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## German Productivity - A Reassessment via the New Ifo Productivity Database

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# **ifo** Working Papers

## German Productivity A Reassessment via the New Ifo Productivity Database

Andreas Kuhlmann

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## German Productivity A Reassessment via the New Ifo Productivity Database

### Abstract

A detailed analysis of the German productivity development is indispensable for understanding, why Europe is lagging behind the US growth since the mid 1990s. In this paper a new and unique database is used to analyze the sources of German productivity growth since 1970. It is shown that investment in information and communication technology (ICT) played a minor role in the German productivity development. The results include detailed descriptive statistics and projections for output and labor productivity growth for the coming decade. The base-case projection puts overall trend output growth at 1.53 percent per year over the next decade. Average labor productivity will grow at an annual rate of 1.59 percent.

JEL Code: O47, F43, R11.

Keywords: Growth accounting, productivity analysis, TFP.

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## 1 Introduction

One of the most puzzling economic developments in the late 1990s is the acceleration of US economic growth (associated with very low inflation rates), paralleled with economic stagnation or growth decline in Europe. The following debate on the sustainability of this outstanding economic US-performance generated a strong demand for detailed productivity studies - not only for the US, but also for Europe and other OECD countries. Meanwhile there is a broad consensus that information technology (IT) is the key to understand the American growth “resurgence”<sup>1</sup> and several studies have compared the American case with European and other OECD countries.<sup>2</sup> Since the mid 1990s the average growth rates of real GDP, labor productivity and total factor productivity in the European Union have fallen behind those in the United States. This is remarkable as for the EU these performance measures have (since World War II) never shown lower growth rates for several years in a row. But the EU is anything but homogeneous in this respect. The variation in productivity performance across countries is quite substantial – in levels as well as in growth rates. According to O’Mahony and van Arc (2003) about 75% of the total EU slowdown in the second half of the 1990s was due to the German and Italian growth weakness, most notably the German one (even if the German *level* of productivity is similar to the one of the US). The aim of this paper is to analyze the German growth-weakness, as it is an essential cause of the European “dragging behind”. The major value added of this study is the quality and detail of a new and unique dataset, which is used for the current growth accounting study.

The quality of growth accounting studies depends in particular on the quality of the growth accounting database, which in turn determines the employed computational method. Existing studies on EU and OECD countries, like O’Mahony, van Arc (2003), Colecchia, Schreyer (2002), and Daveri (2000, 2002, and 2004), also analyze amongst others the German economy, but the data sources they use differ in quality and detail and are in most cases not appropriate for a deeper analysis. While Daveri (2002) refers to a private consortium of several industry associations as its

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<sup>1</sup> See for example Oliner, Sichel (2000, 2002), Jorgenson (2001), Jorgenson, Stiroh (2000), and Jorgenson, Ho, and Stiroh (2003, 2004)

<sup>2</sup> While Colecchia and Schreyer (2002) analyzed nine OECD countries (including the EU-countries Finland, France, Germany, Italy, and the UK), Daveri (2000, 2002, and 2004) focused the whole analysis on Europe.

main data source<sup>3</sup>, Colecchia and Schreier use data from the respective national statistical offices. This implies for a number of countries (like Germany, Italy, or the United Kingdom) that the available asset-data are only available at the aggregate level and represent the owner instead of the economic usage structure of capital allocation. The first study to provide insights into sector specific particularities for the whole EU-15 is O'Mahony and van Ark (2003). The richness of this dataset, which is provided by the Groningen Growth and Development Centre (GGDC)<sup>4</sup>, comes at the price that growth accounting analyzes can only be pursued via the value-added- and not via the gross-output-concept (due to the lack of appropriate data on intermediate input). This can be problematic for industry-level productivity analyzes.<sup>5</sup> This dataset reflects, as well as the data in the other studies cited above, a capital allocation according to the owner concept. Furthermore some of the data had to be extrapolated with average values of other European countries. For the calculation of the German aggregate communication-equipment-investment GGDC resorts to data of the Ifo-Institute. This source, which is the *Ifo Investorenrechnung*, is now used to compute industry-level, asset specific capital stocks and capital services on the basis of the economic-usage-concept, building the newly constructed Ifo Productivity Database..

The aim of this paper is to use the richness of the new data source for a documentation of productivity trends over a long time period in order to establish employment trends and to identify driving and retarding factors of productivity growth in Germany. This will serve as a basis for further sector-specific studies, where the total economic development serves as a benchmark.<sup>6</sup> The main advantage of the recently collected and computed capital stocks and capital services data is that they contain the information according to the economic-usage- (and owner-) concept. The usage-concept is – in contrast to official statistics (where the owner concept is applied) – better suited for productivity research, as it allows a detailed analysis of the industry-level capital allocation. Many investment projects are financed via leasing and other forms of rental arrangements. As a consequence the investments are often used in different sectors than in the one

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<sup>3</sup> The World Information Technology and Services Alliance (WITSA)

<sup>4</sup> See [www.ggdc.net](http://www.ggdc.net).

<sup>5</sup> See Kuhlmann (2006) for a discussion of the properties of the respective concepts.

<sup>6</sup> The productivity development of the total economy, for instance, is a prerequisite for the determination of a sector specific X-factor, as it is used in sector specific incentive regulation of network industries. See Kuhlmann (2006) for an application in the Electricity Industry.

of the owner. The owner concept, in contrast, is better suited for an analysis of the distribution of wealth, which is not relevant for productivity analyses.

Another advantage follows from the, bottom-up approach for the calculation of capital services flows for the German economy. The top-down approach computes or takes the capital stocks and capital services flows data from the national statistical agency and allocates the industry-level shares by several assumptions. The bottom-up approach, in contrast, computes first the industry-level capital stocks and capital services flows and aggregates them subsequently in order to derive the total-economy capital stock data. This procedure allows a more accurate calculation of the capital contribution to aggregate growth.

The richness of this dataset allows it to pursue a detailed growth-analysis for the German economy in a similar as way Jorgenson et al. (2003) did for the US. This implies a quantification of the role of information technology (IT), which shows to be still of minor importance in comparison to the US. Beside the analysis of the historical data there is a second main focus of this paper, namely growth and productivity projections for the next decade.

