PRODUCTIVITY: ADDRESSING THE CAUSES

This is a translated version of the original German-language chapter "Produktivität: An den Ursachen ansetzen", which is the sole authoritative text. Please cite the original German-language chapter if any reference is made to this text.

THE KEY DETAILS IN BRIEF

The development of aggregate productivity is of central importance to the material prosperity of an economy. The slowdown in productivity growth recorded in recent years is therefore a cause for concern. However, this slowdown does not necessarily point to undesirable developments, but reflects instead, among other factors, the successful integration of less productive workers into the labour market since 2005.

Moreover, there are increasing indications of a potential end to the process of restructuring the value chains in the manufacturing sector. While this sector posted considerable increases in productivity until 2008, primarily due to the outsourcing of upstream, labour-intensive value chain processes to other countries, this trend came to an end after the recession in 2009. There is nonetheless unutilised potential for increasing productivity at present, primarily in the service sector, including by eliminating barriers to competition in former government monopolies and reducing red tape for the self-employed

We expect to rather see a moderate increase in labour productivity in the next few years if policymakers are unable to set the course for reigniting productivity growth. A first starting point is the alleged clear direction of causality from investment to productivity growth. The intense discussion of the past two years on investment weakness in the German economy, however, is misleading. There is no conclusive evidence of an investment gap in the sense that companies have failed on a large scale to make investments Germany that could have significantly increased their productivity and thus their earnings.

In fact, the connection between the aggregate investment ratio and overall economic productivity is highly complex. Investment weakness can be triggered, in particular, by slower growth in productivity. In such case it tends to be the result of rational business strategies. Economic policy should not attempt to stimulate investment where it would not be made under the given circumstances, but find ways of accelerating productivity growth instead.

The digital revolution offers a great potential for increasing labour productivity. “Industry 4.0” crystallises the hope of greater productivity growth through innovations in information and communications technology (ICT), particularly in the manufacturing sector. Policymakers are called upon to create a suitable framework so that the economy can successfully carry out this transformation. Education and training also play an important role in enabling all levels of society to participate in technical advances and raising average productivity.

Demographic change poses enormous challenges to the German economy's ability to innovate. Businesses are likely to find ways of successfully overcoming the dearth of younger people, but it is up to policymakers to harness existing flexibility to increase labour force and innovation potential and thus mitigate the negative demographic impact on innovation.

I. TRENDS IN LABOUR PRODUCTIVITY

590. The increase in macroeconomic labour productivity in Germany has **decelerated significantly** in recent years. There are currently few signs of any change in this trend, which is closely linked not least to the relatively weak investment activity in the private sector. However, it could also be the result of structural shifts within the economy and subdued technological progress, i.e. comparatively low economic innovation for creating new products and processes. ↘ BOX 22

As **demographic change** is set to significantly contract labour volume in the medium term, it is likely that the competitiveness of businesses and thus also material prosperity are under long-term threat. It is therefore important to understand the reasons for the slowdown in the growth of macroeconomic labour productivity and thereby to identify ways to improve productivity.

591. Empirical analysis shows that several factors have had a dampening effect on the development of labour productivity in recent years. These include the **successful integration** of over three million people into the labour market, not least as a result of labour market reforms in the middle of the last decade. A significant decline in the average productivity of the entire working population is therefore a likely side-effect.

There are **huge differences** in the developments of the individual economic sectors. Whereas the manufacturing sector recorded high increases in labour productivity which only started to decline in the past seven years, productivity in the service sector has exhibited weak development since the turn of the millennium.

↘ BOX 22

Productivity development: key terms and relationships

Macroeconomic productivity development can be measured using single or multi-factor metrics. Single-factor productivity measures establish a relationship between output and a single input factor, for example macroeconomic **labour productivity**, which is the ratio of GDP (gross value added) to labour input. Labour input can be measured by the number of people in employment or the number of hours worked (labour volume). **Capital productivity** is another single-factor productivity measure, which constitutes the ratio of GDP to capital stock. Multi-factor productivity measures involve establishing a relationship between output and all input factors, and usually assume a specific production function. The resulting variable is called **total factor productivity**. Throughout this chapter productivity is understood as labour productivity, which is easier to measure than total factor productivity. But labour productivity is also highly susceptible to data revisions over time (Jacobs and Norden, 2015).

To illustrate the factors influencing labour productivity, we assume below that aggregate output can be represented using a Cobb-Douglas production function with constant economies of scale. According to this production function, changes in production are due to variations in the production factors labour and capital or a change in total factor productivity. The production function Y_t is defined as follows:

(1) $Y_t = A_t \cdot K_t^{\alpha} \cdot (E_t H_t)^{1-\alpha}$,

where A_t is total factor productivity and K_t is the capital stock. The product $E_t H_t$ defines labour input resulting from the average quality of labour per hour worked, E_t, and the labour volume, H_t. The production elasticity of capital is indicated by α. Dividing Y_t by the labour volume results in labour productivity (hourly productivity), indicated by y_t. The percentage change in labour productivity can be expressed using logarithmic differentiation:

(2) $\Delta ln y_t = \Delta ln A_t + \alpha \Delta ln k_t + (1-\alpha)\Delta ln E_t.$

An increase in labour productivity can thus have three different causes. Firstly, it can result from an increase in capital per hour worked, $\Delta ln k_t$. This illustrates the relationship between investments and labour productivity, although investments are not homogenous capital goods. ↘ ITEM 632FF. Investments in information and communication technology (ICT) as well as in research and development (R&D) have, for example, a much greater effect on productivity than investments in housing. Secondly, an increase in labour productivity can be due to an increase in total factor productivity, $\Delta ln A_t$, which is largely intended to measure technological advance as a result of process and product innovation. ↘ ITEM 669FF. Lastly, an increase in the skills of the workforce, $\Delta ln E_t$, can also result in a rise in labour productivity. Consequently, reforms that facilitate access of less-skilled workers to the labour market are likely to have a dampening composition effect on macroeconomic labour productivity. ↘ ITEM 599FF.

