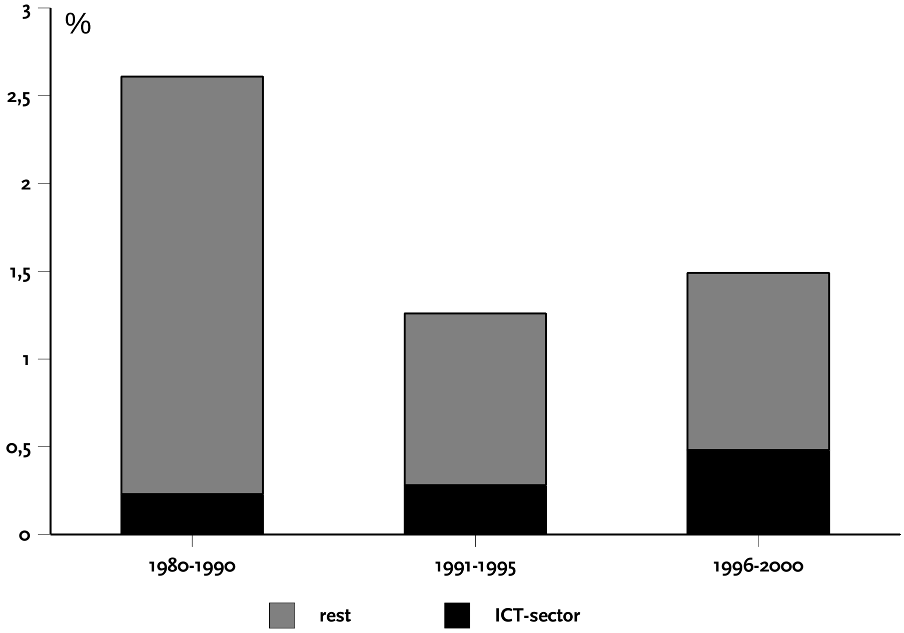
Performance ICT-sector, 1991-2000

	Share	Value added		Labour productivity	
	1995	1991-1995	1996-2000	1991-1995	1996-2000
	%	annual percentages changes			
ICT-sector	100	2.9	11.6	4.0	4.8
ICT-manufacturing	41	2.0	3.5	6.5	3.2
ICT-services	59	3.5	15.7	1.4	5.1
o.w. Telecom	41	2.8	15.0	3.3	9.5
computerservices	19	5.6	18.2	−1.5	1.0

increasing importance of the ICT-sector is even more profound. The contribution of the ICT-sector to labour productivity growth in the market sector can be measured by using a shift-share method.[30] Figure 3.3 show the results for the selected periods.

[30] See appendix B for an explanation of this method.

Figure 3.3 **Contribution of ICT-sector to productivity growth Dutch market sector (in %-points), 1980-2000**



The contribution of the ICT-sector to productivity growth was approximately 0.25 percentage points in the 1980s and early 1990s. In the second half of the last decade, the contribution of the ICT-sector raised to about 0.5 percentage points. Strong productivity growth in this industry, therefore, provides part of the explanation for the slightly better productivity performance of the Dutch market sector in the period 1996-2000. Hence, despite the small GDP share of the Dutch ICT-sector, the productivity performance of this industry definitely affects the productivity outcome at the macro level.

3.3 Applications of ICT

Apart from the direct contribution of the ICT-sector, ICT contributes to productivity improvements by using ICT-capital in the production process. Countries do not have to produce ICT-capital themselves to use and benefit it. Generally, Dutch firms have free access to ICT via import.

To investigate whether beneficial effects of ICT are only limited to specific sectors within the Dutch economy, we divide industries outside the ICT-sector into ICT-intensive sectors and other sectors. Although each ICT producing industry itself uses ICT in its production process, we discern the ICT-sector from other (ICT-intensive) industries in order to measure accurately spill-over effects and other indirect effects of ICT throughout the economy.

In an international context, no straight definition of an ICT-intensive industry is available. Therefore, to mark an individual industry either as an ICT-intensive industry or as other industry, we analysed three ICT-indicators.[31] The first indicator is the share of ICT-capital as a percentage of total capital. The second indicator is the ratio of ICT-capital to output. The last indicator focusses on the use of ICT-capital per worker.

ICT can affect productivity growth, but the causality could also run the other way around. Firms experiencing strong productivity growth might invest more in ICT. Stiroh (2001) correctly argues that it is important to measure ICT-indicators before the acceleration period in order to reduce simultaneity bias from productivity and demand shocks.[32] As suggested by figure 3.1, a trend reversal is observable in 1995. Therefore, the cut-off point for the three indicators is based on that year and 1990.

Although any classification scheme is to some extent arbitrary, based on the indicators we have classified the following five industries as ICT-intensive industries:

- Banking, finance and insurance
- Other market services (like business services but excluding computer services)
- Wholesale and retail trade
- Paper (products), printing and publishing industry
- Metal industry (excluding electronic equipment)

Consequently, the remaining industries within the market sector are classified as other industries.[33] As can be seen in table 3.2, ICT-intensive industries account for almost 60 percent of the market sector in terms of value added. In terms of ICT-capital services, its share is just more than 20 percent.

On average, the share of ICT-capital as percentage of total capital services is strikingly low. By 1995, it made up around 5 per cent of total capital services in the market sector. The ICT-sector is in this perspective a clear exception. Although, the use of ICT is actually highly concentrated in a few industries, hardly any industry does not use ICT at all. The difference between the ICT-intensive industries and the non-ICT intensive industries is more profound regarding the second indicator, i.e. ICT-capital as percentage of gross value added, than the first indicator.

[31] See appendix C for detailed information.

[32] Stiroh, K.J. , 2001, Are ICT spillovers driving the New Economy?, (forthcoming).

[33] Other industries includes agriculture, food, textile, wood, chemicals, oil, distribution of electricity, water and gas, construction and transport.

Table 3.2	**ICT-indicators, 1990 and 1995**					
	Shares		ICT-intensity			
	ICT-Capital	Value added	Capital services[a]		Value added[b]	
	1995	1995	1990	1995	1990	1995
	%					
Market sector	100	100	4.2	5.6	11.6	16.1
ICT-sector	70	7	47.6	52.0	129.6	152.6
ICT-intensive industries	24	56	1.8	3.3	3.4	6.9
Other industries	6	37	0.3	0.7	1.2	2.6

[a] ICT-capital as percentage of total capital services.
[b] ICT-capital as percentage of gross value added (in constant prices)

Table 3.3 reports labour productivity growth results using the new classification of industries for the period 1980-2000. Labour productivity growth slowed down both in the ICT-intensive industry and in the other industry in the 1990s compared with the previous decade. However, the ICT-intensive industry realised a remarkable acceleration of productivity growth in the second half of the 1990s. In contrast, and interestingly, in the other industries labour productivity growth further slackened.

Table 3.3	**Growth rates of labour productivity[a] in the Netherlands, 1981-2000**		
	1980-1990	1991-1995	1996-2000
	annual percentages changes		
Market sector	2.6	1.3	1.6
ICT-sector	3.2	3.9	4.7
ICT-intensive industries	1.7	0.2	1.4
Other industries	3.9	2.7	1.0

[a] Value added per hours worked.

The results in table 3.3 suggest that the productivity gains through ICT were not only confined to the ICT-producing sector but also popped up for ICT-intensive industries. Outside these industries, a recovery in labour productivity growth rates has been absent. Likewise, if we adjust labour productivity growth with a HP-filter for cyclical factors to get productivity trend figures (see figure 3.4 and 3.5). It turns out that the trend of labour productivity growth in the ICT-intensive industries has increased since the early mid 1990s, whereas that of the other industries has continuously decreased over time. In fact, by the end of the 1990s, productivity growth rates of ICT-intensive industries were faster than those of other industries. The box and appendix C present more detailed information on the performance of ICT-intensive and other industries. In the late 1990s, both manufacturing industries and services classified as ICT-intensive experienced a revival in labour productivity growth, whereas industries within the other industry, in particular industries like agriculture and food documented a slow down. The wholesale and retail trade accounted for the largest contribution to the speeding up of productivity growth of the ICT-intensive sector. A recent US report concludes that the whole sale

Figure 3.4 Productivity trend in Dutch ICT-intensive industry, 1970-2000

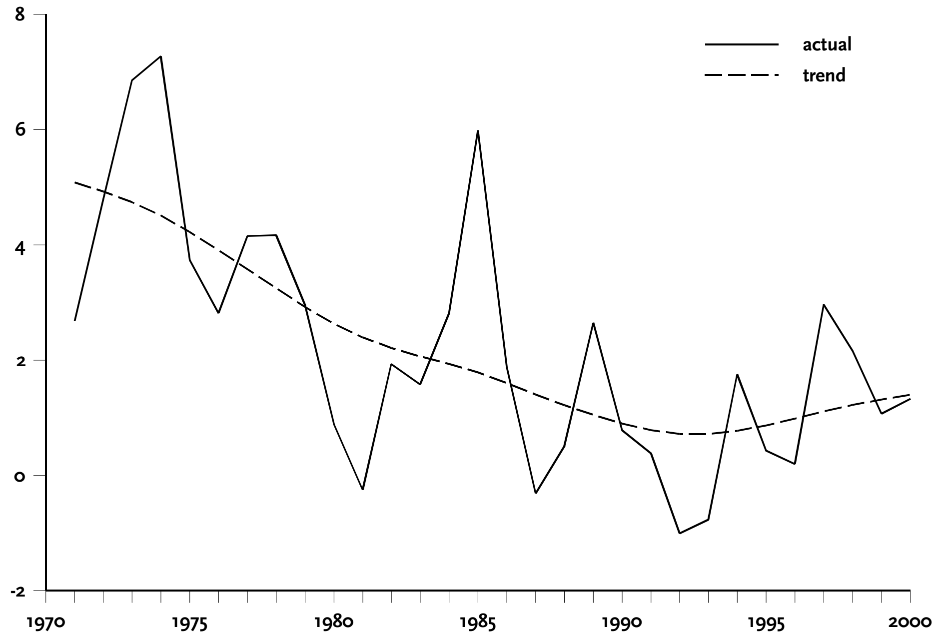
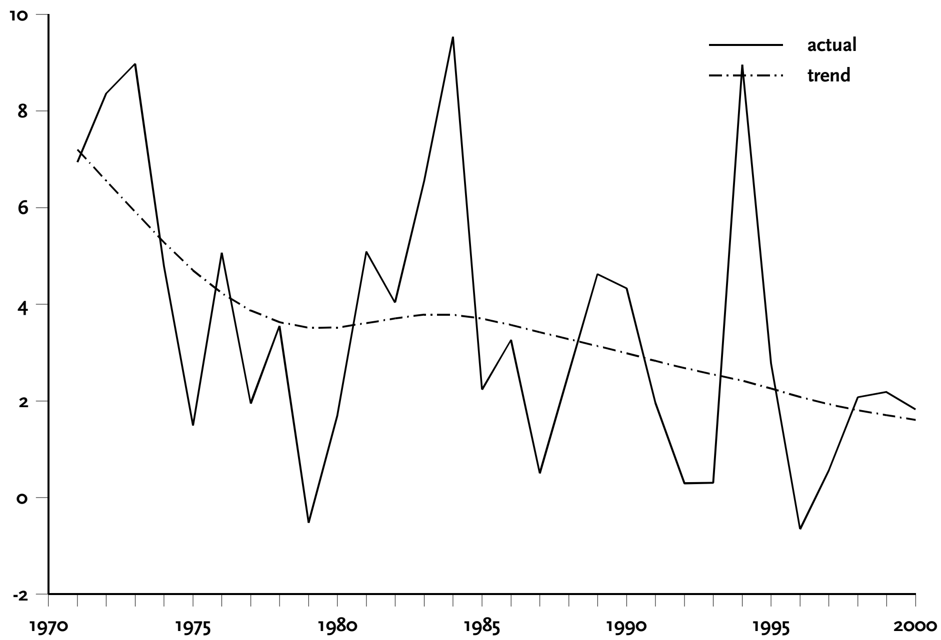


Figure 3.5 Productivity trend in Dutch other industry, 1970-2000



Sectoral performance: a more disaggregated view

According to the main economic indicators, the overall performance of ICT-intensive industries was better than the performance of other industries in the second half of the 1990s. Besides the productivity performance, the developments of ICT-intensive industries outstripped that of the other industries in terms of real value added and employment as well. Moreover, all those indicators considerably accelerated for the ICT-intensive industries in the period 1996-2000.