The next section will describe the Growth Accounting framework that is used here. Subsequently the data sources are presented and described. Section 4 analyzes the historical data from 1970-2003, while in section 5 projections for the coming decade are presented. Section 6 concludes.

## **2 Framework**

Growth accounting involves breaking down growth of GDP into the contributions of labor input, capital input and total-factor productivity. The growth accounting model is based on the microeconomic theory of production and rests on a number of assumptions, among which the following are important: the production technology can be represented by a production function relating total GDP to the primary inputs labor  $L$  and capital services  $K$ ; this production function exhibits constant returns to scale; and product and factor markets are characterized by perfect competition.

For any desired level of output, the firm minimizes costs of inputs, subject to the production technology shown above. Factor input markets are competitive, so that the firm takes factor prices as given and adjusts quantities of factor inputs to minimize costs. The output-growth-rate equals then a weighted average of the growth-rates of the various inputs plus the total or multi-factor

productivity growth. The weights attached to each input are the output elasticities for each factor of production. Output elasticities cannot be directly observed, however, under the assumption of constant returns to scale the factor shares of labor and capital can be used as weights (See Footnote 8).

The methodology used here is based on the *production possibility frontier* concept introduced by Jorgenson (1966) and going back to Solow (1957). This concept captures substitutions among inputs of capital and labor, whereas capital is subdivided in IT-capital (IT standing for *information technology*) and non-IT capital. Jorgenson, Stiroh (2000), and Jorgenson, Ho, and Stiroh (2003) have used this methodology to measure the contributions of information technology to U.S. economic growth and the growth of labor productivity. I will proceed in the same way. Additionally I subdivide the non-IT capital into “construction and buildings” and “other capital”. This seems to be a useful breakdown due to the high relevance (or relative importance) of investment in buildings.

Within the concept of a production possibility frontier output can be decomposed into investment and consumption goods, while inputs consist of capital services ( $K$ ) and labor input ( $L$ ), but in the further analysis I will refrain from decomposing output and focus on the decomposition of input factors. Capital services can be decomposed into the capital service flows from information and communication technology<sup>7</sup> - which is computer hardware ( $K_c$ ), software ( $K_s$ ), and communications equipment ( $K_m$ ) - , buildings ( $K_b$ ) and other capital services ( $K_o$ ). The input function ( $X$ ) is augmented by *total factor productivity* ( $A$ ). The production possibility frontier can then be represented as:

$$(1) \quad Y = A \cdot X(K_m, K_c, K_s, K_b, K_o, L)$$

Under the standard assumptions of competitive product and factor markets, and constant returns to scale, Equation (1) can be transformed into an equation that accounts for the sources of economic growth:

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<sup>7</sup> The data on ICT technology are limited for the period 1970-1990. The former classification system did only cover asset specific data on office equipment, but not explicitly communications equipment and software. These detailed data are yet available since 1991.



$$(2) \Delta \ln Y = \bar{v}_{K_m} \Delta \ln K_m + \bar{v}_{K_c} \Delta \ln K_c + \bar{v}_{K_s} \Delta \ln K_s + \bar{v}_{K_b} \Delta \ln K_b + \bar{v}_{K_o} \Delta \ln K_o + \bar{v}_L \Delta \ln L + \Delta \ln A$$

where  $\bar{v}$  denotes the average input shares. Under the assumption of constant returns to scale they are equal to value shares and add up to one:  $\bar{v}_{K_m} + \bar{v}_{K_c} + \bar{v}_{K_s} + \bar{v}_{K_b} + \bar{v}_{K_o} + \bar{v}_L = 1$ . I refer to the share weighted growth rates in Equation (2) as the *contributions* of the inputs.<sup>8</sup> Total factor productivity (TFP) –  $\Delta \ln A$  – is then calculated as a residual.

*Average labor productivity* (ALP) is defined according to Jorgenson (2003) as the ratio of output to hours worked, such that  $ALP = y = Y/H$ , where the lower-case variable ( $y$ ) denotes output ( $Y$ ) per hour ( $H$ ). Thus equation (2) can be rewritten in per hour terms as:

$$(3) \Delta \ln y = \bar{v}_{K_{ICT}} \Delta \ln k_{ICT} + \bar{v}_{K_b} \Delta \ln k_b + \bar{v}_{K_o} \Delta \ln k_o + \bar{v}_L (\Delta \ln L - \Delta \ln H) + \Delta \ln A$$

where  $\bar{v}_{K_{ICT}} = \bar{v}_{K_c} + \bar{v}_{K_s} + \bar{v}_{K_m}$ . Equation (3) decomposes ALP growth among three components. The first is *capital deepening*, defined as the contribution of capital services per hour and allocated between IT and non-IT components. The interpretation of capital deepening is that increases in capital per worker enhance labor productivity in proportion to the capital share. The second component is *labor quality improvement*, defined as the contribution of increases in labor input per hour worked. This reflects changes in the composition of the work force and raises labor productivity in proportion to the labor share. The third component is *total factor productivity* (TFP) growth, which raises ALP growth point for point.

The above component for labor quality in equation (3) depicts the variation of labor quality ( $\Delta \ln LQ = \Delta \ln L - \Delta \ln H$ ). In the same way capital quality can be described as the ratio of capital services to capital stock or in differences:  $\Delta \ln KQ = \Delta \ln K - \Delta \ln Z$ . With these definitions one can decompose the contributions of capital and labor inputs in a way that reflects the contributions of capital quality and capital stock, as well as labor quality and hours worked:

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<sup>8</sup> The assumption of constant returns to scale is necessary to ensure that the equation of output to total factor income is consistent with equality between factor prices and marginal products. The perfect competition assumption is necessary for getting a value for the social marginal products of labor and capital, which are in this case equal to the rental price of capital and the wage rate. The perfect competition assumption could be dispensed in a growth regression, but this solution has too many other drawbacks and therefore the usual approach to TFP estimation is the non-econometric one. See Barro (1998) p5 for a discussion of these drawbacks.

$$(4) \quad \Delta \ln Y = \bar{v}_K \Delta \ln Z + \bar{v}_K \Delta \ln KQ + \bar{v}_L \Delta \ln H + \bar{v}_L \Delta \ln LQ + \Delta \ln A$$

This equation will be used for productivity projections, following in chapter 5.