Moreover, the three causes cited are very closely related to each other. For a company, for example, a higher staff skill level can increase innovation activity and create incentives to invest in ICT or equipment in order to make production processes more efficient. Investments in ICT can, by the same token, create new potential for product and process innovations. ↘ ITEM 647FF. For this reason, breaking down productivity development should always be viewed as a purely descriptive exercise. Causal statements cannot be made.

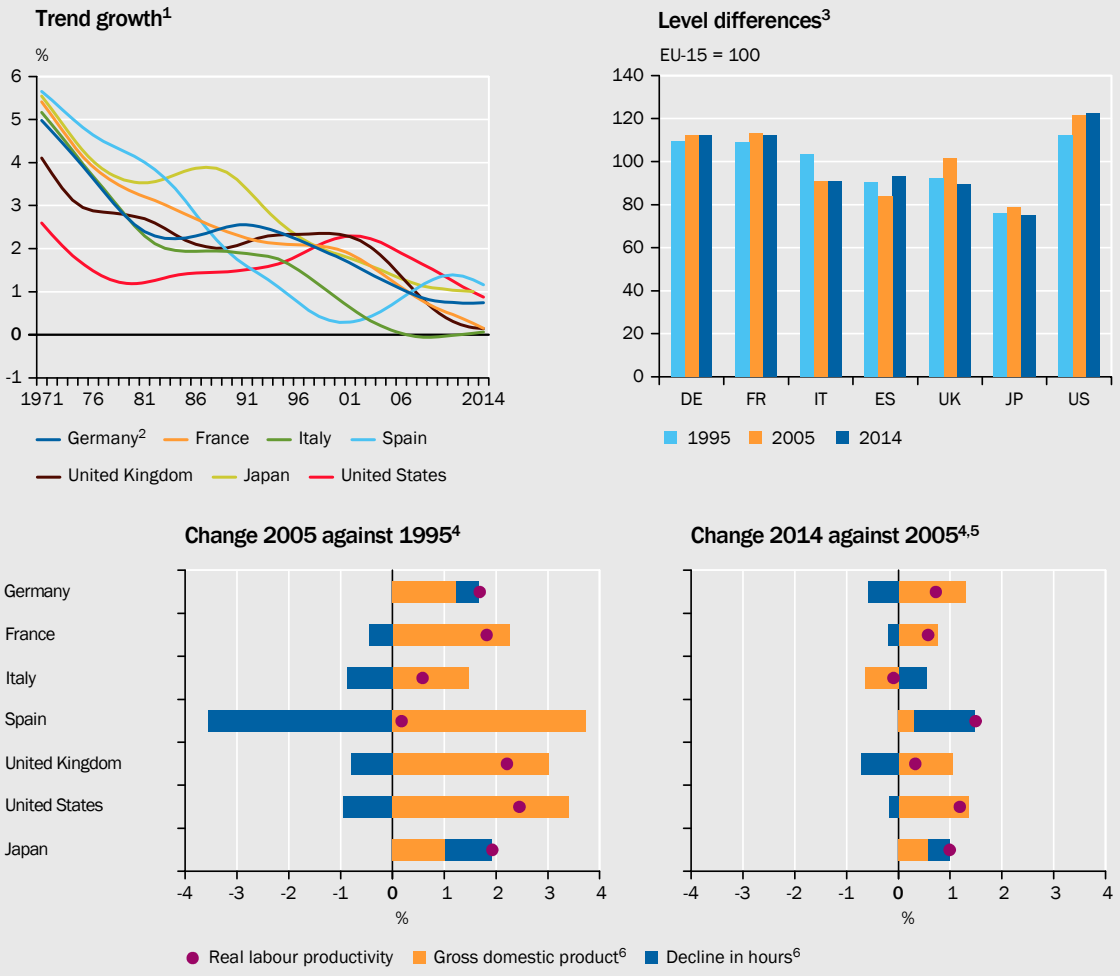
1. Macroeconomic assessment

592. **Macroeconomic labour productivity** of the German economy has only risen moderately since 2005. While gross value added per hour worked (hourly productivity) still rose by an annual average of 1.9 % from 1995 to 2005, it only rose by 0.8 % per year from 2005 to 2014. The annual increase in gross value added per employee (employee productivity) also declined between the two periods, from 1.1 % to 0.4 %. The low rates of growth in employee productivity can be explained by the considerable rise in part-time employment, which was noted in both observation periods. The diagnosis of a slower growth in labour productivity still stands even if the calculation does not include the severe recession of 2009. In such case, the increase in hourly productivity would average 1.3 % for the period from 2005 to 2014.

593. In an international comparison the German development is not special. ↘ CHART 90, TOP Slower growth in labour productivity was observed in nearly all major industrialised nations since the beginning of the new millennium at the latest. Particularly, productivity growth had already declined prior to the onset of the financial crisis. Fernald (2015) demonstrates that the slowdown in productivity growth in the US was evident as early as 2004 and that it was not only limited to the financial and real estate sectors. He attributes the development primarily to the decline in innovation, which commenced in the mid-1990s

↘ CHART 90

Labour productivity per hours worked in selected countries



1 – Change in real GDP per hours worked to the previous year. HP-filter, λ = 100. 2 – Until 1990 the former West Germany. 3 – DE-Germany, FR-France, IT-Italy, ES-Spain, UK-United Kingdom, JP-Japan, US-United States. Nominal GDP per hours worked (for Japan 2013) in purchasing power parities. 4 – Average annual change. 5 – For Japan 2013. 6 – Percentage points.

Source: European Commission

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with the **diffusion of ICT**. For the US it is therefore more a process of normalisation following a period of soaring productivity.