The picture within the ICT-intensive industries is similar per industry with regard to output growth and labour productivity growth. The ICT-intensive manufacturing industries as well as the ICT-intensive services industries experienced higher growth rates in terms of value added and labour productivity in recent years than in the past. In contrast, all other industries could not hold on to labour productivity growth rates in the first five years of the 1990s. In particular, the productivity performance of the other sectors was disappointing. Note that, the productivity growth performance of ICT-intensive services still lags behind that of the other services (i.e. transport). Probably, this is due to the fact that the latter is more exposed to foreign competition and is more capital-intensive.

With regard to employment, it can be seen that the picture is somewhat blurred among industries. The employment in both ICT-intensive manufacturing industries and less ICT intensive manufacturing industries declined in the first half of the 1990s. However, in both periods, the employment expansion in the ICT-intensive industries was stronger than that of the other industries mainly due to the better performance of the ICT-intensive services.

Productivity performance by Dutch industries, 1991-2000

	1991-1995			1996-2000		
	Value added	Employment	Labour productivity	Value added	Employment	Labour productivity
ICT-intensive industries	2.0	1.8	0.2	4.8	3.4	1.4
o.w. manufacturing	0.7	– 1.7	2.4	3.9	1.0	2.9
services	2.3	2.5	– 0.2	5.0	3.8	1.2
Other industries	2.3	– 0.5	2.8	2.0	0.9	1.0
o.w. manufacturing	1.8	– 1.1	2.9	2.4	– 0.2	2.7
services	4.5	1.0	3.5	4.2	1.8	2.4
other sectors	0.8	– 0.4	1.3	1.6	1.6	0.0

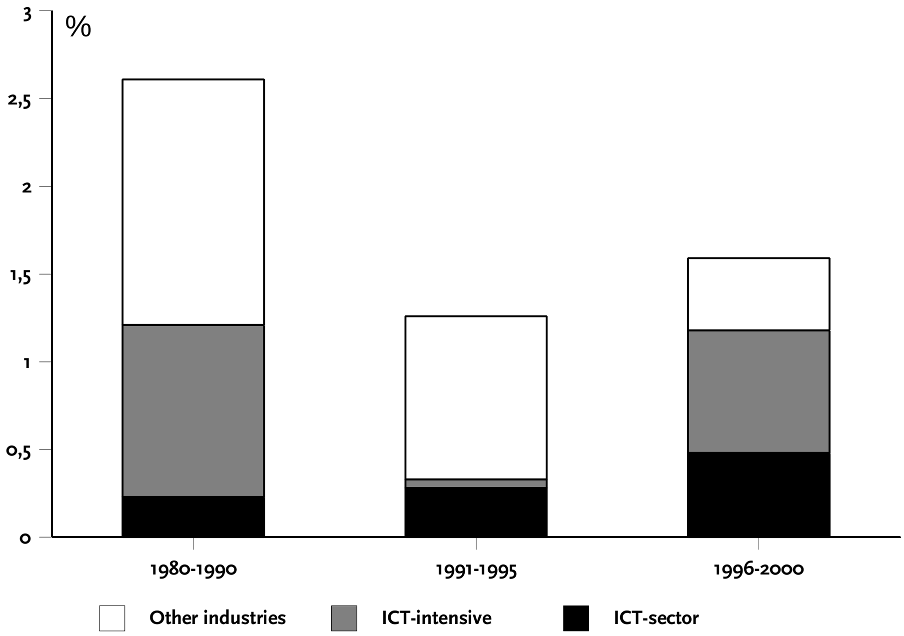
and retail trade still have opportunities to improve its production process.[34]

Concerning the recent productivity performance of ICT-intensive industries, figure 3.6 is very illustrative. The contribution of the ICT-intensive industry to labour productivity growth of the Dutch market sector shrank to almost nihil in the first half of the 1990s. After that, this industry underwent a strong productivity resurgence, while the contribution of the other industry

[34] McKinsey Global Institute, 2001, US Productivity growth 1995-2000; Understanding the contribution of Information Technology relative to other factors.

declined further. In the 1980s, the other industry accounted for approximately 50 percent of the productivity growth of the Dutch market sector. In the second half of the 1990s, this share dropped to less than 30 percent. Altogether, in percentage points, the overall contribution of ICT-related industries to productivity growth has almost returned to its contribution in the 1980s.

Figure 3.6 Contribution of industries to productivity growth in Dutch market sector (in %-points), 1980-2000



So, the slight productivity growth recovery in the market sector in the second half of the 1990s is due to both the ICT-sector and ICT-intensive industries.[35] Both ICT-related industries registered faster labour productivity growth rates in the period 1996-2000. In contrast, the less ICT-intensive industries documented a slow down of productivity growth.

[35] Appendix D elaborates further on this issue by using an econometric technique to test the impact of production and use of ICT on the overall productivity performance. In summary, the preliminary econometric results do not reject the positive effects of the ICT-sector and the ICT-intensive industries on the productivity performance of the Dutch market sector in the late 1990s.

4 Does ICT affect the Dutch economy?

4.1 ICT and capital deepening

This section documents the growth accounting results. First, it starts with a close analysis of the effect of capital deepening through ICT. ICT investments can enhance labour productivity by increasing the amount of capital per worker (or hours worked)

The rate of total capital accumulation in the market sector has, on average, marginally changed since the beginning of the past decade (see table 4.1). The acceleration was largely due to rapid growth rates of ICT. Investments in ICT are exuberantly growing in each sector, but not at the same speed. With regard to the sectoral developments, table 4.1 presents at least two interesting results. First and upmost, the growth rates of ICT-capital of the other industries are somewhat faster than that of the ICT-intensive industries are. This result confirms our earlier statement that, by now, ICT appears in each industry. It also suggests that those industries are closing the gap and become more ICT-intensive. Second and opposite to the first result, other industries considerably lagged behind ICT-intensive industries in investments in other capital. Other capital grew at an annual rate of 1½ percent in the other industries in the 1990s compared to roughly 4 percent per year in the ICT-intensive industries.

Table 4.1 Growth rates of capital services in the Netherlands, 1991-2000

	ICT-capital		Other Capital		Total capital	
	1991-1995	1996-2000	1991-1995	1996-2000	1991-1995	1996-2000
	annual percentages changes					
Market sector	9	12½	2½	2¾	3	3¼
ICT-sector	6¼	9½	2¾	4¾	4½	7½
ICT-intensive industries	17½	17¾	3¾	4	4¼	4½
Other industries	19	20	1¾	1½	1¾	1½

It is clear from table 4.1 that ICT-capital has been increasing very rapidly over time. Nevertheless, the share of ICT in the overall capital services remained small in most industries except the ICT-sector itself. Due to the rapidly falling prices of ICT, firms substitute ICT-capital to other capital generating quickly growing ICT-capital services. This relative adjustment is, however, to some extent counteracted by the speedy pace of ICT innovations making existing ICT-equipment rapidly obsolete.

Quality adjustments in capital

The difference between growth rates of capital services and capital stock remained modest until the mid-1990s. In the late 1990s, differences were growing both for the ICT-sector and for ICT-intensive industries. As discussed in section 2, differences between the pace of growth of capital stock and capital services point towards quality changes in the capital stock. In fact, the growth in capital services can be separated into two effects:
quantity changes, and changes in the composition of the capital stock. A shift in the capital stock toward ICT-investments with large marginal products leads capital services to grow faster than the capital stock.
For both aforementioned sectors, changes in the composition of the capital stock accounted for 0.4%-point stronger growth in capital services in 1996-2000. For ICT-intensive industries, in particular, the acceleration in the expansion of the capital services is largely caused by compositional changes.
In an international context, the Dutch figures for 'quality' changes are rather low. In France, the contribution of quality to capital growth accounted for about 17 per cent. The quality change was even much higher in the US in the 1990s, and accounted for about 30 per cent of the growth in capital services (OECD 2001a). In the Netherlands, instead, the contribution is lower than 10 per cent. One possible reason for this huge disparity among countries is that both the US and France apply hedonics to ICT.

Growth rates of capital services versus capital stock, 1981-2000

	Capital services			Difference [a]		
	1981-1990	1991-1995	1996-2000	1981-1990	1991-1995	1996-2000
	annual percentages changes					
Market sector	2.5	2.9	3.3	0.0	0.1	0.2
ICT-sector	5.0	4.5	7.5	0.1	0.1	0.4
ICT-intensive industries	2.7	4.2	4.6	0.0	0.2	0.4
Other industries	2.2	1.7	1.6	0.0	0.0	0.0

[a] Growth rates of capital services minus growth rates of capital stock

4.2 Growth accounting results

Based on the growth accounting framework, table 4.2 decomposes labour productivity growth into the contribution of TFP growth, capital deepening by ICT respectively other capital for selected periods.

The medium term outlook for Dutch productivity growth

The medium term outlook for Dutch productivity growth does look promising (see table 4.2). Labour productivity growth for the market sector is expected to speed up to an annual growth rate of 2¼% over the period 2003-2006.[a] The Dutch ICT-producing industries will likely continue to experience significant increases in productivity as they still will benefit to some extent from past developments. But the productivity performance of those industries are not the sole drivers of productivity growth in the medium term perspective. Two other sources need to be mentioned.

First, the acceleration in productivity growth up to 2006 is partly due to the positive impact of the business cycle. In 2002, the Dutch economy is likely to be positioned beneath its potential level of GDP. Hence, cyclical effects will enable productivity to grow faster than its structural growth pace in the years ahead.

Moreover, labour productivity growth will accelerate across the Dutch economy in the coming years because industries will probably reap the benefit from the diffusion and better use of ICT.

[a] See CPB, 2001, Economische verkenning 2003-2006 (only in Dutch). Section 5.2 documents the medium term perspective on labour productivity growth at the level of industries.

Table 4.2 Decomposition of Dutch labour productivity growth[a], 1980-2000

	1980-1990	1991-1995	1996-2000	2003-2006
	annual percentage changes			
Market sector	2.6	1.3	1.6	2¼
o.w. TFP	1.9	0.5	1.2	1½
ICT-capital	0.2	0.3	0.4	¼
Other capital	0.5	0.4	0.0	½
ICT-sector	3.2	3.9	4.7	4
o.w. TFP	1.8	1.4	3.9	2½
ICT-capital	1.1	2.1	1.0	1¼
Other capital	0.3	0.4	− 0.2	¼
ICT-intensive industries	1.7	0.2	1.4	2
o.w. TFP	1.1	− 0.6	1.0	1¼
ICT-capital	0.2	0.3	0.3	¼
Other capital	0.4	0.5	0.2	½
Other industries	3.9	2.7	1.0	2
o.w. TFP	2.9	1.9	0.7	1½
ICT-capital	0.1	0.1	0.2	¼
Other capital	0.9	0.6	0.1	¼

[a] Volume gross value added per hour worked; contributions of TFP, ICT and other capital are in % -points.