## 2.1 The Gross Output and the Value Added Concept

For an international comparison of productivity and growth determinants the value added concept (as it is used above in equation (30), where only capital and labor are used as production inputs and no intermediates) is the appropriate method. Value added can be derived with relatively low data requirements and avoids double counts of intermediate products, which is important at the aggregate level. For the total economy analysis of the current paper the value added approach is therefore the predominant concept.

However, if industry-level data are analyzed and related to aggregate data, the value added concept gives a biased picture of industry-level TFP – in particular when intermediates play an important role. In the real world there is no analog to value added that is actually produced by a plant. In order to allow TFP comparisons with specific sectors, the aggregate gross-output-based-TFP-measure is declared separately.<sup>9</sup> In this case the total economy TFP is not computed as a residual, but as a weighted sum of industry-level TFP-values. The respective weights are calculated according to the Domar approach of TFP aggregation (see Domar (1961)). The Domar weight of an industry is defined as the industry's gross output divided by aggregate value added. In general, these weights sum to more than one.

## 3 Data

### 3.1 Capital Stocks

Capital stocks data stem from Ifo Capital Stock and Investment Database (Ifo Investorenrechnung), which provides industry- and asset-specific capital stocks data for 1970 until 1990 for West Germany. From 1991 onwards, industry- and asset-specific capital stocks are

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<sup>9</sup> The gross output (GO) and the value added (VA) productivity measure are always different, but also related to each other: the rate of change of VA-based-TFP equals the rate of change of GO-based-TFP multiplied by the inverse of the nominal share of VA in GO. See OECD (2001)

calculated according to the perpetual inventory method using investment data from the same data source:

$$(5) \quad S_{i,j,t} = S_{i,j,t-1} (1 - \delta_{i,j}) + I_{i,j,t}$$

$S_{i,j,t}$  is hereby the capital stock in industry  $i$  of the investment asset  $j$  in period  $t$ .  $I_{i,j,t}$  is the corresponding investment in industry  $i$  of investment asset  $j$  in period  $t$  and  $\delta_{i,j}$  is the industry and asset specific depreciation rate. These data can be found in the Ifo Productivity Database<sup>10</sup>.

### 3.2 Capital Services

For the capital services calculations, the Ifo Productivity Database parallels the method in Jorgenson and Stiroh (2000). Capital services  $K_{i,j,t}$  of asset  $j$  in industry  $i$  during period  $t$  are assumed to be proportional to the average capital stock  $S_{i,j,t}$  used in one sector with  $q_{i,j}$  denoting a constant of proportionality. The capital services are therefore proportional to the average capital stock, where the constant of proportionality  $q_i$  is set equal to unity.

$$(6) \quad K_{i,t} = q_i \frac{(S_{i,t} + S_{i,t-1})}{2}$$

The price of capital services (the costs of capital), which is necessary for the computation of the value share of capital services, is computed via a rental price formula, which is based on an arbitrage condition for capital services. It is assumed that an investor is indifferent whether he invests at the capital market and earns a nominal interest  $i_t$  for his investment or whether he invests in an asset of price  $P$  and earns a rental fee  $c_{i,j,t}$  less the depreciation  $\delta_{i,j}$  of the asset.

$$(7) \quad (1 + i_t) P_{i,t-1} = c_{i,j,t} + (1 - \delta_{i,j}) P_{i,t}$$

Rearranging the arbitrage condition yields the familiar cost of capital equation:

$$(8) \quad c_{i,t} = (i_t - \pi_{i,t}) P_{i,t} + \delta_i P_{i,t+1}$$

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<sup>10</sup> This database is currently restricted for internal use, but will be accessible for external researchers in 2006. The Ifo Investorenrechnung database is already accessible. For a detailed methodological documentation (in German) of the second see Gerstenberger et al. (1989)

where the industry and asset-specific capital gains  $\pi_{i,j,t}$  in period  $t$  are given by the percentage change of the asset prices in industry  $i$  during period  $t$ :  $\pi_{i,t} = (P_{i,t} - P_{i,t-1}) / P_{i,t-1}$

Equation (8) states that the costs of capital equal the difference between the nominal interest rate and the capital gains of the asset weighted by the industry- and asset-specific price deflator plus the asset and industry-specific depreciation of the asset weighted by the same price deflator. The cost of capital data that are computed via such industry- and asset specific price deflators and depreciation rates are more reliable compared to only asset-specific data which are usually taken for growth accounting exercises (as in O'Mahony and van Ark (2003) and Jorgenson, Ho, Stiroh (2003)). The use of this method was only possible due to the availability of the Ifo Investorenrechnung Database which is according to our knowledge the only database offering such high quality data on the industry-level for Germany.

For a detailed description of the computation methods and data sources concerning the investment data, see Fuchs and Kuhlmann (2005).

### **3.3 Output, intermediate and labor input, demography**

The data on output ( $Y$ ), intermediate input ( $M$ ), and the wage sum ( $WS$ ) originate from the German Statistical Office (GSA) or are derived from GSA-data. For the period 1970-1990 Fachserie 18 (FS18) or the DEStatis archive (DEStatis) is used. For 1991-2003 I mainly resort to the Genesis time series database (Gen).<sup>11</sup>

Output (value added and gross output) stems from Gen 81000BJ321 (for 1991-2003), and from GSO FS 18 segment 1496 (for 1970-1990).

*Intermediate input* at the industry-level is calculated for the early period via input-output-tables, using industry-level price-deflators (GSO, former time series service TSno.1428, or DEStatis 7849xxx 7846xxx) and subsequently adjusted to the stated value of the main sectors from DEStatis 78490xx, which is also the basis of the aggregate data. For the later period Gen 81000BJ321 is used. Here, for several subsectors, no price index is available. In such cases the

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<sup>11</sup> See <http://www.destatis.de/genesis> for the major time series for output and labor input as described above.

respective nominal values of the subsectors are deflated with the price index of the superordinate sector.