594. The International Monetary Fund (IMF, 2015a) also states that slower productivity development in industrialised countries commenced well before 2008. One reason it cites for this trend is the normalisation of productivity development in the US due to less ICT innovation. Another explanation is that many industrialised countries experienced a **structural shift** away from highly productive economic sectors, such as manufacturing, to areas with lower productivity, such as many service sectors. The IMF concludes further that increases in **workforce skill levels** in many countries contributed less to productivity growth than they had in the past.

595. An analysis of the value added contributions of individual sectors in an international comparison shows the **major significance** that the **manufacturing industry** continues to have for Germany's macroeconomic productivity growth. Compared to the service sector, the increases in hourly productivity are consid-

erably higher in all countries analysed. Other countries such as the UK and France also achieved large productivity increases in the manufacturing industry. Its significance for these national economies, however, noticeably declined from 1995 to 2014. ↘ TABLE 26 Part of the excellent German track record can be attributed to the continuing important role of the manufacturing industry.

596. Breaking hourly productivity growth rates down into **contributions related to the rise in GDP** and the decline in labour volume highlights considerable differences between the industrialised countries. ↘ CHART 90, BELOW For the period from 1995 to 2005, productivity growth was accompanied by a reduction in hours worked in Germany and Japan only. Some of the other industrialised nations heavily increased their labour volume and thus also employment rates. Part of the increase in economic output per hour worked enabled by the productivity increase in those countries was thus harnessed to increase employment.

597. A completely different picture has developed since 2005. The rise in employment in Germany and the UK was accompanied by a slower rise in labour productivity. However, the contrast between growth contributions of overall economic activity is even more significant. From 1995 to 2005, high increases in labour productivity went hand in hand with high economic growth, in the UK and the US above all. The contribution of economic growth declined most significantly in those two countries between 2005 and 2014. In Germany, in contrast, it remained stable at a moderate level. This breakdown therefore suggests that **changes in employment** and its composition are likely to play a **relatively important role** in explaining the trend in labour productivity, not only in Germany.

↘ TABLE 26

Real labour productivity (value added per hours) in selected countries[1]

Average annual growth in %

Country	1995 – 2005			2005 – 2014			Reporting:	
	all economic sectors	including		all economic sectors	including		share of manufacturing[2]	
		manu-facturing	service sectors		manu-facturing	service sectors	1995	2014
Denmark	1.2	2.7	0.8	0.4	3.6	0.3	17.0	13.9
Germany	1.9	3.1	1.3	0.8	1.6	0.6	22.8	22.6
Finland	2.6	6.2	1.2	0.2	0.9	– 0.0	25.4	16.7
France	1.8	4.4	1.2	0.8	2.4	0.7	16.2	11.2
Italy	0.5	0.9	0.3	0.1	1.0	– 0.3	20.9	15.4
Netherlands	1.7	3.8	1.6	0.6	1.4	0.6	17.2	12.1
Austria	1.8	3.3	1.0	1.0	2.5	0.8	20.0	18.4
Spain	0.0	1.1	0.0	1.6	2.0	1.0	17.6	13.2
United Kingdom	2.2	3.6	2.1	0.4	1.7	0.6	19.0	9.5
United States	2.3	5.9	1.2	0.9	2.3	0.4	15.9	12.0

1 – Own calculations. 2 – Share of total gross value added.

Sources of data: BEA, Eurostat

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598. The most recent increases in productivity in Spain demonstrate to which large extent cyclical and structural **labour market developments** impact macroeconomic productivity growth. The drastic rise in labour productivity since 2007 can largely be explained by **"dismissal productivity"**. This phenomenon arises when a certain added value is produced with considerably fewer workers. Conversely the widespread dip in productivity observed in 2009 is likely due to **labour hoarding**, leading to temporary underutilisation of labour capacities. The subsequent recovery in labour productivity demonstrates that the national economy was only temporarily less productive.

599. In Germany, in contrast, structural factors due to fundamental changes in the labour market (GCEE Annual Economic Report 2013 items 511ff.) were largely responsible for the declining trend in labour productivity growth rates. It can be assumed, in particular, that the labour force increase of 3.4 million workers since 2005 was a key factor in the weaker productivity development. As these individuals were previously unsuccessful at offering their skills on the labour market, it can be assumed that they were less productive than the average worker in 2005. This resulted in a **composition effect** among workers, which had a dampening effect on labour productivity growth rates in the multi-year transitional phase to the new structural labour market equilibrium.