First, we concentrate on the results for the first half of the 1990s compared with the results of the 1980s. Although the contribution of capital deepening stabilised in the first half of the 1990s, a strong drop in the growth of TFP held back labour productivity growth in the market sector. Particularly, ICT-intensive and other industries were not able to maintain their pace of TFP-growth of the 1980s.

In the last five years of the 1990s, the increase in TFP-growth almost entirely drove the slight improvement of labour productivity growth in the Dutch market sector. To some extent, this speeding up came from a large pickup in TFP growth in the ICT-sector. As discussed in section 3.2, the ICT-sector has undergone a tremendous change. New regulatory reforms for telecommunications, the take-off of internet, the increasingly use of mobile phones induced strong demand for ICT-products and innovations. Faster TFP-growth seems to have fully picked up the effect of these developments.

Additionally, the rebound in labour productivity growth rates in ICT-intensive industries in the late 1990s again goes along with an upward leap in TFP-growth. Here, TFP-growth was about 1½ percentage points faster after the mid 1990s compared with the early 1990s.

Strikingly, the increased use of ICT only slightly accounted for higher labour productivity growth rates during the last years. This is in contrast with findings for the US.[36] Why? The answer is simple. The share of ICT-capital in Dutch ICT-intensive industries has been still too small to generate a significant and comparable effect on labour productivity growth as in the US. ICT-capital deepening affected labour productivity growth the most in the Dutch ICT-sector

[36] See e.g. Oliner and Sichel 2000.

Measurement problems in ICT-capital

The exact effect of the use of ICT on productivity growth strongly depends on the accuracy of the measured real output and ICT-capital services as well (see section 2.3). One of the main problems for statistical agencies is that adequate measures for prices and quantities of ICT-capital are difficult to obtain. Moreover, international comparability is hindered by differences in methodology for deflating ICT products. In contrast to US statistics, Statistics Netherlands do not employ hedonics for ICT-products yet. Schreyer (2001) states that those countries that employ hedonic methods to construct ICT deflators tend to register a larger drop in ICT prices than countries that do not. So, the effect of ICT-capital on labour productivity growth could be understated in the Netherlands because of less rapidly falling ICT prices.

One way to cope with this issue is to use a constructed 'harmonised' price indices for ICT products. This approach assumes that price ratios between ICT and non-ICT products evolve in a similar manner across countries, using the US as the benchmark. The harmonised price approach assumes that US measures of ICT-products based on hedonics are correct. Moreover, it postulates that other countries use (and produce) identical ICT products.

Here, we apply an alternative, but simpler, approach by assuming that ICT-prices declined 25 percent each year in the Netherlands before 1995. After 1995, we assume that Statistics Netherlands sufficiently measured the price development of ICT-products. Probably, the guestimate of 25 per cent annually decline overstates the 'correct' price decline and, therefore, overstates the effect of ICT-capital on Dutch productivity growth. Hence, this guestimate can be seen as a maximum range. The table compares the basic results with the guestimate in the period 1980-2000. Across the industries, the contribution of ICT-capital to labour productivity growth would be roughly at most 0.2%-points higher in the 1990s when ICT price are adjusted downwards. The effects are somewhat higher for the ICT-sector.

Comparison effect of ICT-capital using different ICT-price deflators, 1980-2000

	Basic			Guestimate		
	1980-1990	1991-1995	1996-2000	1980-1990	1991-1995	1996-2000
	contribution in %-points					
Market sector	0.2	0.3	0.5	0.2	0.5	0.7
ICT-sector	1.1	2.1	1.0	1.1	2.4	1.6
ICT-intensive industries	0.2	0.3	0.3	0.4	0.6	0.4
Other industries	0.1	0.1	0.2	0.2	0.3	0.2

Overall, the contribution of other capital shrank across the economy in the second half of the 1990s compared with the first half. This could be due to substitution of other capital for ICT as the latter became much cheaper. Additionally, it could be caused by the rapid expansion of employment. Though the negative result in the ICT-sector suggests that this industry did not invest in other capital during the second half of the 1990s anymore, this explanation is not true. It is simply the result of the fact that the expansion of employment outstripped the increase of the stock of other capital in this period. The ICT-sector was forced to invest more in labour inputs given the strong demand for ICT-products and the tight labour market for ICT-workers ahead.

The effect of software on Dutch labour productivity: A back-of-the-envelope calculation

So far, ICT-investments exclude investments in software due to a lack of detailed information for the period prior to 1995. With the implementation of the SNA93, Statistics Netherlands officially has published estimates of software and other intangible investments in its national accounts for the period 1995-2000. The measurement of software etc at current prices is problematic (see Van der Ende et. al.1999). Constant price estimations are even more questionable.

Here, we present a back-of-the-envelope calculation of the contribution of software to Dutch labour productivity growth in the 1990s. The price index of US software is used to deflate current expenditures. Moreover, treating software as an investment, intermediate inputs and therefore real value added is adjusted for the period before 1995. Investments in software surged in the last decade, especially in the late 1990s. This surge is partly related to the emergence and rapid diffusion of internet. Moreover, at the end of the 1990s, the Y2K-problem urged many firms to install new software, probably sooner than they had planned. Although the share of software in the Dutch capital stock is still small, the contribution to labour productivity growth as a whole is remarkable and somewhat smaller than for the US. The ICT-sector experienced the greatest effect of software. The effect in the ICT-intensive industry is smaller, but not to neglect.

Contribution of software to labour productivity growth, 1991-2000

	1991-1995	1996-2000
	contribution in %-points	
Market sector	0.1	0.2
ICT-sector	0.4	0.5
ICT-intensive industries	0.2	0.3
Other industries	0.0	0.1

ICT and spill-over effects

As discussed, in the second half of the 1990s, TFP growth accelerated beyond the ICT-sector itself. This result suggests that ICT has contributed to higher TFP-growth across industries. This indirect effect, however, is controversial. It is one of the main issues in the discussion on the New Economy and its effect on economic growth. ICT could raise the social rate of return beyond the private rate of return of firms that invest and use ICT in their production process. According to proponents of the New Economy this ICT-externality is a basic change in the economic process, and therefore, old economic experiences and insights are no longer valid.

In the US, a fierce debate has been going on among economists what caused the rebound in US TFP growth. There are two positions. Either this rebound is primarily due to technological progress in the ICT-sector or it is (also) caused by efficiency gains or spill-over effects in ICT-using sectors. The proponents of the former position emphasise that the ICT-revolution is a pure neoclassical story of relative price declines of ICT and input substitution. More ICT-capital per worker enhances labour productivity in the ICT-using industries but not their TFP growth.

Proponents of the other position assume that ICT could differ from other inputs because of the importance of network externalities that might occur. Network externalities enhance the benefits of the investor in a particular technology as the number of users of compatible products or technologies expands. The use of new network technologies, internet and e-commerce might further lift productivity improvements. ICT also allows firms to reduce X-inefficiency. Firms could reduce transaction costs due to more transparent information. Moreover, ICT could help to invent new products and processes that could induce higher productivity.

There are, however, counter effects. High switching costs could reduce the aforementioned positive externalities. A user who switches to a new technology incurs costs. Both network externalities and switching costs can lock users into a particular product or technology and, therefore, affect (price) competition. This could induce negative externalities. For instance, producers of ICT with large market shares might have greater market power than is common in other industries.

Appendix E tests the issue whether ICT is a special type of capital or not. The preliminary econometric tests are not conclusive. This might be because TFP growth is a catch-all term. The speeding up of Dutch TFP growth in the late 1990s may also come from developments in the economy that are independent of ICT. TFP includes the effect of (disembodied) technological progress, but also the effect of organisational changes, new products and measurement errors. On the other hand, some of these changes could be correlated with ICT.

To wrap up this section, two important conclusions follow from the growth accounting analysis.

- The often quoted phrase of Solow (1987) '*You see computers everywhere except in statistics*' might to some extent be outdated. The (direct) effect of computers, and broader ICT, on labour productivity growth seems to be quantifiable at a meso and macro level. Until now, the effects, however, are still small in the Netherlands.
- The slight recovery of Dutch labour productivity growth in the late 1990s is mainly accompanied with faster TFP-growth in ICT-related industries. The higher TFP-growth in the second half of the 1990s could be related to ICT, but TFP growth may also come from developments in the economy that are independent of ICT.

5 An international comparison and policy issues [37]

5.1 ICT rebounds US economy

5.1.1 Introduction

Both the US and the Netherlands experienced a strong increase in economic growth in the second half of the 1990s. However, the drivers of economic growth were different between both countries (see table 5.1). The higher Dutch GDP growth rate in the second half of the 1990s completely stemmed from the remarkable expansion in the labour supply, whereas an acceleration in labour productivity growth almost entirely drove the stronger US growth.

Table 5.1 Key data for the Dutch and US economy, 1991-2000

	the Netherlands		US	
	1991-1995	1996-2000	1991-1995	1996-2000
	annual percentage changes			
GDP	2.1	3.7	2.1	4.3
Employment	0.9	2.6	1.3	1.7
Labour productivity	1.3	1.1	0.8	2.6
Investments	1.0	5.6	3.6	9.1
o.w. ICT	11.6	19.8	13.3	23.2

Sources: the Netherlands: CPB; US: OECD 2001b.

Until the mid-1990s, labour productivity growth had historically been faster in the Netherlands than in the US. Dutch firms could reach high rates of productivity growth by imitation and catching up on technological progress made in countries that had higher levels of productivity, such as the US. In 1995, the level of output per hour worked in the Netherlands was among the highest in the world, and comparable to that in the US.[38] Since the mid-1990s, this position has reversed as labour productivity growth has accelerated in the US but has further slowed down in the Netherlands.

This subsection documents the proximate causes of the labour productivity growth disparity between both countries. Particularly, it focusses on the role of ICT by addressing the following questions: what do we know about the size of the ICT-sector and its impact on the US economy?

[37] Unfortunately, lack of detailed data hinders the international comparison in this section. In particular, similar growth accounting results, like the one presented in section 4, are missing at the moment. Another hampering factor is that performances of countries might deviate due to differences in the phase of the business cycle.

[38] See e.g. McGuckin, R.H. and B. van Ark, 2001, Performance 2000: Productivity, employment and income in the world's economies, The Conference Board.

How widespread is the use of ICT in the US economy and its contribution to labour productivity growth?

At the outset, the huge discrepancy in the growth rates of investments is most strikingly between both countries. If ICT is just another investment good than Dutch firms could have invested more in other capital goods to raise productivity, but they did not. The US had an overall investment boom in the 1990s. In particular, the gap in growth rates of investments widened in the second half of the 1990s partly due to stronger US investments in ICT. The latter accounts for more than 50 per cent of business sector investment growth in US. Most part of the acceleration of the labour productivity growth in the US probably comes from the greater impact of capital deepening, notably ICT-capital. Yet, this is not the whole story. US TFP-growth also accelerated in the second half of the 1990s.

5.1.2 Comparison of Dutch and US ICT-sector

Based on the OECD-definition, the share of the ICT-producing industries in the output of the total business sector is larger in the US than it is in the Netherlands.[39] In 1998, the ICT sector in the US accounts for 8.6% against 5.0% for the Dutch ICT-sector. The differences in shares are bigger for ICT-producing manufacturing than for ICT-producing services. The US is on the forefront of ICT-products produced by manufacturing industries. According to OECD (2000b), 36 of the largest IT-firms in 1998 were US based.[40] The US ICT-producing manufacturing has a comparative advantage in the production of computers and semiconductors. On the other hand, the Netherlands may have a comparative advantage in packaged software services.