For the period 1970-1990 the basic data for the *wage sum* (WS) stem from the GSO FS 18 segment 2279 and are price adjusted with the GDP-deflator. These data cover only employed workers and exclude the self-employed. In order to correct for this the deflated values are multiplied with the yearly, industry-level ratio of all workers to the employees. For the period 1991-2003 Gen 81000BJ323 is used.

*Total hours worked* (H) for the period 1970-1990 are estimated via average weekly working hours per worker (in Western-Germany) for the years 1995-2002 (DEStatis 4049xxx), prolonged backwards via index time series for average working hours (DEStatis 4043xxx) and adjusted to a yearly basis. For some industries the index time series were fragmentary – in these cases the index of the superordinate category or a weighted sum of similar categories were used. Afterwards these yearly-per-person-working-hours were multiplied by the number of employees in order to get total hours worked. Finally these total hours were scaled to the designated total hours of the respective superordinate class (according to GSO FS18, S.21). The data for the period 1991-2003 stem from Gen 81000BJ323. Also in this period the data are not available for every subsector. In these cases the ratio of employees in the specific subsector to employees in the superordinate class is used to estimate hours worked in the subcategory.

For demographic trends in Germany of the years 2002-2050 see Statistisches Bundesamt (2003).

Labor quality data stem from the “Industry Growth Accounting Database – Germany” of the Groningen Growth and Development Center (GGDC).

#### **4 Assessment of the historical data**

In this section the historical data from 1970 to 2003 are analyzed to identify drivers and barriers of German economic growth. For this analysis I will focus on the sources of total economic (GDP) growth and on those of average labor productivity growth (GDP per hour worked). This partition basically reflects the main equations (2) and (3).

#### 4.1 Sources of Growth in GDP

Table 1 as well as Figure 1 report the sources of economic growth following equation (2). For the period 1971-1990, output grew 2.55 percent per year, where capital input contributed 42.4 percent of this growth or 1.08 percentage points. Labor input variation contributed not at all to this growth. The moderate average growth contribution of 0.3 percentage points in the 1980s is totally outweighed by a negative contribution in the 1970s of the same amount. This development is mainly due to significant reductions in total hours worked. The almost permanent negative influence of hours worked on labor input in the period 1970-1990 can only be offset by a constant moderate growth in labor quality. The major part of total growth (for this period) remains unexplained by input growth and is therefore captured by growth in TFP.

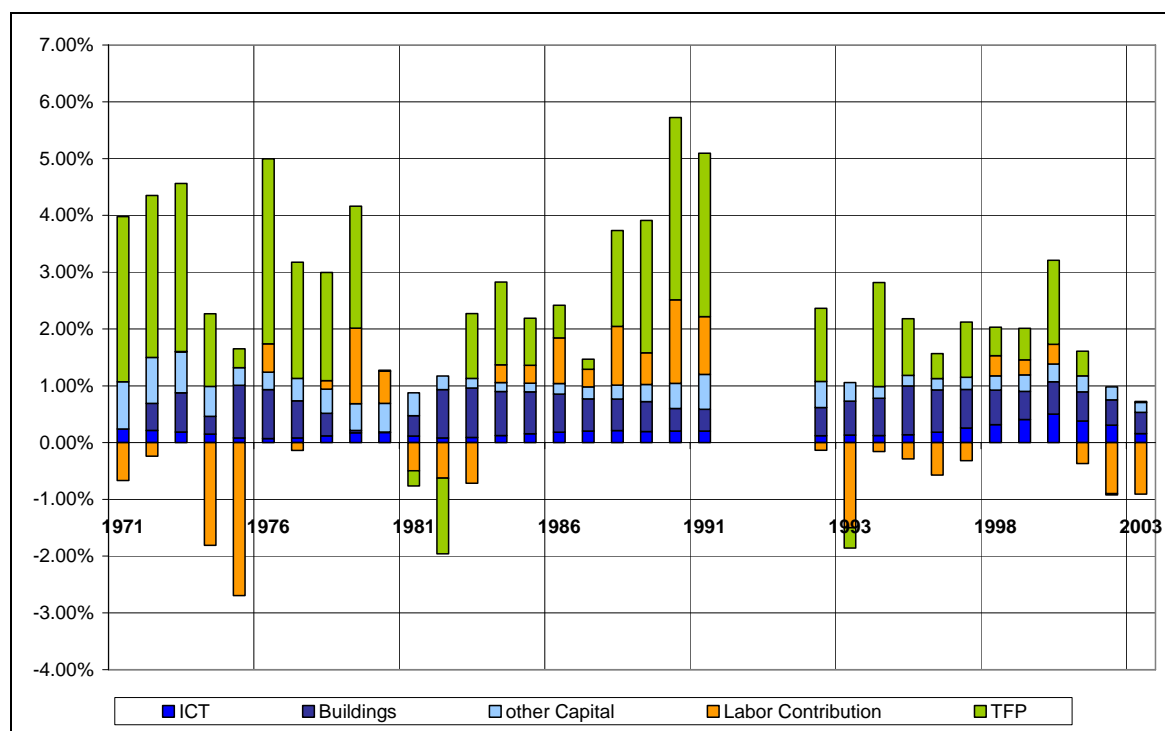
The later period from 1991-2003 comprises the extended geographical region of unified Germany. The burden of the German reunification with all the related restructuring measures is certainly one out of several reasons for the sluggish German growth performance since the beginning of the 1990s. The growing unemployment-problem is visible in the data – in particular in 1993, where the decline in total hours worked explains almost the whole gap between negative economic growth and the positive growth contribution of capital (TFP for this year is close to zero).