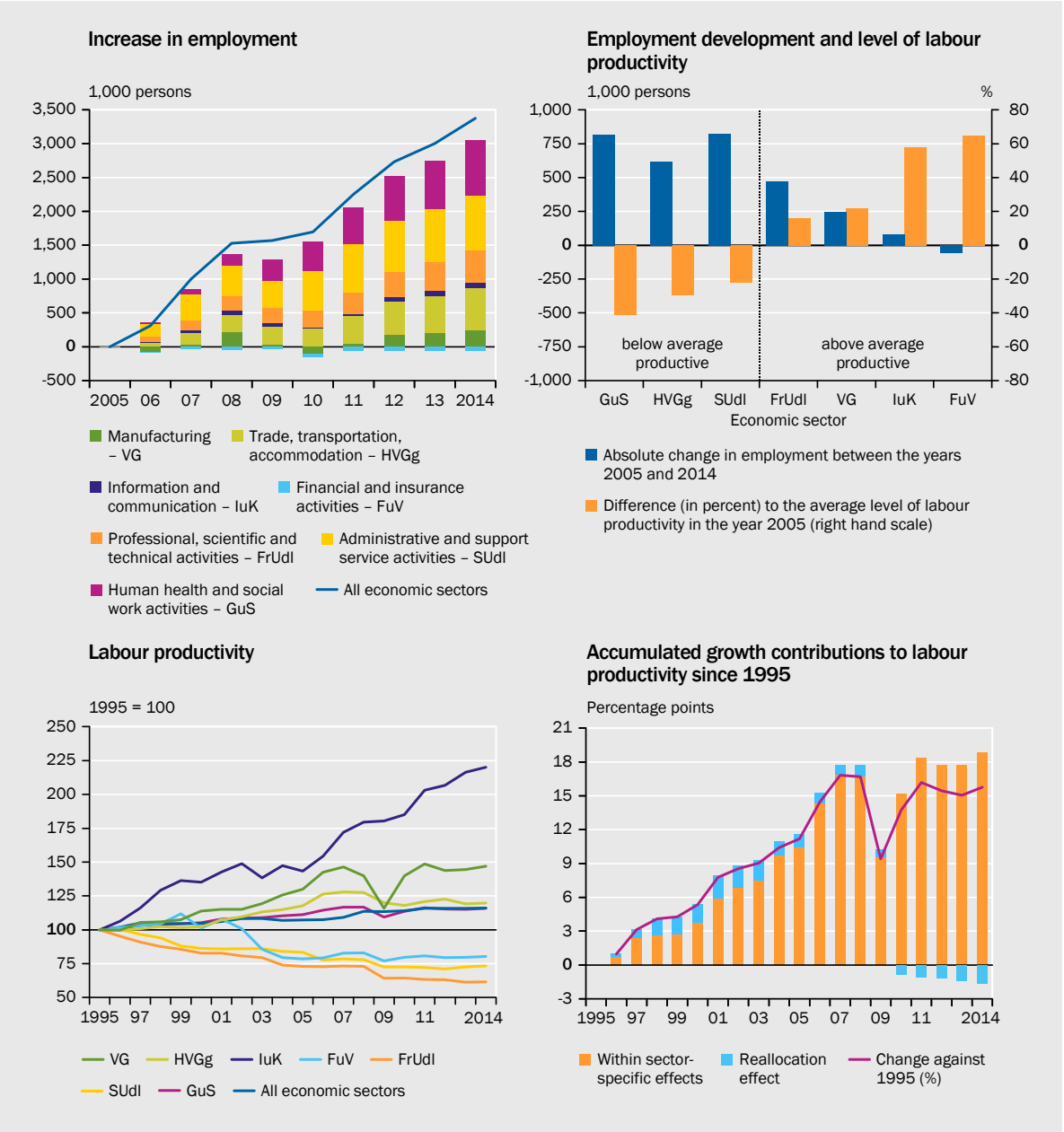
600. There are two factors underlying this composition effect. Firstly, jobs were created especially in labour-intensive and less productive service sector areas. ↘ CHART 91, UPPER RIGHT The number of workers increased considerably above all in the economic sectors trade, transportation, accommodation, healthcare and administrative and support services (especially temporary work). ↘ CHART 91, UPPER LEFT This consequently resulted in a **structural shift** in the German economy, as these sectors gained relative importance in terms of employment, at the expense of the highly productive manufacturing sector. Secondly, the increase in the number of less productive employees had a negative impact on **sector-specific labour productivity** in the relevant labour-intensive service sectors. ↘ CHART 91, LOWER LEFT

601. It is possible to obtain a general idea of the size of the composition effect by means of a disaggregated analysis at the sector level (De Avillaz, 2012). We examine which aggregated development would have resulted due solely to the effects within the individual economic sectors (**within sector-specific effects**) and what significance the shift in employment between the sectors had (**reallocation effect**). The within sector-specific effects thus reflect the development of macroeconomic labour productivity for the hypothetical situation in which the employment shares of the national economy had not changed over time.

602. The corresponding decomposition of German productivity development shows that the reallocation effect has not been very significant to productivity advances since 1991. ↘ CHART 91, LOWER RIGHT The productivity gains over the past 25 years largely stemmed from developments within the individual sectors. The **reallocation effect** made only a slightly positive contribution to the increase in labour productivity in the period from 1995 to 2005. Employment during this period increasingly shifted to the productive economic sectors.

↘ CHART 91

Employment development and labour productivity[1] for selected economic sectors



1 – Real gross value added per person employed.

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However, a reversal of the reallocation effect has been evident since the turn of the millennium. The structural shift towards the relatively unproductive service sectors had a significantly negative effect on macroeconomic labour productivity. The growth contribution from the reallocation effect for the period 2005 - 2013 is therefore negative. ↘ TABLE 27 Overall, this negative reallocation effect has caused the annual increase in macroeconomic employee productivity to decline by around 0.3 percentage points since 2005 compared to the previous 10 years. This result is the same whether productivity is calculated per hour or per person employed.

603. The analysis of the **within sector-specific effects** shows that the growth contributions of the economic sectors trade, transportation, accommodation, healthcare and administrative and support services (particularly temporary

↘ TABLE 27

Growth contributions to aggregate labour productivity
Percentage points

	Share[1]	Per person employed		Per hour	
	%	1995 – 2005	2005 – 2014	1995 – 2005	2005 – 2014
Within sector-specific growth contributions					
Manufacturing	22.4	0.7	0.3	0.8	0.4
Service sector	69.8	0.2	0.3	0.8	0.6
including:					
Whosesale and retail trade, repair of motor vehicles, transport and storage, accommodation	16.5	0.3	0.0	0.5	0.1
Information and communication	4.6	0.2	0.3	0.2	0.3
Professional, scientific and technical activities	6.3	– 0.2	– 0.1	– 0.1	– 0.1
Administrative and support service activites	4.3	– 0.1	– 0.1	– 0.0	– 0.0
Human health and social work activities	6.6	0.0	0.1	0.1	0.1
Reallocation effect		0.1	– 0.2	0.2	– 0.2
Development of labour productivity (%)					
Actual development[2]		1.1	0.4	1.9	0.8
Development without structural shifts[3]		0.9	0.7	1.6	1.0

1 – Share of the corresponding sector in total gross value added in the year 2005. 2 – Average annual change of total gross value added per person employed and per hour, respectively. 3 – Without the reallocation effect. Difference in total due to rounding.