Productivity performance of the ICT-sector seems to differ between both countries too (see table 5.2). The ICT-producing manufacturing in the US experienced much more rapid productivity growth than its counterpart in the Netherlands and contributed much more to overall productivity growth in the 1990s. Conversely, the productivity growth in the Dutch ICT producing services is three times stronger than the ICT-producing services in the US in the period 1996-1999. The better productivity performance is probably due to the excellent productivity performance of the Dutch telecom in the late 1990s. This could to some extent be due to the late reforms in Dutch telecommunication and the Netherlands is probably ahead of the US in wireless communication.

Although the Dutch ICT-sector has substantially increased in size because of its outstanding performance in ICT-producing services in the late 1990s, its overall contribution to labour productivity growth was somewhat lower than the contribution of the US ICT-sector. However, it should be borne in mind that definition and measurement problems seriously hinder this comparison, especially problems in adjusting price measurements for quality improvements

[39] In contrast to the definition in earlier sections, the OECD-definition also includes the wholesale and retail of computers.

[40] OECD, 2000b, OECD information Technology outlook 2000; ICTs, e-commerce and the Information economy.

(see section 2.3). The US is among the few countries that use hedonic methods to address these problems.

Table 5.2 Summary statistics US and Dutch ICT-sector, 1991-1999

	the Netherlands		US	
	1991-1995	1996-1999	1991-1995	1996-1999
	annual percentage changes			
Real output				
ICT-sector	2.9	13.0	5.6	11.6
o.w. ICT-producing manufacturing	1.4	2.6	8.2	18.9
ICT-producing services	3.5	16.6	4.3	6.9
Labour productivity				
ICT-sector	4.0	4.3	4.8	7.2
o.w. ICT-producing manufacturing	7.1	2.3	10.0	16.8
ICT-producing services	1.8	4.4	2.1	1.5
	%-points			
Contribution to overall lab. productivity growth				
ICT-sector	0.1	0.5	0.3	0.7
o.w. ICT-producing manufacturing	0.0	0.0	0.2	0.4
ICT-producing services	0.1	0.5	0.1	0.2

Source: Van Ark (2001).

5.1.3 Differences in use of ICT between the Netherlands and United States

As noted in section 5.1.1, investments in the US grew tremendously in the second half of the 1990s. In particular, rapid increases in ICT-investments can be observed. Consequently, the rate of capital accumulation in the US business sector almost doubled in the period after 1995. The sharp decline in the relative prices of ICT has contributed to this increasingly rate of capital accumulation. It has also contributed to a change in the composition of the capital stock as a consequence of the substitution of ICT capital for other capital and labour. According to a number of mostly US studies, the contribution of ICT-capital to labour productivity growth rapidly increased in the US during the 1990s. Table 5.3 compares the US results from Oliner and Sichel (2001) with the Dutch results.

Table 5.3 Contribution of ICT to labour productivity in market sector in the Netherlands and the US, 1991-2000

	the Netherlands		US	
	1991-1995	1996-2000	1991-1995	1996-1999
	annual percentage changes			
Labour productivity	1.3	1.5	1.5	2.6
o.w. contribution ICT[a]	0.4	0.6	0.5	1.0
contribution of other capital	0.4	0.0	0.1	0.1
contribution of TFP	0.5	0.9	0.9	1.5

[a] Dutch-figures include contribution of software 0.1 respectively 0.2%-punt for each period.
Source: US Oliner en Sichel (2001), Nonfarm business sector. The Netherlands: see section 4.

A priori, if there are no restrictions or other market rigidities, the indirect impact of ICT on productivity should not be confined to the US only since Dutch firms have mostly free access to these products as well. Nevertheless, ICT-capital contributed less significant to Dutch productivity growth on an aggregated level. It suggests that the Netherlands have not (yet) sufficiently exploit the opportunities of ICT. This could, for instance, be due to the first-mover effect of the US that will disappear in the course of time. Another explanation could be that ICT was cheaper in the US. Dutch firms could also have different perceptions of risks and prospects. Section 5.3 elaborates further on the issue of the US lead. It should be noted that the development of the contribution of TFP and other capital also made the difference between the Netherlands and the US.

Unfortunately, at the moment, detailed results of the impact of ICT-capital to productivity growth at the US industry level are lacking. An alternative approach is to compare the productivity performance of ICT-intensive industries and other industries between the Netherlands and the US. For example, Stiroh (2001) finds a strong link between ICT-capital accumulation and productivity growth across some US industries.[41] Productivity growth of ICT-intensive industries, i.e. those industries that made relatively huge IT-investments in the early 1990s, was faster in the late 1990s than in the first half of the 1990s (see table 5.4). He concludes that ICT-producing and ICT-using industries account for nearly all of the productivity revival in the US. In particular, IT-intensive industries considerably contributed to the acceleration of labour productivity growth in the latter part of the 1990s.

[41] Stiroh, K.J., 2001a, Information technology and the U.S. productivity revival: What do the industry data say?, Federal Reserve Bank of New York, January 24, 2001.

Table 5.4	Decomposition of US aggregate labour productivity, 1987-1999		
	1987-1995	1995-1999	Direct contribution to change
	annual percentage changes		%-points
Overall productivity growth	1.0	2.3	1.4
o.w. IT-producing	9.1	15.8	0.3
using	1.1	2.8	1.2
Other industries	1.2	0.4	– 0.3

Source: Stiroh (2001a), table 8. Contribution of industries to overall productivity change do not sum to total due to the omission of the reallocation-effect. IT-producing industries are industrial machinery and electronic and other electric equipment.

Additionally, Baily (2001) reports that ICT-using services particularly account for much of the acceleration of labour productivity growth. Heavy ICT-using services like wholesale and trade, finance and business services had all increases in labour productivity growth above that of the economy as a whole. In contrast, Gordon (2000) finds no empirical support for ICT-effects outside the ICT-sector itself. Certainly, if productivity figures are adjusted for business cycle effects and national account revisions (e.g. introducing hedonic price indexing) are not taken into account.

Stiroh's results are largely in line with the results for the Netherlands seen in section 3. A shortcoming of Stiroh's analysis is that the IT-producing sector does not include ICT-producing services, i.e. telecommunication and computer services. A recent paper of van Ark (2001) also includes the impact of ICT-producing services on productivity growth for the US (see table 5.5).[42]

Table 5.5	Decomposition of aggregate labour productivity, 1991-1999			
	1991-1995		1996-1999	
	US	the Netherlands	US	the Netherlands
	annual percentage changes			
Overall productivity growth	1.4	1.3	2.6	0.9
contribution of ICT-producing	0.3	0.1	0.6	0.5
ICT-using	0.4	0.3	1.0	0.6
Other industries	0.7	0.9	1.0	– 0.2

Source: Van Ark (2001)

At least we can make two comments on table 5.5. First, although the ICT-using industries substantially contributed to the acceleration of labour productivity growth in the Netherlands,

[42] Ark, B. van, 2001, The renewal of the old economy: an international comparative perspective, OECD, STI Working Papers 2001/5. Note that Van Ark analysed the economy as a whole, whereas section 3 and 4 focus on the performance of the market sector. Moreover, ICT-using industries also includes chemicals in the paper of Van Ark but excludes the retail.

their impact lagged behind that of the ICT-intensive industries in the US in the 1990s. The smaller contribution stems from slower productivity growth since the size of the Dutch ICT-intensive industry is comparable with the US. Second, a huge gap between the Netherlands and the US exists in the productivity performance of other, less ICT-intensive, industries. The pickup in Dutch overall labour productivity growth is fully counterbalanced by the disappointing productivity performance in other industries. In contrast, other industries in the US strengthened the productivity rebound.

5.2 Performance in other countries

Labour productivity growth in OECD countries (except for the US) does not appear to have accelerated in the latter half of the 1990s. The EU documented slower growth rates of labour productivity as well. A similar development can be observed for the Netherlands. Nevertheless, Dutch productivity growth rates lag behind, for instance, the European's growth performance on average. Again, we assess to what extent ICT may account for this divergence. The analysis is strongly based on the results of three recent OECD-studies[43]:

- The impact of information and communication technology on output growth; Issues and preliminary findings[44]
- Productivity growth in ICT-producing and ICT-using industries-- a source of growth differentials in the OECD[45]
- The renewal of the old economy: An international comparative perspective (Van Ark 20001).

The first OECD-paper extends and updates Schreyer (2000).[46] The latter documented the contribution of ICT to output growth for the g7 countries. He found that ICT-capital has been an important contributor to economic growth for all seven countries, although the role of ICT has been more profound in the US. Due to timeliness of comparable data and lack of harmonised ICT-data, Schreyer's results were limited and preliminary. Instead of using private ICT source data, a follow-up, the second OECD study, was carried out using official series of ICT investment. As in Schreyer, this OECD-study tries to control for differences in deflation

[43] Unfortunately, the OECD-studies are not able to apply the growth accounting technique on lower levels of aggregation partly because data on ICT investments are still scarce for some countries.

[44] OECD, 2001b, The impact of information and communication technology on output growth; Issues and preliminary findings, DSTI/EAS/IND/SWP (2001)11.

[45] OECD, 2001c, Productivity growth in ICT-producing and ICT-using industries-- a source of growth differentials in the OECD, DSTI/EAS/IND/SWP(2000)3/REV1.

[46] Schreyer, P., 2000, The contribution of information and communication technology to output growth: a study of the g7 countries, OECD, STI Working Papers 2000/2.

methods by using harmonised deflators. Two other significant extensions of Schreyer's paper are that more countries are included and the new analysis covers the second part of the 1990s. The main conclusions are, however, akin.

Many OECD countries have witnessed a rapid increase in ICT-investments since the 1980s (see table 5.6). Growth rates even accelerated in the second part of the 1990s, except for Japan. Finland and France registered similar growth rates as the US did. In Finland, investments in communications equipment were the most important driver of the fast growth. The Dutch investment performance on ICT stands out well.

Table 5.6 Growth of real ICT investments business sector, 1980-1999

	1980-1990	1991-1995	1996-1999
	annual percentage changes		
US	12.2	13.3	23.2
Australia	18.4	13.9	15.8
Finland	15.3	9.4	20.5
France	13.0	10.1	22.2
Germany	12.1	8.1	14.8
Italy	13.1	6.5	14.8
Japan	20.0	8.7	11.0
the Netherlands	15.8	11.6	19.8

Source: OECD, 2001b for all countries except the Netherlands; figures for the Netherlands (excluding software) are based on CPB.

Given the fast growth rates of ICT-investments across the board, it is to be expected that ICT-capital accounts for a larger share in output in the second part of the 1990s than before. Although the contribution was smaller than for the US, all OECD-countries experienced increasing contributions of ICT-capital to output growth in the period 1996-1999 (see table 5.7).[47] However, in most countries, ICT-capital is not the main driver for speeding up GDP-growth, except for the US of which a quarter of the acceleration stemmed from developments in ICT-capital.

[47] Unfortunately, at the moment, OECD is not able to present the labour and TFP contributions to the changes in output growth.

Table 5.7 Changes in output growth through capital, 1996-1999 versus 1990-1995

	output	contribution of ICT-capital	other capital
	annual change between periods in %-points		
US	1.8	0.4	0.3
Australia	1.2	0.2	0.1
Finland	6.1	0.3	0.0
France	1.6	0.2	− 0.1
Germany	− 2.0	0.0	− 0.2
Italy	0.3	0.1	0.1
Japan	− 0.4	0.0	− 0.5
the Netherlands	1.6	0.2	0.0

Source: OECD, 2001b for all countries except the Netherlands; figures for the Netherlands (excluding software) are based on CPB.