**Table 1 Growth in GDP and the Sources of Growth - 1971-2003**

Sources of Growth	1971-1980	1981-1990	1971-1990	1992-1997	1998-2003	1992-2003	92-03 less 71-90
Growth in GDP ( <b>Y</b> )	2.79	2.32	2.55	1.46	1.39	1.43	-1.12
Contribution of Capital ( <b>K</b> )	1.12	1.04	1.08	1.10	1.10	1.10	0.02
Other	0.83	0.26	0.40	0.27	0.26	0.26	-0.14
Total IT-contribution	0.15	0.15	0.15	0.16	0.34	0.25	0.10
Computer	0.15	0.15	0.15	0.08	0.23	0.15	0.00
Software				0.04	0.08	0.06	
Communications				0.04	0.04	0.04	
Buildings ( <b>B</b> )	0.44	0.63	0.53	0.67	0.50	0.59	0.06
Contribution of Labor ( <b>L</b> )	-0.30	0.30	0.00	-0.50	-0.20	-0.35	-0.35
TFP (VA-Residual)	1.97	0.98	1.48	0.86	0.49	0.68	-0.80
TFP (GO-Domar-weighted)	1.29	0.85	1.07	0.50	0.65	0.58	-0.49

Source: Author's calculations based on German Statistical Office, Ifo Productivity Database, and GGDC.

**Figure 1 Sources of Growth in Germany 1971-2003**



Source: Author's calculations based on German Statistical Office, Ifo Productivity Database, and GGDC.

The contribution of capital to total growth is over the whole period (1971-2003) more or less constant at about 1.1 percentage points. Quite significant is the increase of ICT contribution beginning in the late 1990s.

#### 4.1.1 The Role of Information and Communication Technologies

The contribution of ICT to productivity can be traced through three transmission channels, namely through investment in ICT (capital deepening), technological change in ICT producing industries leading to TFP growth, and possible spillovers from the use of ICT. The last effect enhances the capabilities of labor primarily through more efficient use, which requires investments in organizational change and human capital.<sup>12</sup> Growth accounting distinguishes only the first two channels, whereas further analysis needs to uncover the third. According to van Arc (2006) the regulatory environment needs to provide sufficient incentives to realize indirect gains. Rigid labor

<sup>12</sup> ICT use may, for example, enable new organizational models and other innovations in the production process, as well as the production of new goods and services. New ICT investment goods make it possible for firms to innovate and accumulate firm-specific capital, yielding additional output gains, which show up as additional total factor productivity growth in ICT using industries. See van Arc (2006).

and product markets set a bad environment for trial and error processes that are important for letting excellent firms grow and failing firms die. The European markets generally exhibit more rigid framework conditions, and this is certainly one reason for the fact that Europe has benefited to a less extent from the “ICT-revolution” in the late 1990s compared to the US.

Overall gains from ICT can be classified as direct (through capital deepening) and indirect (through TFP). According to van Arc (2006) Germany fails on indirect gains, but also the direct gains are below the expectations. German ICT-investment was quite constant during the 1970s and 80s with an average annual contribution of 0.15 percentage points (see Table 1). But, as one might expect, total ICT-contribution became more prominent in the (late) 1990s with an average annual contribution of 0.34 percentage points from 1998-2003. However, the *additional* growth contribution of ICT capital in 1991-2003 compared to the earlier period 1970-1990 is with an average of 0.1 percentage points in comparison to the U.S. of minor importance.<sup>13</sup> According to Jorgenson, Ho, and Stiroh (2003) the additional U.S. growth contribution of ICT capital in 1995-2000 (the booming time of the so called New Economy) was compared to 1973-1995 about 0.56 percentage points and therefore much higher than in Germany or in Europe as a whole.<sup>14</sup> Investments in ICT technology, which played a substantial role in the U.S. productivity revival, therefore seem to have still a non-negligible potential in Germany.

## 4.2 Sources of Growth in Average Labor Productivity

Table 2 and Figure 2 present estimates of the sources of ALP growth from equation (3). For the period 1971-1990 as a whole, growth in ALP of 3.01 percentage points per year accounted for 118% of output growth, due to capital deepening of 1.22 percentage points per year, improvement of labor quality of 0.31 percentage points, and TFP growth of 1.48 percentage points. The decline of hours worked of 0.46 percentage points per year (reflecting demographic trends and the unions

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<sup>13</sup> The reclassification of the asset types, which is implemented since 1991, supports this observation. Software and communications equipment were not explicitly enumerated in the early period, and this suggests that total IT contributions were even higher at the time. The actual increase of IT-contributions is therefore even lower than the computed value of 0.1 percentage points suggests.

<sup>14</sup> A direct comparison for the same period is not feasible, as the German reunification took place within the first time period, which denotes a structural interruption in the data. A comparison of 1998-2003 with 1971-1990 yields an increase in ICT contribution of 0.19 percentage points.



success at that time in cutting working hours without suffering remarkable wage cuts) are the reason that the German economy grew only with an average rate of 2.55 percent in this period.

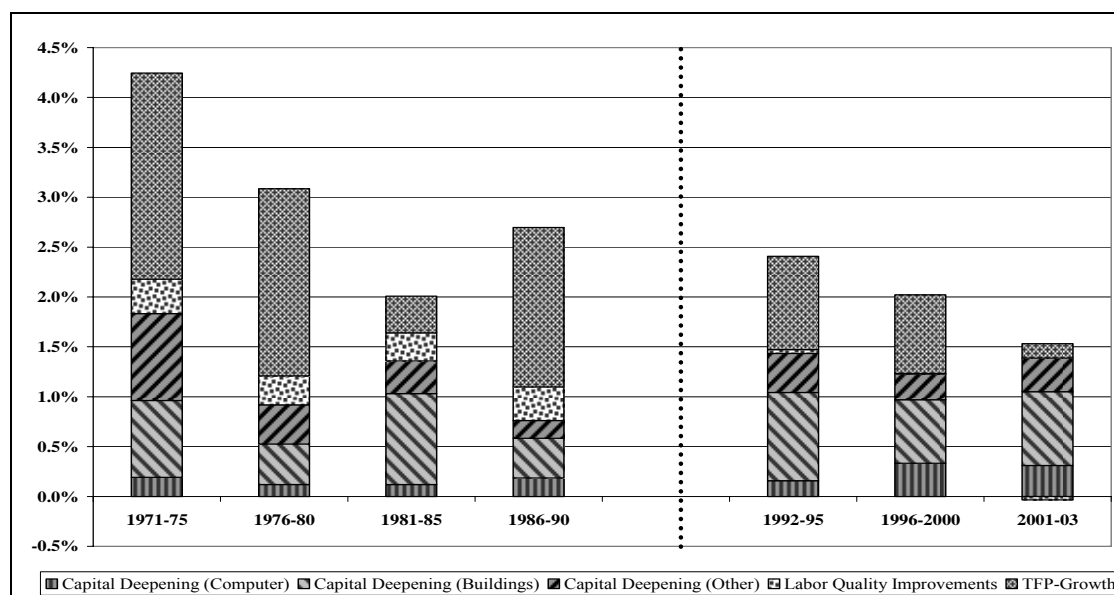
This decline in total hours worked did actually accelerate in the years after the German reunification but slowed down in recent years.