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work) in total have contributed an annual 0.3 percentage points less to the rise in overall productivity per employee since 2005 than it was the case for the period 1995 - 2005. Along with the reallocation effect, this indicates that the annual decline in the growth rate of macroeconomic employee productivity, from 1.1 % for the period 1995-2005 to 0.4 % since 2005, can largely be explained by the composition effect, which is the result of the successful integration of less productive workers into the labour market. A similar conclusion can be drawn for hourly productivity. This is a side-effect of the German labour market miracle.

604. The productivity gain generated by the **manufacturing sector** has declined considerably since 2005. The manufacturing sector's overall contribution to growth of macroeconomic labour productivity has declined by 0.4 percentage points. A closer study of this sector is thus appropriate. ↘ ITEM 605FF. Moreover, the growth contribution from the **service sectors** for both periods is noticeably weak although it accounts for a large share of German output. The question here is whether there are structural problems and whether eliminating them could contribute to considerably raising productivity. ↘ ITEM 616FF.

2. An end to outsourcing in manufacturing?

605. As the manufacturing sector is a major driver of macroeconomic productivity, the **noticeable slowdown** in its productivity growth in recent years has had a particularly detrimental effect. The average annual increase in hourly productivity of 3.1 % for the period 1995 - 2005 fell by roughly one half to just 1.6 % for the period 2005 - 2014. ↘ CHART 92, TOP

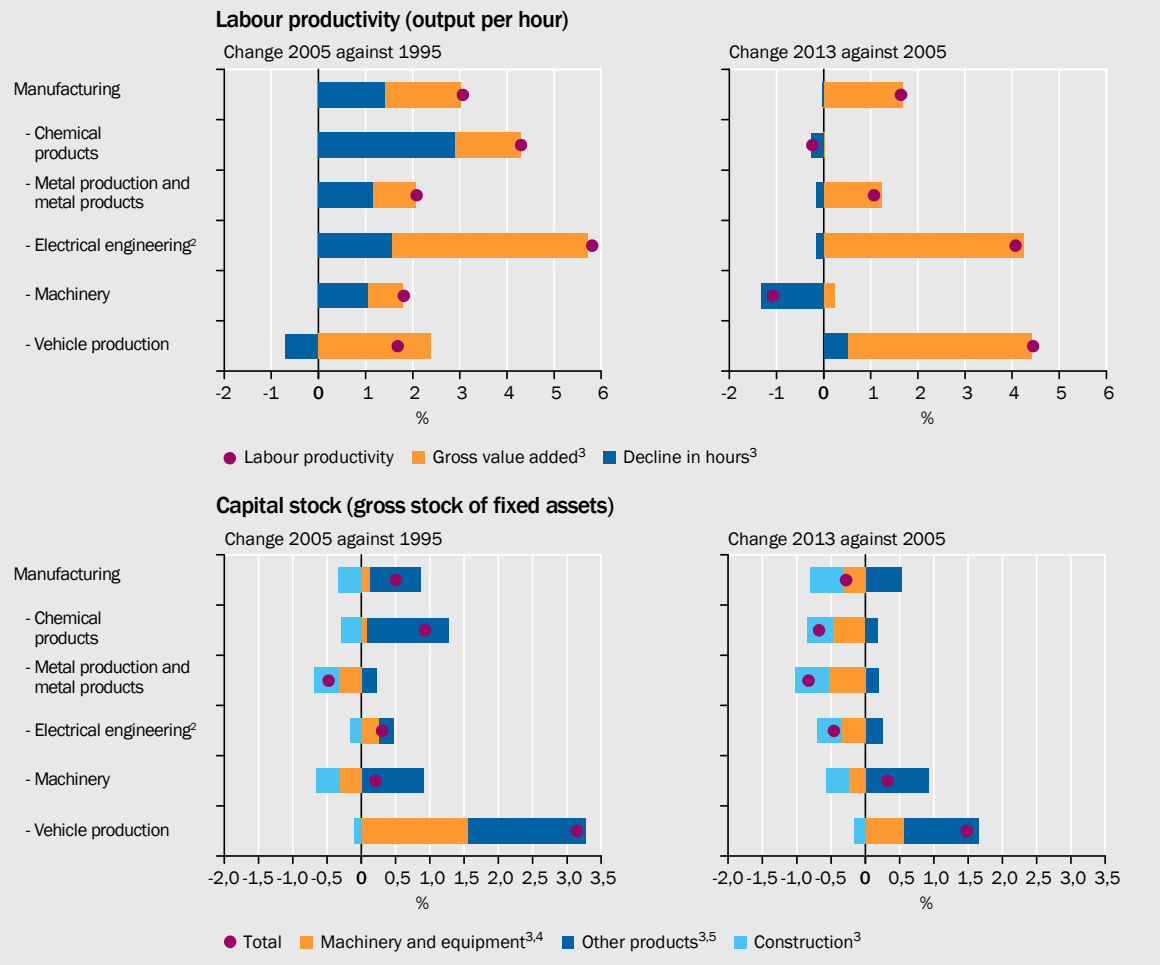
As this sector is highly export-focused, it seems reasonable to assume that the moderate global economic growth and the euro-area crisis are the reasons behind the weak productivity growth. However, **no significant underutilisation** of production capacities can be found in the data. Capacity utilisation in 2013 and 2014 stood at 82.1 % and 83.9 % respectively. As both values are close to the long-term average, normal utilisation can be therefore assumed.

606. In fact, the decline in labour productivity in the manufacturing sector is, above all, likely due to the fact that the **process of restructuring** the value chains **has come to an end**. Vertical integration in manufacturing measured as a proportion of gross value added to production value declined progressively from the mid-1990s until 2008. ↘ CHART 93, TOP Companies focused more and more on the final assembly of highly specialised products and increasingly outsourced upstream value chain processes.