It is important to note that all OECD-papers point to the fact that countries do not necessarily need a large ICT-producing sector to benefit from ICT. ICT is a necessary but not sufficient enabler of productivity improvements. In general, the latest ICT-technologies are almost immediately worldwide available. Therefore, countries with small-sized domestic ICT-sectors can potentially benefit from productivity effects of using foreign ICT technologies across their economies.

Both the second and third OECD paper report that ICT-producing sectors considerably affected overall productivity growth across OECD countries, except for Italy. The second OECD paper also concludes that ICT is having spill-over effects on productivity growth beyond the ICT-sector itself. For some countries evidence exists that the productivity performance of certain ICT-using services improved in the second half of the 1990s. However, based on more recent data from the third OECD-paper, it can be concluded that several OECD-countries registered contracting labour productivity growth rates in ICT-using industries in the period 1996-1999. Finland, US and the Netherlands are clear exceptions (see table 5.8).[48]

[48] Due to reallocation effects, ICT-intensive industries can still positively contribute to overall labour productivity acceleration in this period.

Table 5.8 Growth of labour productivity[a] in international perspective, 1991-1999

	Denmark	Finland	France	Germany	Japan	UK	US	Neth.	mean
	annual percentage changes								
Period 1996-1999									
Total economy	1.0	2.3	1.3	1.7	0.8	1.2	2.6	0.9	1.2
ICT-sector	4.4	13.7	8.5	11.1	4.1	4.9	7.2	4.3	6.4
ICT-using sectors	1.8	4.9	0.7	1.5	0.4	1.3	3.5	1.8	1.9
Other sectors	0.5	0.7	0.9	1.1	0.5	0.7	1.7	0.2	0.5
Changes period 1996-1999 versus 1991-1995									
Total economy	– 1.1	– 0.6	0.2	– 0.4	0.0	– 1.3	1.3	– 0.3	– 0.8
ICT-sector	– 3.1	5.9	4.4	4.3	– 0.1	– 1.9	2.4	0.3	0.9
ICT-using sectors	0.1	4.4	– 0.2	– 0.7	– 1.1	0.0	1.9	0.5	0.0
Other sectors	– 1.4	– 2.5	– 0.1	– 0.8	0.2	– 1.8	0.7	– 0.9	– 1.3

[a] Volume gross value added per employee.
Source: Ark, B. van, 2001. For Germany period 1992-1998, for France and Japan period 1991-1998.

Despite the turn in productivity trends in some Dutch sectors during the 1990s, data by industry pinpoints to poor productivity performance of several industries in an international perspective. Dutch ICT-sector's productivity growth is less fast than that of most OECD counterparts in the 1990s. Slower labour productivity growth rates go along with higher growth rates of employment in the Netherlands.[49] Nevertheless, the productivity performance of the Dutch ICT-sector was of vital importance for the overall productivity performance in the Netherlands (see the box *the Dutch ICT-sector in an international perspective: David or Goliath?)*

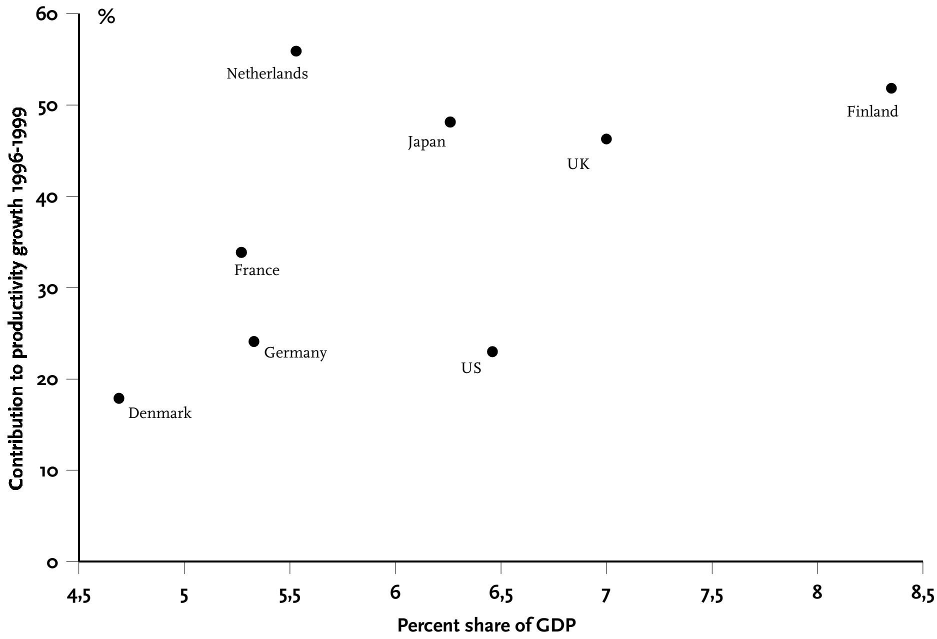
[49] This result is to a great extent the same for ICT-producing manufacturing and ICT producing services.

The Dutch ICT-sector in an international perspective: David or Goliath?

The Dutch ICT-sector is among the smallest ICT-sectors in an international perspective (see figure). It accounts for 5½% percent of GDP. Finland has the largest ICT-sector when measured by percent share of GDP, half as much as the share in the Netherlands. Denmark habits the smallest one for the selected countries.

Although its share is relatively small, the Dutch ICT-sector accounted for almost 60 percent of the overall labour productivity growth in the second half of the 1990s. In contrast, Denmark's ICT-sector contributed much less to productivity growth. The outstanding Dutch performance was mainly due to poor productivity growth elsewhere in the Dutch economy since labour productivity growth of the Dutch ICT-sector was less remarkable (see table 5.8).

Share in GDP and contribution to overall productivity growth ICT-sector

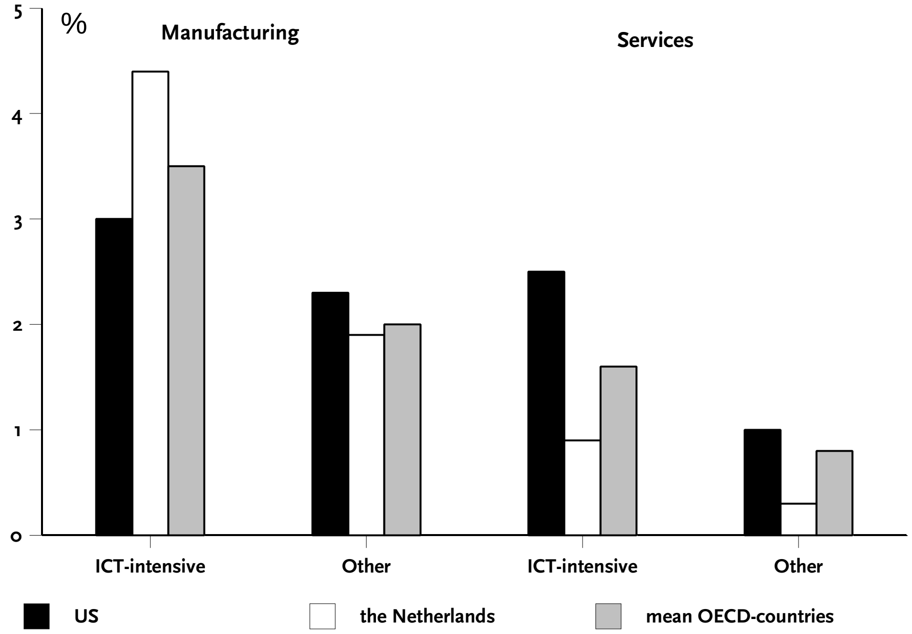


Source: Own calculations based on Van Ark (2001)

Beyond the aggregate level of ICT-using industries, the picture is more promising for some Dutch ICT-using industries. The productivity growth of ICT-using manufacturing is excellent in an international contest (see figure 5.1).[50] In contrast, ICT-intensive services lag behind productivity developments in other countries. Earlier research also shows that labour productivity growth in Dutch business services is low in an historical and international setting (see e.g. Van der Wiel 1999). In addition, the productivity performance of other services was much lower in the Netherlands than in the US and on average in the OECD.

[50] Also less ICT-using manufacturing industries stand out well.

Figure 5.1 Sectoral productivity performance of ICT-using industries: an international comparison, 1991-1999



Source: Own calculations based on Van Ark (2001).

It is time to summarise the main findings. The US is not the only country that witnessed a marked effect of ICT on labour productivity growth in the second part of the 1990s. In particular, Finland and the Netherlands experienced a pickup of productivity growth in ICT-related industries as well. In contrast, the productivity performance of Dutch services lagged behind developments in other OECD-countries. If economic conditions are right, there can be a catch up in these industries.

5.3 Policy issues

From an historical and international perspective, Dutch labour productivity growth rates have been lacklustre. The effect of ICT on the Dutch economy was smaller than in the US where overall labour productivity growth considerably accelerated in the second part of the 1990s. The strong rebound in the US productivity growth is almost entirely due to ICT and complementary changes. Labour productivity growth in Dutch market services only slightly accelerated at the end of the 1990s. Some of this small recovery comes from ICT, and in particular by developments in the Dutch ICT-sector. Due to innovations and deregulation, the Dutch telecom, for instance, experienced huge productivity gains in the second half of the 1990s. The Dutch ICT-intensive industries as a whole also documented an acceleration in productivity growth in this period. However, the productivity performances of services lagged behind their counterparts in other OECD-countries.

As growth rates of labour supply will decline in the next five years, higher labour productivity growth is needed to prevent Dutch GDP growth from a slowdown. For instance, high GDP growth is desirable in coping with ageing. The challenge for the Netherlands, therefore, is to raise the growth of productivity. The main questions, then, to be addressed are: how can productivity gains be attained? Why do productivity growth rates in other industries still slow down? Which policies can reverse this trend and strengthen labour productivity growth? Should the Netherlands imitate the US if they are to succeed?[51] Or, is it justified assuming that the diffusion of ICT will follow the developments of the US with a certain delay?

With regard to the last question van Ark (2001) stated that the present productivity advantage in the US over the European countries could erode when European firms make a larger and more effective use of ICT. But, are there enough incentives for Dutch firms to encourage them to improve their productivity performance? In general, nowadays, the US economy can be characterised by flexible product and labour markets and fierce competition due to early deregulations. According to McGuckin and Van Ark (2001), many US industries that today lead in ICT-use were subject to extensive structural reforms in the 1970s and 1980s.[52] As a result, there has been strong demand for new technologies.

So far, a lot of questions have been put forward without answers. Unfortunately, growth accounting only explains what happened to the Dutch productivity performance and not why it happened. The method solely focusses on proximate sources and not on ultimate sources of productivity growth, i.e. the underlying explanations. The latter needs an analysis of the incentives and behaviour of firms and industries. Such an extensive firm-level analysis is beyond the scope of this document.

Here, we confine to some general remarks on policy issues. What is the role of Dutch government in order to reap the full benefits of ICT and other technologies? There can be a role for government when markets fail. Market failures occur if there exists information asymmetry, market power, and externalities. Due to network externalities and switching costs, ICT can lead to these types of failures. However, firms themselves can develop strategies to reduce or even prevent market failures in particular with regard to information asymmetry.[53] Hence,

[51] It should be borne in mind that differences in preferences can also contribute to the gap observed between the US and the Netherlands. There is definitely a tradeoff between the amount of work people want to do and the amount of income they want to earn. The low number of hours worked suggests that Dutch people may freely prefer more leisure and be willing to accept a lower income, and consequently a lower GDP.

[52] McGuckin, R.H and B. van Ark, 2001, Making the most of the Information Age: Productivity and Structural Reform in the New Economy, The Conference Board, Perspectives on a global economy.