**Table 2 Sources of Growth in Average Labor Productivity - 1971-2003**

Sources of Growth in Average Labor Productivity	1971-1980	1981-1990	1971-1990	1992-1997	1998-2003	1992-2003	92-03 less 71-90
Growth in GDP (Y)	2,79	2,32	2,55	1,46	1,39	1,43	-1,12
Hours Growth (H)	-0,88	-0,04	-0,46	-0,95	-0,23	-0,59	-0,86
ALP-Growth	3,66	2,35	3,01	2,41	1,62	2,02	-0,26
Capital Deepening	1,38	1,06	1,22	1,48	1,19	1,34	0,42
Other Capital Deepening	1,22	0,91	1,07	1,29	0,84	1,07	0,30
IT Capital Deepening	0,16	0,15	0,15	0,19	0,35	0,27	0,12
Labor Quality	0,32	0,31	0,31	0,07	-0,06	0,01	-0,32
Aggregate TFP	1,97	0,98	1,48	0,86	0,49	0,68	-0,36

Source: Author's calculations based on German Statistical Office, Ifo Productivity Database, and GGDC.

**Figure 2 Sources of German Labor Productivity Growth**



Source: Author's calculations based on German Statistical Office, Ifo Productivity Database, and GGDC.

The comparison of the early with the later period reveals that despite an acceleration in capital deepening a strong decrease in TFP and labor quality growth have induced a sharp decline

in total economic growth. Measured as a residual TFP could be interpreted as a “measure of economic ignorance” as Abramovitz (1956) has expressed it, in fact it combines a couple of “soft facts” that are in some cases hard to quantify. These include motivation and competencies, market characteristics, institutions and regulations, as well as innovation and technological change.

One more or less obvious reason for the decline in TFP-growth was the German unification, whereby the low growth of the eastern part of the country has pulled down the German average. Additionally the high demand for public funds in the east has increased the public debt enormously, which in turn has contributed to international investors’ reluctance to invest in Germany. But in the 1990s there were additional factors causing modified conditions and market characteristics. At that time Germany had to manage an intensified globalization and eastern EU-enlargement with a lot of new low-wage-competition. The EU-integration was for at least one reason problematic for Germany: it has enlarged the market size of small countries entailing additional scale economies (which helped the small countries more than the big ones). Then the euro has been introduced, which lowered the risk premium for investments in all euro-area-countries to a level that has formerly been “reserved” for Germany. For a more detailed discussion of these simultaneous shocks for the German economy see Sinn (2005).

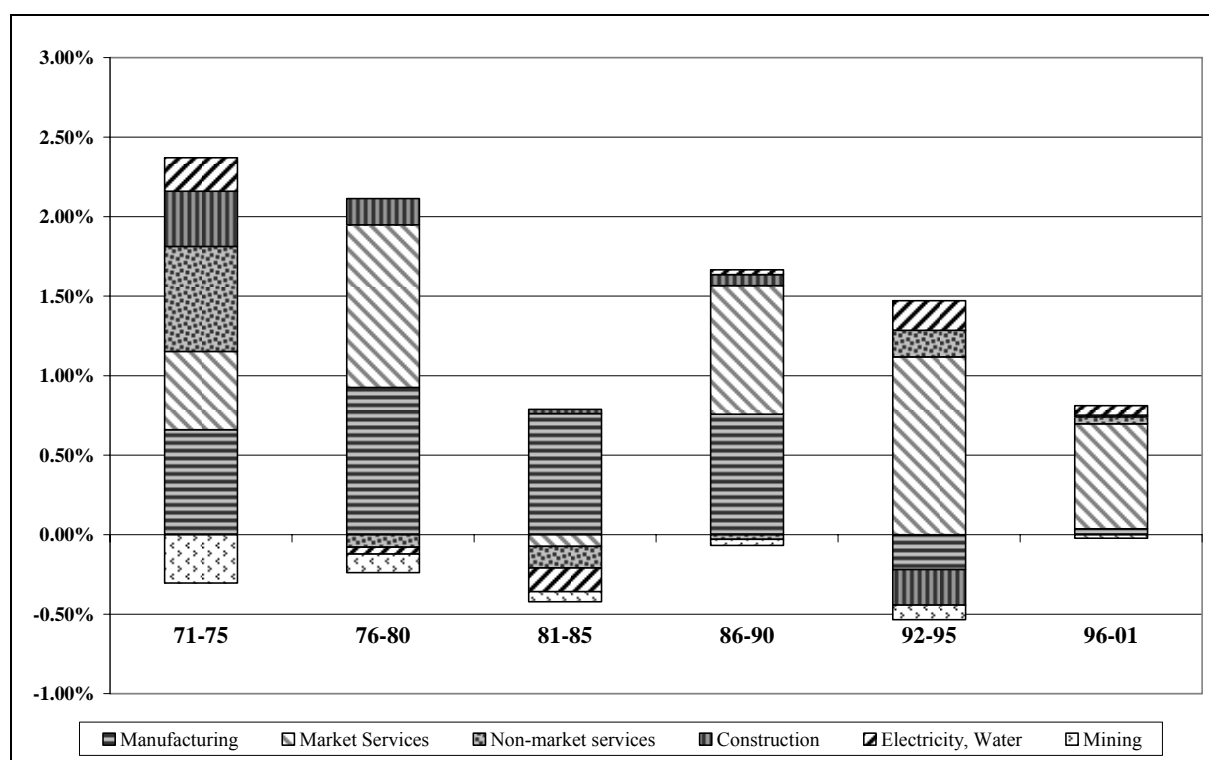
### **4.3 Industry-specific contributions to aggregate TFP-growth**

Complementary to the determination of aggregate TFP as a weighted sum of industry-level TFP-measures, the Domar approach of aggregation (see Domar (1961)) allows determining the amount that every industry has contributed to aggregate TFP-growth.<sup>15</sup> Figure 3 shows the resulting industry-shares for 5-year-averages, scaled to the above VA-TFP-results.