607. This restructuring process had a positive effect on manufacturing labour productivity, primarily in the period from 1995 to 2005. Apparently it was precisely labour-intensive and **less productive value chain steps** that were **out-**

↘ CHART 92

Growth contributions to labour productivity and capital stock in the manufacturing sector[1]



1 – Average annual change. 2 – Manufacture of computers, electronic and optical products and electrical equipment. 3 – Percentage points. 4 – Including military weapon systems. 5 – Including research and development, software and databases, copyright, mineral exploration and cultivated assets.

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sourced. However, the sector retained final production, with the highest added value and relatively low labour utilisation. This can be seen most clearly in the fact that labour volume declined despite increasing value creation. Breaking down the change rate of labour productivity for this period into the percentages contributed by the rise in gross value added and the decline in labour volume shows that both factors contributed about one half each to the average annual rise in productivity of 3.1 %. ↘ CHART 92 TOP This changed from 2005 onwards. The number of hours worked has not decreased since then, but the growth contribution of overall economic activity has remained the same.

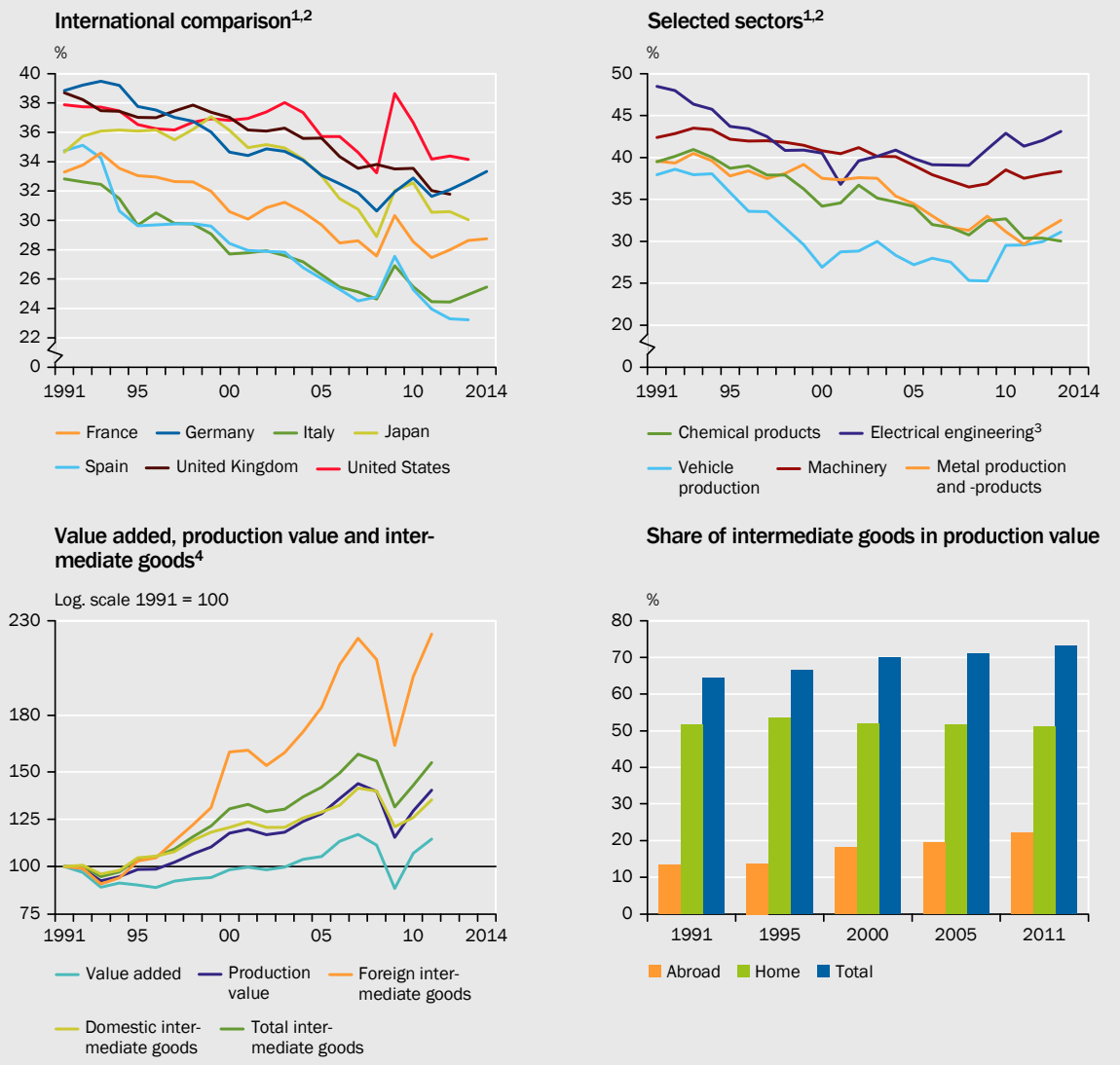
608. However, the **gross fixed capital formation** of the manufacturing sector, which still grew at a moderate rate in the period 1995-2005, shrank during the period 2005-2013. It can be assumed that outsourcing value chain steps explains a significant part of this decrease of capital stock in fixed assets. This estimate is supported by the observation of individual manufacturing sub-sectors: there is a high correlation between changes in hourly productivity and changes in capital stock in fixed assets. In contrast, capital stock in other assets, of which research and development constitute a large share, rose. ↘ CHART 92, BELOW

609. As regards **macroeconomic labour productivity**, it makes a difference whether these upstream value chains were outsourced primarily to the domestic service sector or to other countries. Simply shifting production steps to the domestic service sector would ultimately have no effect on macroeconomic labour productivity, as the increase in productivity in the manufacturing sector would be offset by an equally large negative development in the service sector.