[53] Blokland, D.A. and M. A. Feenstra, 2001, Beheerst interveniëren (only in Dutch), ESB-Dossier Informatiegoederen en marktwerking, pp. D3-D6.

government intervention is not always needed when markets fail. Moreover, uncertainties and lack of information limit the effectiveness of government intervention and regulation.[54]

In general, competition is the driver of economic efficiency and innovation. In that respect, the OECD have addressed the implications for public policy. Recently, the OECD growth project investigated the causes of the growth disparities across the OECD countries (OECD, 2001a). It analysed the role of factors such as innovation, knowledge, human capital, and start-up firms. The growth project came up with five interrelated policy recommendations:

- Strengthen economic and social fundamentals
- Facilitate the diffusion of ICT
- Foster innovation
- Invest in human capital
- Stimulate firm creation

All five recommendations are fundamental and applicable to the Dutch economy. Likewise, Oosterwijk (2001) of the Dutch Ministry of Economic Affairs identified three pillars for a policy aimed at raising Dutch productivity growth: enhancing market dynamics, improving the tax environment, and strengthening knowledge and innovation potential.[55]

As briefly discussed, government action can be needed if markets fail due to information asymmetry, market power and externalities. The poor productivity performance in Dutch services is remarkable and needs further research. Although we are not able to answer the question whether markets do fail in Dutch services, a short analysis of some relating facts about ICT-investments, innovation and competition sheds some light on this issue.

Investments in ICT and use of ICT-products are relatively high in the Netherlands, but countries like Finland, Australia and the US run in front. There seems to be scope for a catch up. But, is the rate of return of ICT investments in the Netherlands comparable to rates in other countries? If not, what are the causes?[56] It also raises the question whether all firms, in particular small and medium-sized firms, have sufficient information on and access to ICT.

Second, innovations are the engine of economic growth, not only for manufacturing but also for services. The innovation performance of Dutch services lags behind their counterparts in an international setting. Innovation expenditures made by innovating enterprises in the Dutch services sector are lower than the average of the European innovative services firms.[57] This could

[54] Gelauff, G.G.M and P. de Bijl, 2000, The renewing economy, CPB report 2000/1

[55] Oosterwijk, J.W., 2001, Nieuwe bronnen van welvaartsgroei, Economische Statistische Berichten 86, January 5, 4-7.

[56] See also Bartelsman, E.J. and J. Hinloopen, 2000, De verzilvering van een groeibelofte (only in Dutch), in *ICT en de economie*, Koninklijke Vereniging voor Staathuishoudkunde, Preadviezen 2000.

[57] Wiel, H.P. van der, 2001, Innovation and productivity in services, CPB Report 2001/1.

be an explanation for the sloppy productivity performance of Dutch services. It raises the question whether there are sufficient incentives (e.g. competitive pressure, tax facilities, copyrights, scientific environment) for firms in services to innovate. Another issue that needs further research is the role of organisational changes and human capital in relation to product and process innovation. Several international studies showed that for productivity gains through innovations to be realised, firms must adapt their organisational structure. Moreover, a complementarity exists between high-skilled labour on the one hand, and physical capital and new technology on the other hand.[58] Research for the Dutch business services are in line with the results that non-technological changes might be necessary to reap the full benefits of innovations.[59]

Finally, the competitive intensity in Europe including the Netherlands is probably less than in the US. The OECD (2001a) finds that the United Kingdom and the US were among the least regulated countries in 1998. The Netherlands were close behind. In fact, the heavier administrative burdens on start-ups caused the backwardness. Since 1998, many countries have implemented new reforms. Some of them are still in the pipeline, but much remains to be done. Both the OECD and Dutch government promote regulatory reforms including further reduction of entry barriers. Entry barrier reductions tend to be good for static efficiency since it enhances competition. It is also good for dynamic efficiency because it increases the willingness to invest in new markets and stimulates entry by innovative newcomers.[60] Moreover, the adoption of new technologies and their speed of diffusion across the economy are more likely to be efficient in a competitive and entrepreneurial environment. Since halfway the 1990s, Dutch public policy has strengthened the importance of competition and has put into operation several regulatory reforms. In that respect, Kox (2001) finds that the Dutch and UK markets for business services are among the most liberalised ones nowadays. Dutch business services firms can benefit from future deregulation and liberalisation of this type of industries in other OECD countries when their demand will expand.[61] On the other hand, there is still some doubt about the intensity of competition in Dutch business services. Huge firm creation and destruction in Dutch business services did not affect productivity growth so far.[62]

[58] Arnal, E., O. Wooseok, and R. Torres, 2001, Knowledge, work organisation and economic growth, OECD, Labour Market and Social Policy , Occasional papers No. 50, June 2001.

[59] See Van der Wiel, 2001.

[60] Benett, M. P de Bijl, and M. Canoy, 2001, Future Policy in Telecommunications: An Analytical Framework, CPB Document No 005.

[61] Kox ,H, 2001, Exposure of the business services industry to international competition, CPB Document No. 10, August 2001.

[62] Wiel, H.P. van der, 1999, Firm turnover in Dutch business services; The effect on labour productivity, CPB Research Memorandum No 159.

6 Conclusions

This document analyses the effect of ICT on Dutch labour productivity growth. Using the growth accounting framework at an aggregated level and at the level of industry, it addresses the question whether ICT has boosted Dutch productivity growth. ICT can have wide-ranging productivity effects across the economy like other important general purpose technologies had in the past.

The growth accounting framework provides a breakdown of labour productivity growth into components associated with changes in factor inputs like ICT-capital, other capital and TFP. The latter reflect technological progress and other elements that could also be related to ICT. The framework cannot measure how large the role of ICT is in the TFP-growth since TFP is measured as a residual, and not from direct observation. However, dividing the market sector into three sectors – ICT-sector, ICT-intensive industries and other industries – can shed additional light on whether ICT led to an increase in labour productivity growth in specific Dutch industries in the 1990s.

The main conclusions of the analysis in this document are as follows. Labour productivity growth in the Dutch market sector slightly accelerated in the second half of the 1990s.[63] This acceleration is mainly due to a strong recovery in TFP-growth. ICT mattered for labour productivity growth. The productivity performance of the Dutch ICT-sector accounts for a large share in this rebound of TFP growth. The faster TFP-growth rate of the ICT-sector mainly stemmed from the excellent productivity performance of ICT-producing services. In fact, the Dutch ICT-services registered stronger productivity growth than its counterpart in the US in the second half of the decade. The good Dutch performance is due to an increased efficiency in the production of ICT-products, deregulations and the use of cellular phones and the emergence of the internet.

The benefits of ICT probably accrue to the users of ICT as well. Labour productivity growth rates markedly accelerated in ICT-intensive industries in the late 1990s. Again, the resurgence in labour productivity growth in those industries goes mostly along with an upward leap in TFP growth. This suggests that the benefits of ICT have started to diffuse among Dutch industries. Moreover, by the end of the 1990s, the productivity performance of ICT-industries surpassed the performance of other industries. Yet, the increasingly use of ICT modestly popped up in a higher contribution of capital deepening to productivity growth in recent years. This is in contrast with findings for the US, but explainable. ICT-capital still forms a smaller share of the capital stock in Dutch ICT-intensive industries than in the US.

[63] It is important to note that labour productivity growth for the economy as a whole further flagged in the second half of the 1990s.

In the late 1990s, ICT effects can be seen on a wide scale in industrialised countries. Many countries experienced positive effects on labour productivity growth from ICT-producing industries. However, disparities can be noticed in the pace at which countries are benefiting from the use of ICT. Although the Netherlands lagged behind the US, the contribution of the Dutch ICT-intensive industries to overall labour productivity growth was relatively high in the second half of the 1990s. This is counterbalanced by the performance of the other industries in the Netherlands. As a result, the overall productivity performance of the Netherlands is disappointing in an international perspective. Particularly, labour productivity growth rates of Dutch services lag behind their counterparts in most OECD-countries.

Looking forward to the next five years, improvement of labour productivity will be a key issue in the Netherlands. Due to slower growth rates of labour supply, Dutch labour productivity growth has to increase in the upcoming years in order to prevent a substantial decline in GDP growth. Larger investments in and better use of ICT may boost labour productivity growth. Particularly, less ICT-intensive industries could improve their productivity when they catch up with developments seen in similar industries in other countries. The role of the government is mainly to facilitate the diffusion of ICT and other innovations across the economy, because these are the engines of economic growth. According to literature, one of the most efficient policy options seems to be creating a competitive environment. Competition leads to an increase of efficiency and exploring new ways of doing business among incumbents. In a competitive environment, new innovative firms can enter the market and boost productivity growth as well. Finally, competition induces inefficient firms to stop their activities or to implement productive innovations to survive.

Appendix A Data and measurement issues

The industry data are sourced from the sectoral time series database of CPB. This database contains annual industry data series on a wide range of variables such as gross output, value added, employment, intermediate inputs, investments per type of asset from early postwar years onward. Recently, we have constructed sectoral capital stock figures for the postwar period. These figures are still preliminary, due to lack of sufficient information on a disaggregated level and further research plans by Statistics Netherlands.[64]

Capital stock and capital services per industry

Capital service is one of the variables used as an input in the production function, relating flows of input to flows of output. Capital is an aggregate of various types of fixed capital. Since capital goods differ substantially in marginal productivity, it is necessary to focus on the flows of capital services rather than the stock of capital. Unfortunately, capital services are usually not available directly except for leasing. However, capital services can be inferred from capital stock data.

The estimates for total capital stock by industry are based on the perpetual inventory method (PIM). The PIM requires time series on investment by asset and by industry over a very long period and accurate price indexes to revalue past investments to current time series. This document distinguishes seventeen branches of industries (=i) and eight different types of capital assets (=j).

$$K_{ij}(t) = \sum_{b=0}^{b=t} S_{ij}(t,b)\ \Phi_{ij}(t,b)\ I_{ij}(b)$$

Where	S	Proportion of investment I at time b that survives to time t
	Φ	Economic efficiency at time t
	I	Original investments in real prices at time b

Next, a truncated normal distribution is used with a stochastic mean service life centred about the mean life (see table A.1). We assume that the actual service life is a random variable. This randomness is due to factors such as destruction, fire, theft and unanticipated obsolescence. The normal distribution is truncated, with a variance of one quarter of the mean life, at 50 percent above and below the mean. Further, a beta-decay function, (β=0.90), is applied to the remaining stock to reflect efficiency loss by each type of asset as it ages.

[64] In the future, Statistics Netherlands will carry out a project to construct new investment time-series for the past. They also aim to construct more adequate capital stock measures by industry.

$$\Phi_a = \frac{m_{ij} - a_{ij}}{m_{ij} - \beta a_{ij}}$$

where a Asset's service life

β Curvature parameter (β=0.90)

m Mean service life

Φ_a Proportion of asset's original productive efficiency remaining at age a

Table A.1 Mean service lives per type of assets

Asset	mean service lives in years
Building	35-60
Machinery and equipment (excluding ICT)	10-25
Cars and road transport	10-15
Rail	40
Vessels	25-40
Aircraft	15
Civil engineering	35-45
ICT-hardware	5

Investment in ICT

IT investments comprise expenditures on hardware and system software in administrative and industrial automation. This includes outlays on computers, terminals, peripherals, system software etc. After 1995, data is sourced from the National Accounts of Statistics Netherlands. For the period 1985 to 1995, data is derived from CBS-databank.[65] Both time series are linked to each other to construct longer time series for IT. Due to a lack of detailed information, communication investments are only available for telecommunication.

Treating software (including software developed on own account) and other immaterial assets as (ICT) investment was recommended in the 1993 System of National Accounts. Hitherto, Statistics Netherlands counted software as part of current expenditures or intermediate inputs. From the year 1995 onwards, it started to extend the asset boundary to include produced intangible assets, computer software and large databases as gross fixed capital formation. Application software is not considered part of ICT investments in the main calculations of this report, due to missing data for the past.