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<sup>15</sup> The Domar weight of an industry is defined as the industry’s gross output divided by aggregate value added. In general, these weights sum up to more than one

**Figure 3 - Industry Contributions to aggregate TFP-growth**



Source: Author's calculations based on German Statistical Office, Ifo Productivity Database, and GGDC.

One can see that the decline in TFP-contribution of the manufacturing sector (up to even negative values in the early 1990s) can only partly be offset by a higher contribution of market services.

An important application of such an analysis of historical data is to examine to what extent these numbers are suited to project future productivity growth.

## 5 Projecting productivity growth

In this section projections of growth trends for output and labor productivity for the next decade are presented, abstracting from business cycle fluctuations. The key assumptions are that output and the reproducible capital stock will grow at the same rate ( $\Delta \ln Y = \Delta \ln Z_R$ )<sup>16</sup> and that labor

<sup>16</sup>The derivation of the projection equation is adopted from Jorgenson et al. (2003). Assuming that output and the capital stock grow at the same rate refers to a property of the balanced growth equilibrium in the standard neo-classical growth model.

hours and the labor force will also grow at the same rate. These are characteristic features of most industrialized economies over periods longer than a typical business cycle.

I begin by decomposing the aggregate capital stock between reproducible capital stock and land, which I assume to be fixed. This implies:

$$(9) \quad \Delta \ln Z = \bar{\mu}_R \Delta \ln Z_R + (1 - \bar{\mu}_R) \Delta \ln LAND = \bar{\mu}_R \Delta \ln Z_R$$

where  $\bar{\mu}_R$  is the value share of reproducible capital stock in total capital stock.

Estimates of trend output and labor productivity growth are constructed, conditional on the projected growth of the remaining sources of economic growth. More formally, if  $\Delta \ln Y = \Delta \ln Z_R$ , then Equations (3), (4), and (9) imply that trend labor productivity and output growth are given by:

$$(10) \quad \Delta \ln y = \frac{\bar{v}_K \Delta \ln KQ - \bar{v}_K (1 - \bar{\mu}_R) \Delta \ln H + \bar{v}_L \Delta \ln LQ + \Delta \ln A}{1 - \bar{v}_K \bar{\mu}_R}$$

For the projection of labor productivity one has to make several assumptions, in order to have tangible values for every single component of equation (10).

For complete growth projections based on Equation (10), estimates of capital and labor shares, the IT output share, the share of reproducible capital stock, capital quality growth, labor quality growth, and TFP growth are required. Labor quality growth and the various shares are relatively easy to project, while extrapolations of the other variables are subject to considerable uncertainty. To give consideration to these problems, I present three sets of projections, following Jorgenson et al. (2003): one base-case scenario, a pessimistic scenario, and an optimistic scenario.

Several parameters are kept constant, while others vary according to the respective scenario. Those that remain constant across the three scenarios are labor quality growth, the capital share, the reproducible capital stock share, and the IT output share. These are referred to as the “common assumptions.” The parameters that vary across these scenarios are IT-related TFP growth, hours growth, the contribution to TFP growth from non-IT sources, and capital quality growth. They are labeled “alternative assumptions”.

## 5.1 Common Assumptions

Comparing the 1980s and 90s one can see that labor quality growth ( $\Delta \ln LQ$ ) declined significantly in Germany. Ho and Jorgenson (1999) have shown that in the US the dominant trends in labor quality growth are due to rapid improvements in educational attainment and the rise in female participation rates in the 1970s. The improvement in educational attainment of new entrants into the labor force largely ceased in the 1990s, although the average educational level continued to rise as younger and better educated workers entered the labor force and older workers retired. This seems to be in line with the German data.

The capital share ( $\bar{v}_K$ ) features a slight upward trend over the past 30 years, but also stagnation in the last decade. Therefore this share is assumed to be constant at 40.3 percent, the average for 1995-2003.

The fixed reproducible capital share ( $\bar{\mu}_R$ )<sup>17</sup> has shown little change in the last three decades and we assume that it remains constant at 83.7 percent, the average for 1970-2001.

## 5.2 Alternative Assumptions

Differing from Jorgenson et al. (2003) hours growth ( $\Delta \ln H$ ) projections are integrated in the category of alternative assumptions. This is due to the fact that an official and relatively broad dataset is available, containing demographic trend projections by the German Statistical Office<sup>18</sup>. These projections comprise trends for population growth for 10 different scenarios in terms of migration and life expectancy. For our context the focus will be on the group of those aged between 15-65, growth in the potential labor force. Three out of the ten scenarios are chosen in order to get one base-case, one optimistic and one pessimistic scenario<sup>19</sup>. Even if the group of those aged 15-65 is not equal to the active labor force, it is assumed that both groups grow with the same rate.

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<sup>17</sup> In particular the natural resources are not reproducible (excluding renewable primary products).

<sup>18</sup> Statistisches Bundesamt (2003)

<sup>19</sup> The *base case scenario* (version 1) assumes a migration balance of 200000 migrants per year. Life expectancy at birth is assumed to be 81.1 years for men and 86.6 for women. The *pessimistic scenario* (version 5) assumes a migration balance of 100000 and a lower life expectancy of 78.9 years for men and 85.7 for women. The *optimistic scenario* (version 9) is calculated with a migration balance of 300000 and a high life expectancy of 82.6 years for men and 88.1 for women.

Total TFP-growth for the base case scenario is equal to the average of 1995-2003 , which is 0.60%. The pessimistic scenario assumes that TFP-growth is as sluggish as in the late observation period, which is 0.49%. The optimistic value is equal to the higher average of the early 1990s, which is 0.94%.