However, it is evident that **intermediate goods and services purchased abroad** largely explains the decline in the vertical integration of the manufacturing sector. ↘ CHART 93, LOWER LEFT In absolute terms, domestic intermediate goods play a bigger role in production; however, its contribution to the output value of the manufacturing sector for the period 1995-2011 stagnated. ↘ CHART 93, LOWER RIGHT The increase in labour productivity in the manufacturing sector was accompanied by a positive development in macroeconomic labour productivity as less productive value chain steps were outsourced abroad.

610. **Outsourcing** production steps abroad was **discontinued**, however, in 2009. Vertical integration in manufacturing has even risen again slightly; the development of foreign intermediate goods, in contrast, remained slow. One reason for this could be the adjustment of production structures as a result of the global recession. For instance, it was easier during the crisis for multinational companies to adjust their staff abroad than at home (GCEE Annual Economic Report 2011 item 470ff.). Improved labour market conditions may also have induced multinationals to bring part of their production back to Germany. Moreover, the potential in outsourcing upstream stages of production may have reached its limit. And finally, the impacts of the global financial crisis may have been a factor for German companies exercising more restraint in building up new foreign production structures. This effect is likely to be manifest in other European countries above all.

↘ CHART 93
Indicators for production depth in manufacturing



1 – Share of gross value added in production value. 2 – Current prices. 3 – Manufacture of computer, electronic and optical products as well as electrical equipment. 4 – Price adjusted.

Sources: Eurostat, Federal Statistical Office, OECD, Thomson Financial Datastream

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However, this is not inconsistent with the finding that the German corporate sector still uses a large part of its profits to expand production capacities abroad. In fact, there may have been increased investment in those production facilities abroad primarily aimed at **production of end-products** for the markets in those countries, and less at intermediate goods for the German manufacturing sector. This would seem particularly plausible for direct investment outside of the euro area, such as in Asian emerging markets.

611. The end of the outsourcing process provides an explanation for the substantial increase in hours worked in **machinery** in recent years. ↘ CHART 92, UPPER RIGHT Moreover, employment was only adjusted with a delay to the significant production increases in 2004 and 2007. Mechanical engineering companies at that time handled production increases through overtime, hiring temporary staff and contracting orders to third parties.

This meant that a portion of hours worked were recorded in other areas of the economy such as other business services, resulting in a significant rise in mechanical engineering's hourly productivity in this period. In recent years, in contrast, more and more skilled workers have been hired to better tackle the future consequences of demographic change despite relatively weak external demand.

612. The observation that skilled workers are already being hoarded is true for the **chemical industry** as well. Moreover, this export-focused sector suffered particularly badly from the economic slack in the euro area. The international competitiveness of the chemical industry is also largely determined by the relative development of commodity and energy costs. The sector lost competitiveness compared to the US with particular respect to commodity costs. Uncertainty about exemptions from the renewable energy surcharge is also likely to have dampened willingness to undertake long-term investment projects. ↘ APPENDIX ITEM 696FF.

Moreover, the German Chemical Industry Association (Verband der chemischen Industrie – VCI) has reported innovation obstacles from inside and outside of companies (Attar et al., 2015). While external factors primarily relate to regulation and bureaucracy, company-internal factors include a lack of willingness to take risks. This could be closely related to the demographic development. ↘ ITEM 673FF.

613. The **automotive manufacturing sector** had a special status in productivity development since 2005. Particularly in this economic sector, gross value added rose drastically. The end of the outsourcing process may have muted productivity growth in this sector, too. However, this slowdown is more than offset by strong product and process innovations which are reflected in very high investments in research and development. ITEM 670FF. These innovations are likely to have contributed to the automotive manufacturing sector posting considerable revenue gains outside the euro area, above all in China.

614. The potential for achieving productivity gains from value chain restructuring processes now seems largely exhausted. This raises the question of the extent to which process and product innovations will drive further increases in **labour productivity**. In this regard, the manufacturing sector is distinct from other sectors of the economy in that a higher proportion of productivity growth is realised **internally** and not through the entry of new innovative companies.

615. Studies for the US show that more than 80 % of the increases in labour productivity in the retail sector can be explained by the entry of new and exit of existing businesses (Foster et al., 2006), while about 50 % of the advances in productivity in the manufacturing sector is based on progress in existing companies (Foster et al., 2001). Regarding Germany, GCEE calculations show that the role of existing companies in advancing productivity is significantly greater in the manufacturing sector compared to the US. ↘ BOX 23 A high proportion of productivity increases in Germany's manufacturing sector is realised within established companies and not through the entry of new innovative firms.

↘ BOX 23

Analysis of labour productivity in the manufacturing sector

The results of **two analyses** are presented below to illustrate the productivity development in the manufacturing sector. The analyses begin by examining 20 sub-sectors in the manufacturing sector, and continue with a company-level microdata analysis.

At **sub-sector level**, the change in labour productivity in manufacturing at a certain time is broken down into effects specific to the individual sub-sectors and a reallocation effect. The **sub-sector-specific effects** reflect how high the manufacturing sector productivity gain would be in a given economic structure. The **reallocation effect**, in contrast, describes those productivity effects that result from structural shifts within the manufacturing sector. These structural shifts represent changes in the relative proportions of the manufacturing sub-sectors as measured by the number of employees or employee hours worked. **Labour productivity** in the manufacturing sector is measured as follows:

$$(1)\quad \left(\frac{LP_t^{MS}-LP_0^{MS}}{LP_0^{MS}}\right) = \sum_{i=1}^{20}\left(\frac{LP_t^{i}-LP_0^{i}}{LP_0^{MS}}\right) n_0^i + \sum_{i=1}^{20}\left(n_t^i - n_0^i\right)\frac{LP_t^i}{LP_0^{MS}},$$

with LP_t^{MS} denoting overall manufacturing sector labour productivity at time t and LP_t^i representing the labour productivity of sub-sector *i* at time *t*. n_t^i is the relative proportion of the labour force or employee hours worked in manufacturing sub-sector *i*. The first term on the right side of the equation describes the sub-sector-specific effects and the second term defines the reallocation effect.