[65] Pronk, J.J.M, and C.H. v.d. Berg, 1997, CBS-databank, Toelichting op de dataverzameling door het CBS voor het onderzoek naar de economische effecten van ICT (only in Dutch),

Problems with constructed capital stock

The calculation of capital stocks based on PIM is fraught with difficulties. A comprehensive discussion of these difficulties is beyond the scope of the document, but some difficulties are briefly highlighted below.

First, the growth rates of the capital stock at the level of industry could be biased due to measurement problems with regard to the initial capital stock. Annual series on required investments are available from the year 1948 onwards. Since the mean service life for the longest-lived asset type goes back to before 1948, we have constructed a capital stock per type of asset and industry for 1948 in two ways. The first estimate is based on an old exclusive investigation of Statistics Netherlands. This investigation guesstimated the total capital stock of the Netherlands around the early 1950s.[66]

The second estimate uses the following formula to calculate a capital stock for 1948:

$$K_{ij}(0) = \frac{(\sum_{0}^{7} I_{ij}(t)) \ / \ 7}{(I_{ij}g7 \ + \ 1/m_{ij})}$$

Where $I_{ij}g7$ Average growth rates of investments over seven years

Due to the long period after 1948, the differences in capital stock growth rates are modest between both methods. We have therefore applied the first estimate.

Second, the quality of the estimates of the capital stock also depends on the reliability and consistency over time of the required investment series. Unique investment series per type of asset do not exist due to several revisions and reclassifications in the period 1948 to 1995. Here, the retention of time series is based on the best changes.

Further, based on limited empirical evidence, the shape of the decay function is supposed to be concave, implying that efficiency first declines slowly and then more rapidly as the asset ages. This pattern is consistent with two different assumptions concerning maintenance and repair practices: the decline in efficiency with any uniform level of maintenance and repair (i.e. output decay), the increasing costs of maintenance and repair required to maintain 100% of efficiency (i.e. input decay). However, the exact value of the beta-decay is unknown. In this document, the value is set at 0.90 for the basic scenario. By setting different values for β, we have analysed the sensitivity of the results. Except for the ICT-sector, the differences were very modest (see table A.2).

[66] See Verbiest, P., 1996, The capital stock in the Netherlands (only in Dutch: De kapitaalgoederenvoorraad in Nederland), CBS-Voorburg.

Table A.2 Growth of capital stock using different values of the beta parameter, 1980-2000	Central variant	β=0.75	β=0.95
	annual percentage changes		
Market sector			
1981/1990	2.5	2.3	2.5
1991/1995	2.7	2.6	2.7
1996/2000	2.9	2.8	2.9
ICT-sector			
1981/1990	4.9	4.8	4.9
1991/1995	3.3	3.0	3.5
1996/2000	5.8	5.7	5.9
ICT-intensive industries			
1981/1990	2.7	2.6	2.7
1991/1995	4.0	3.9	4.0
1996/2000	4.2	4.0	4.2
Other industries			
1981/1990	2.2	2.0	2.3
1991/1995	1.7	1.6	1.8
1996/2000	1.5	1.4	1.6

Finally, the assumptions on service lives may very well be wrong. Overly long service lives will overstate the size of the capital stock, and too-short lives will understate it. However, a change in asset-life assumptions will have a more limited effect on growth rates than on the size of the capital stock. More serious could be the effect of changing asset lives over time, and changing the composition of capital stocks within the seven types of assets. In this document, we assume that both effects are absent.

Capital services

The flow of capital services is a weighted sum of past investments, with weights given by the efficiency of each asset of different age. Each type of capital input must be weighted by its marginal product. To aggregate each type of asset to the total capital input, rental prices of capital are needed.

$$\triangle \ln K_i = \sum_j W_{ij} \ (\triangle \ln K_{ij})$$

with

$$W_{ij} = \frac{p_{ij}^{k} \cdot K_{ij}}{\sum_{j} p_{ij}^{k} \cdot K_{ij}}$$

where p_{ij}^{k} is user cost of capital. The user-cost of capital for each type of asset is based on long-bond and equity returns, as well as tax information and specific sectoral information on tax deductibility, accelerated depreciation allowances, and investment tax credits:

$$u_{ij} = T_{ij} \, [(1-u)r + d_{ij} - P^{e}_{ij}] \, P_{ij}$$

with

$$T_{ij} = \frac{(1 - wir_{ij} - uIA_{ij})}{(1 - u)}$$

where d Depreciation percentage (= 1/m)

d	Depreciation percentage (= 1/m)
IA	Fiscal investment facilities
$P^{(e)}$	(expected) purchase price of asset
r	Long-term interest
u	Corporate tax rate
wir	Investment premiums

Appendix B Shift share method

The shift share method enables to measure the contribution of a particular industry to overall productivity growth. Moreover, it disentangles labour productivity growth into, respectively, a within effect (the first term on the right-hand side), a reallocation effect and a covariance term:

$$\Delta \ln y/l = \frac{[\sum \Delta(\frac{y_i}{l_i}) * \frac{l_i}{l}] + [\sum (\frac{y_i}{l_i} - \frac{y}{l}) * \Delta(\frac{l_i}{l})] + [\sum \Delta(\frac{y_i}{l_i}) * \Delta(\frac{l_i}{l})]}{\sum \frac{y_i}{l_i}}$$

The first term gauges the contribution of labour productivity growth within individual industries to the overall labour productivity growth. The reallocation effect, i.e. the second term, reflects changing market shares, weighted by the deviation of initial industry productivity from the average productivity level (the term without subscripts). If industries increase their share, they positively contribute to the overall productivity only if they have a higher productivity level than the average initial productivity level for the market sector. The third term on the right-hand side is a cross term that can be either negative or positive. If an industry raises both its market share and productivity level, this effect will be positive.

Appendix C Classification issues and detailed growth accounting results

In contrast to the ICT-sector, there exists no common definition of ICT-intensive industries or other industries. This study uses three indicators to divide the non ICT-producing market sector into the ICT-intensive industries respectively non-ICT intensive industries:

- ICT-capital as % of total capital
- ICT-capital as % of real value added
- ICT-capital per worker

The first indicator is probably the most significant one because this indicator measures the importance of ICT-capital as percentage of the total use of the factor capital in the production process. Another implicitly argument was that the size of both types of industries should not differ too much. Table C.1 shows the outcome of these classification criteria. Having said this, the classification is to some extent arbitrary. For instance, chemicals is a doubtful case. In this report, it is classified as a 'other industry' since the ratio ICT-capital total capital is relatively low in 1995. Moreover, for example, growth rates of investment in ICT of chemicals were lower than that of metals.

Table C.1 Composition of ICT-intensive and other industries

Industry	ICT-intensive	ICT-capital/total capital		ICT-capital/value added		ICT-capital per hour worked	
		1990	1995	1990	1995	1990	1995
		% share				x 1000	
Agriculture	no	0.1	0.2	0.2	0.5	0.1	0.3
Food	no	0.5	1.0	1.5	2.9	1.0	2.4
Textile	no	0.7	1.2	1.4	3.3	0.6	1.5
Wood	no	0.5	1.2	1.0	2.7	0.4	1.0
Paper	yes	1.2	2.6	2.4	6.3	1.3	3.9
Chemicals	no	1.0	1.4	3.2	4.2	2.7	4.7
Metal excl. electronic equipment	yes	0.8	1.7	2.1	4.2	1.0	2.1
Oil	no	0.5	0.8	3.6	5.3	6.6	11.7
Electricity	no	0.1	0.3	0.8	3.3	1.0	4.9
Construction	no	0.7	2.0	0.7	2.3	0.3	0.9
Wholesale and retail	yes	1.5	2.5	2.8	4.9	1.3	2.3
Transport	no	0.1	0.4	0.6	2.1	0.3	1.4
Finance	yes	3.2	5.6	10.7	21.8	7.5	15.1
Other service excl computer serv.	yes	1.7	3.7	1.8	5.1	0.7	1.9
ICT-intensive industries		1.8	3.3	3.4	6.9	1.6	3.2
Other industries		0.3	0.7	1.2	2.6	0.6	1.5

Table C.2 Shares of industries in Dutch market sector, 1995 and 2000

Industry	Value added (prices 1990)		Hours worked	
	1995	2000	1995	2000
	% share			
Agriculture	6.8	5.8	5.5	4.8
Food	5.2	4.5	3.2	2.7
Textile	0.7	0.6	0.8	0.6
Wood	3.0	2.7	4.2	3.9
Paper	3.3	3.1	2.7	2.4
Chemicals	5.4	5.1	2.5	2.1
Metal excl. electronic equipment	6.4	6.3	6.1	5.6
Oil	0.7	0.4	0.2	0.1
Electricity	2.8	2.3	0.9	0.7
Construction	7.2	6.6	9.3	9.2
Wholesale and retail	19.8	20.8	21.0	21.2
Transport	8.0	7.9	6.4	6.1
Finance	6.6	6.6	4.9	5.3
Other service excl computer serv.	19.8	20.1	26.5	29.1
Electronic equipment	3.0	2.9	2.3	2.0
Computer services	1.4	2.6	1.2	2.4
Telecommunication	3.0	4.9	1.8	2.0
ICT-sector	7.4	10.3	5.3	6.4
ICT-intensive industries	55.8	56.9	61.8	63.6
Other industries	36.8	32.7	32.9	30.0

Tables C.3 and C.4 present the growth accounting results at the level of industry within Dutch manufacturing and market services for the selected periods.

Table C.3 Decomposition of labour productivity growth Dutch manufacturing industries [a], 1980-2000

	1995	1980-1990	1991-1995	1996-2000
	Share in value added market sector (in %)	annual percentage changes		
Manufacturing	26.9	3.7	3.2	2.7
o.w. TFP		2.7	1.9	2.1
ICT-capital		0.1	0.1	0.1
Other capital		0.9	1.1	0.5
Food and beverages	5.2	4.0	4.3	2.4
o.w. TFP		2.4	2.9	1.5
ICT-capital		0.1	0.1	0.2
Other capital		1.6	1.1	0.8
Chemicals	5.4	4.8	5.5	3.7
o.w. TFP		3.9	3.2	2.6
ICT-capital		0.2	0.1	0.1
Other capital		0.6	2.0	1.0
Metals	9.4	3.2	3.7	2.9
o.w. TFP		2.5	2.6	2.6
ICT-capital		0.1	0.1	0.1
Other capital		0.6	0.9	0.3
Other manufacturing industries	7.0	3.0	0.5	2.5
o.w. TFP		2.2	−0.6	1.7
ICT-capital		0.1	0.2	0.2
Other capital		0.7	0.8	0.6

[a] Volume gross value added per hour worked; contribution of TFP, ICT and other capital is in % -points.

Table C.4 Decomposition of labour productivity growth Dutch market services[a], 1980-2000

	1995	1980-1990	1991-1995	1996-2000
	Share in value added market sector (in %)	annual percentage changes		
Market services	58.6	1.6	0.4	1.8
o.w. TFP		1.0	– 0.3	1.4
ICT-capital		0.2	0.4	0.5
Other capital		0.3	0.4	– 0.1
Wholesale and retail trade	19.8	2.6	0.1	3.0
o.w. TFP		1.8	– 0.6	2.3
ICT-capital		0.2	0.2	0.3
Other capital		0.6	0.5	0.4
Transport	8.0	2.3	3.5	2.4
o.w. TFP		1.7	2.9	2.4
ICT-capital		0.0	0.1	0.1
Other capital		0.6	0.5	– 0.1
Telecommunication	3.0	3.3	3.3	9.5
o.w. TFP		1.1	0.3	8.0
ICT-capital		1.7	2.8	1.9
Other capital		0.4	0.2	– 0.4
Finance and insurance	6.6	0.7	– 0.3	0.0
o.w. TFP		0.1	– 1.9	– 0.1
ICT-capital		0.5	0.6	0.5
Other capital		0.1	0.9	– 0.4
Other market services	21.1	0.4	0.0	0.5
o.w. TFP		– 0.1	– 1.1	– 0.1
ICT-capital		0.1	0.3	0.2
Other capital		0.4	0.8	0.4

[a] Volume gross value added per hour worked; contribution of TFP, ICT and other capital is in % -points.