In Table 3 the three scenarios and the components of the respective projections are presented. The top panel shows the projected growth of output and labor productivity. The subsequent panel reports the four factors that are held constant across the scenarios. These are labor quality growth, the capital share, the IT output share and finally the reproducible capital stock share. The bottom panel includes the components that vary across scenarios – hours growth and capital quality growth.

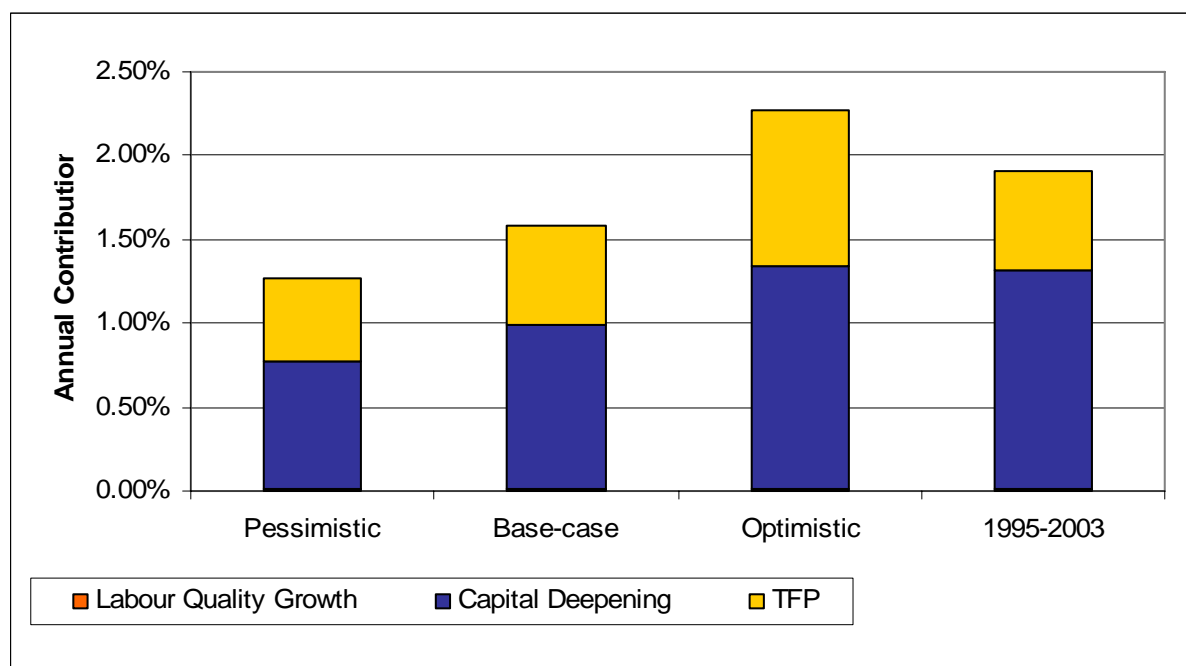
The base case scenario puts trend labor productivity growth at 1.67 percent per year, and trend output growth at 1.62 percent per year. Figure 4 presents this projection of labor productivity growth and its decomposition in comparison to the period 1995-2003.

**Table 3 Output and Labor Productivity Projections - Total Economy**

		<b>Projections</b>		
		Pessimistic-case	Base-case	Optimistic-case
Output Growth	$\Delta \ln Y$	1.03%	1.53%	2.32%
ALP-Growth	$\Delta \ln y$	1.30%	1.59%	2.28%
		<b>Common Assumptions</b>		
Labor Quality Growth	$\Delta \ln LQ$	0.01%	0.01%	0.01%
Capital Share	$v_K$	40.30%	40.30%	40.30%
Reproducible Capital Stock Share	$\mu_R$	83.7%	83.7%	83.7%
		<b>Alternative Assumptions</b>		
Hours Growth	$\Delta \ln H$	-0.24%	-0.05%	0.05%
Capital Quality Growth	$\Delta \ln KQ$	0.80%	1.10%	1.40%
Total Growth in TFP	$\Delta \ln A$	0.49%	0.60%	0.94%
Impl. Capital Deepening Contrib.		0.67%	0.89%	1.23%

Source: own calculations

**Figure 4 – Labor Productivity Projections**



Source: own calculations

## 6 Conclusions

The German productivity development is not only interesting from a national point of view. Europe is still lagging far behind the US economy in terms of growth rates and its productivity development. This is to a large extent due to the German productivity slowdown, which makes the Lisbon agenda<sup>20</sup> and its goals even more unrealistic than with a moderate German growth development.

This paper uses a new and extensive database with complete information on industry-level and asset specific capital services flows, which allows for a detailed productivity analysis of the European “problem child” Germany. It gives a broad overview to the German total-economy- and labor-productivity development of the years 1970-2003 and allows projections of productivity trends for the next decade.

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<sup>20</sup> In March 2000, the EU Heads of States and Governments agreed to make the EU "the most competitive and dynamic knowledge-driven economy by 2010".

The historical records show that the continuous decline in TFP-growth and the accompanying decline in labor quality growth could not be compensated by moderate capital deepening, which resulted in declining labor productivity growth. German investments in IT assets played a growing but still minor role in growth contributions over time. A remarkable “New-Economy” effect, which was a major reason for the US productivity revival, can not be identified for Germany. Germany failed to benefit sufficiently from direct effects through capital deepening (at least in comparison to the US) and it failed to benefit sufficiently from indirect effects, which is at least partly due to market rigidities and other general framework conditions.

Another interesting result is that a strong decline in total hours worked has charged a high price in terms of annual economic growth. In the 1970s and 80s this decline was mainly due to a continuous reduction in the weekly hours of work. This trend has been weakened recently by an increase in the weekly working hours for many sectors – but the overall demographic decline has thwarted this development and it has not reached its peak for a long time yet.

An analysis of the sector specific contributions to total factor productivity growth shows that the continuous declining contribution of the manufacturing (and construction) sector has not been compensated by a slightly growing contribution of the service sector.

The paper provides productivity trend projections for the coming decade for Germany. The base-case projection puts trend output growth at 1.53 percent per year with a confidence range of 1.30 percentage points. Average labor productivity will grow at an annual rate of 1.59 percent within a range of 1.01 percentage point.

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