Appendix D Econometric tests on productivity effects of ICT-related sectors

This appendix econometrically tests whether the productivity improvements in the Dutch market sector in the late 1990s are related to ICT-intensive industries. For the purpose here, we follow one of the approaches of Stiroh (2001): the difference in difference estimator applied on the period 1991-2000. First, we look at the labour productivity performance. After that, we concentrate on the TFP-developments.

The difference in difference-method uses a number of dummies to gauge the effect of ICT on an aggregated level:

$$d\ln y - d\ln l = \alpha + \beta T + \gamma C + \delta T{*}C + \varepsilon_{i,t}$$

Where T is a time dummy, this dummy equals 1 if t>1995 and 0 otherwise, C is equal to 1 if it is an ICT-intensive industry and 0 otherwise. The parameters can be interpreted as follows: α is the annual (unweighted) growth rate for other industries in the period before 1995; β represents the acceleration for non-ICT-intensive industries; $\alpha + \gamma$ is the mean growth rate for ICT-intensive industries before 1995; δ is the acceleration of the ICT-intensive industries relative to others after 1995; $\beta + \delta$ is the pickup of productivity in ICT-intensive industries.

Likewise, we run regressions on TFP:

$$TFP = \alpha + \beta T + \gamma C + \delta T{*}C + \varepsilon_{i,t}$$

Table D.1 Results of difference in difference estimates, 1991-2000

	Labour productivity		TFP	
	including ICT-sector	excluding ICT-sector	including ICT-sector	excluding ICT-sector
Constant	2.480	2.480	1.314	1.314
	(3.3)	(3.3)	(2.0)	(2.0)
Time dummy (= T)	– 0.236	– 0.236	– 0.492	– 0.492
	(– 0.2)	(– 0.2)	(–0.4)	(– 0.4)
ICT dummy (=C)	– 0.790	– 1.538	– 1.331	– 1.587
	(– 0.8)	(– 1.6)	(– 1.5)	(– 1.8)
Time dummy & ICT dummy	1.500	1.101	2.554	2.019
(=T*C)	(0.9)	(0.7)	(1.6)	(1.3)
R^2	0.01	0.01	0.02	0.01
Number of observations	170	140	170	140

T-statistics are in parentheses.

Table D.1 reports the ordinary least squares estimates for labour productivity and TFP as well. It presents four regression results. For each productivity indicator, we either included or excluded the ICT-sector in the selected period.

The coefficient for the time dummy is negative, suggesting that productivity growth in the other industries did not accelerate after 1995. The coefficient for the ICT dummy is also negative. The latter result confirms that labour productivity growth was less fast in ICT-intensive industries than it was in non-ICT intensive industries in the first half of the 1990s. Finally, the combined dummies, i.e. ICT-dummy and time dummy, show that productivity picked up in ICT-intensive industries after 1995.

The results for the regression on TFP are to a great extent comparable to the results for labour productivity growth. So, the acceleration in TFP-growth might be related to developments in ICT-intensive industries as well.

These regression analyses provide only preliminary indications of the role of ICT on both labour productivity growth and TFP growth. ICT mattered for productivity growth. To some extent, the developments in ICT-related industries affect the acceleration in labour productivity growth and TFP-growth in the late 1990s. Nevertheless, the regressions results are not robust in the sense that most of the estimated coefficients appear insignificant.

Appendix E Is ICT a special type of capital?

The main issue to be addressed in this appendix is whether ICT is a special type of capital. In the neoclassical theory, the use of ICT only contributes to labour productivity growth, but not to TFP growth of the ICT-using industries.[67] However, if ICT is special than a link between ICT-capital and TFP growth should be there.[68] Then, the use of ICT creates productivity gains beyond the direct contribution of capital deepening due to spill-over effects and network effects. To test both positions, we run two simple econometric tests. Starting from a Cobb-Douglas production function, we get a standard form for a production function regression:

$$\ln y_{i,t} = \beta_o \ln k_{o,i,t} + \beta_c \ln k_{c,i,t} + \beta_l \ln l_{i,t} + a(t) + \mu_i + \epsilon_{i,t}$$

Where a(t) is a common productivity growth path for each industry, K_o and k_c are other capital respectively ICT-capital, l is labour input (i.e. total hours worked), μ_i are a set of industry specific effects, and $\epsilon_{i,t}$ are serially uncorrelated random errors for each industry.
Using first differences, industry specific effects are removed:

$$d\ln y_{i,t} = \beta_o d\ln k_{o,i,t} + \beta_c d\ln k_{c,i,t} + \beta_l d\ln l_{i,t} + \gamma_t + \nu_{i,t}$$

Where γ_t are year dummy variables[69] and ν is the differenced variable of the error term.
This equation tests the question whether the neoclassical assumption of constant returns to scale can be rejected, i.e. the sum of coefficients (=$\beta o + \beta c + \beta l$) is not equal to one. The next equation is a more direct way to test the link between ICT-capital and TFP.

$$d\ln tfp_{i,t} = \beta_o d\ln k_{o,i,t} + \beta_c d\ln k_{c,i,t} + \beta_l d\ln l_{i,t} + \gamma_t + \nu_{i,t}$$

Here, we apply the Ordinary Least Square (OLS) regression method. OLS assumes that productivity is uncorrelated with input choices across industries and time. However, to the

[67] In appendix D, we already used one method to test the possibility of spill-over effects of ICT-industries on the overall productivity growth. Although a relation seems to exist, the results were not significant.

[68] In that case, the income share of ICT-capital is not equal to the output elasticity of ICT-capital anymore. Then, it can be proven that the following relation exists between ICT-capital and TFP: $d \ln TFP = d \ln A + \delta \, d\ln Kc$; where A is disembodied technological change and δ is the sum of output elasticity and the spill-over effect.

[69] Fixed time effects are usually implemented by including a time dummy for each period, omitting one dummy for an arbitrarily chosen base period.

extent that differences in efficiency are known to industries when they choose their inputs, the classic simultaneity problem will bias the estimated production function parameters.[70] More sophisticated regression methods probably produce better estimates of the coefficients than OLS but they probably do no alter the sign of the coefficients.

The table shows the results of both equations on output and TFP. Additionally, it distinguishes two variants: A and B. B includes an additional ICT industry dummy. Strikingly, the ICT-capital coefficient is negative in all situations. This result would mean that an investment in ICT is unproductive. Stiroh (2001b) also finds a negative ICT-coefficient for the US manufacturing industries, and in particular, he finds negative coefficients for ICT-software and telecommunication equipment. The coefficient of labour input roughly corresponds with the income labour share. The sum of all input coefficients is equal to approximately 0.9, just near the neoclassical assumption of constant return to scale. However, if an ICT industry dummy is added to the regressions, the results run off further from the assumption of constant return to scale.

Table E.1 Results of production function and TFP regressions, 1985-2000

	Output		TFP	
	A	B	A	B
ICT capital	– 0.02	– 0.01	– 0.02	– 0.02
	(– 1.0)	(– 0.9)	(– 1.4)	(– 1.2)
Other capital	0.47	0.39	0.01	0.01
	(3.3)	(2.2)	(0.6)	(0.0)
labour	0.43	0.44	– 0.20	– 0.19
	(3.6)	(3.6)	(– 1.7)	(– 1.6)
ICT industry dummy		1.17		1.15
		(1.3)		(1.3)
Intercept	2.42	2.37	2.49	2.43
	(2.6)	(2.5)	(2.5)	(2.5)
R^2	0.37	0.38	0.15	0.15
Number of observations	272	272	272	272

A= pooled cross-section; B also includes an ICT industry dummy which is 1 if the industry is ICT-intensive; t-statistics are in parentheses.

As for the TFP-regressions, they can conclude that the coefficient of ICT-capital is again negative, but not significant. Moreover, a positive link between other capital and TFP-growth seems absent too.

[70] Therefore, in further research, an instrumental variable (IV) approach could be considered assuming that productivity and input choices are correlated.

The regression results suggest that neither a clear link between ICT-capital and labour productivity growth nor a link between ICT-capital and TFP-growth exist. The latter are in line with the neoclassical view that TFP-growth is exogenous. However, this tentative conclusion must be accompanied with some critical remarks. TFP growth is a catch-all term. It covers the effect of (disembodied) technological progress, but also the effect of organisational changes, new products and measurement errors. So, TFP growth may also come from developments in the economy that might be independent of ICT.

Various studies at the firm level showed that the effect of ICT on productivity is enhanced when organisational changes have accompanied ICT investments, such as new strategies, new organisational structures or a larger proportion of high-skilled staff. These studies confirm the complementarity between ICT investments and organisational changes.[71]

ICT has all the characteristics of a general purpose technology. As a general purpose technology, ICT can prevent a slowing of productivity growth over the long term, then a stable growth rate could still point to the influence of ICT.[72] Although the selected period encloses more than one business cycle and also the emergence of the use of internet, the effect of ICT-use on both labour and TFP-growth might still be masked and will pop up later. In fact, the literature on the introduction of general purpose technologies suggests that a considerable time-lag between the introduction of new technologies and positive impacts on productivity could exist.

Additionally, measurement problems could bias the aforementioned results. Both output and input measurement problems could have affected the results. For instance, if the growth of ICT-capital is understated, TFP growth will be overstated (see box measurement problems in ICT-capital in section 4). Conversely, if output growth is understated than TFP growth is also understated.

[71] See Black , S.E. and L.M. Lynch, 2000, What's driving the New Economy? The benefits of workplace innovation, National Bureau of Economic Research, Working Paper No. 6210. Brynjolfsson, E. and L.M. Hitt, 2000, Beyond computation: Information technology, organizational transformation and business performance, Journal of Economic Perspectives 14, pp. 23-48.

[72] See Gelauff et al, 2000.

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Abstract

From an historical and international perspective, Dutch labour productivity growth rates have been lacklustre. Using a growth accounting framework, this document analyses whether ICT has recently boosted Dutch labour productivity growth, similar to developments in the US.

Labour productivity growth in the Dutch market sector slightly accelerated in the second half of the 1990s. The acceleration seems to be related to the production and use of ICT. The productivity performance of the Dutch ICT sector accounts for a large share in the rebound of labour productivity growth. Strong productivity growth in the ICT sector is partly due to increased efficiency in the production of ICT products, particularly ICT-services. Users of ICT benefit from its opportunities as well. Labour productivity growth rates markedly accelerated in ICT-intensive industries in the late 1990s.

The effect of ICT on Dutch labour productivity growth is not lower than that witnessed in other OECD countries (except for the US). Nevertheless, Dutch labour productivity grew slower than productivity in most other OECD countries because of lagging productivity growth rates, particularly in the services sector.

Due to slower growth rates of labour supply, Dutch labour productivity growth must increase in upcoming years in order to prevent a substantial decline in GDP growth. Labour productivity growth may be boosted by larger investments in and better use of ICT. The role of the government is mainly to facilitate the diffusion of ICT and other innovations across the economy, because these are the engines of economic growth. Based on studies for the US, one of the most efficient policy options seems to be creating a more competitive environment, which will cause firms to increase efficiency and to explore new ways of doing business.