In the two periods 1995-2005 and 2005-2013, the reallocation effect at the sub-sector level hardly had any impact on productivity development in manufacturing. ↘ TABLE 28 The **structural shifts**, such as the textile industry's loss of economic importance, thus had **very few effects** overall. The decrease in average annual productivity gains can be explained instead by lower productivity gains within sub-sectors. With the exception of the automotive industry, **all important economic sub-sectors** have recorded a **slowdown in their productivity increases** since 2005. The slowdown was particularly marked in the chemical, engineering and computer manufacturing sector. The latter sub-sector, however, still posts a high level of productivity increases. The development in the automotive manufacturing sector is impressive. This sub-sector has achieved considerable productivity gains since 2005.

↘ TABLE 28

Growth contributions to labour productivity in selected sectors of manufacturing
Percentage points

	Share[1]	Per person employed		Per hour	
	%	1995 – 2005	2005 – 2013	1995 – 2005	2005 – 2013
Within sector-specific growth contributions					
Manufacturing		2.7	1.1	3.1	1.8
including:					
Vehicle production	17.1	0.2	0.7	0.2	0.9
Machinery	14.7	0.2	– 0.2	0.3	– 0.2
Electrical equipment	7.1	0.1	0.0	0.1	0.0
Computer, electronic and optical products	6.6	0.9	0.4	1.0	0.7
Metal production and metal products	13.1	0.2	0.1	0.3	0.1
Chemical products	7.6	0.4	– 0.0	0.5	– 0.0
Reallocation effect		– 0.1	0.1	– 0.0	0.0
Actual development %[2]		2.7	1.3	3.1	1.6

1 – Share of the corresponding sector in total gross value added of manufacturing in the year 2005. 2 – Average annual change of real gross value added per person employed and per hour worked, respectively.

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The analysis at the economic sub-sector level can, however, significantly underestimate the actual significance of reallocation effects, as a large portion of reallocation takes place between companies in the same sub-sector. The actual reallocation effects do not generally appear until a more detailed analysis is conducted. The GCEE has therefore conducted a **company-level analysis**, using the official company data for Germany (amtliche Firmendaten für Deutschland – AFiD) for the manufacturing sector for the period 1995-2013. A benchmark for company-level labour productivity – the logarithm of revenue per employee – can be determined on the basis of this data for all manufacturing sector companies with at least 20 employees. Using such panel data means that the same companies can be observed at different times, thereby enabling analyses of changes in company-level labour productivity over time.

The development of labour productivity in the manufacturing sector was broken down into the following components based on Foster et al. (2006). Firstly, a **company-specific contribution** was determined to measure productivity increases of existing companies. Secondly, a **reallocation effect** was determined which records the productivity gain resulting from the shift in relative significance of the number of employees in existing companies. Finally, the **specific contributions from entering and exiting companies** in the manufacturing sector were determined. New companies can raise manufacturing sector productivity if their recorded productivity is above the aggregate average. Companies winding up would have the same effect if they are unproductive businesses, and their exits would consequently raise average company-level labour productivity in the manufacturing sector.

The calculations show that **advance within companies** makes the **greatest contribution** to productivity growth. ↘ TABLE 29 This factor explains more than 80 % of productivity growth in manufacturing in the period since 1995. However, company-internal advance has obviously **slackened** in recent years. Company-internal factors accounted for more than 2.5 percentage points of the increase in labour productivity until 2010. Since then the growth contribution declined to 1.3 percentage points. The reallocation effects between existing companies in the manufacturing sector, in contrast, do not appear to play a large role. Productivity gains result instead from the **exit of unproductive firms**.

↘ TABLE 29

Growth contributions to labour productivity in manufacturing firms

Percentage points

Components	1995 – 2000	2000 – 2005	2005 – 2010	2010 – 2013
Average annual change (%)	**3,6**	**3,0**	**2,9**	**2,0**
firm-specific contribution	2,8	2,5	2,8	1,3
reallocation effect	0,2	– 0,1	– 0,1	0,2
new firms	– 0,1	– 0,2	– 1,2	– 0,6
exiting firms	0,6	0,9	1,2	1,1

1 – Labour productivity per person employed. Own calculations for firms with a minimum of 20 persons employed.

Source: Research Data Centres of the Federal Statistical Office and the statistical offices of the Länder, AFiD-Panel Industriebetriebe 1995 – 2013

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If we only consider the five-year period, companies newly entering the market appear less productive than existing ones. However, the negative effect of new entries in 1995 reverses when observing a ten-year horizon. **Newly entering companies** demonstrate **above-average productivity** in comparison to existing ones over this longer horizon. This could indicate that investments are necessary in the first few years and do not pay off until a later date when they result in higher labour productivity. New firms entering after 2005 show particularly low productivity. This may indicate that market conditions have deteriorated. A significant decline in businesses newly entering the market has also been observed in this period. During the period 1996-2004, an average of 6 % of manufacturing sector companies were new firms with more than 20 employees; this figure dropped to an average of 3 % for the period 2005-2013.

3. Barriers to competition in the service sector

616. Service sub-sectors contributed 69 % of aggregate gross value added in 2014, which put them far ahead of the manufacturing sector (23 %). In terms of **labour productivity** increase, however, service sub-sectors lag considerably behind manufacturing. While hourly productivity in the manufacturing sector averaged a 2.3 % p.a. increase in the period 1995-2014, service sector productivity rose by just 1.0 %.

The individual sub-sectors of the service industry experienced **very mixed** developments. While labour productivity in the information and communication technology sector has been rising disproportionately for years, and even exceeding the manufacturing sector's growth momentum, labour productivity in the remaining sub-sectors is stagnant or even declining. ↘ CHART 91, LOWER LEFT The results for business service providers as well as financial and insurance service providers are particularly negative. For the latter two sub-sectors the weak development was primarily caused by a drop in productivity in the year 2003. The financial crisis, in comparison, had little impact on the increase in labour productivity.

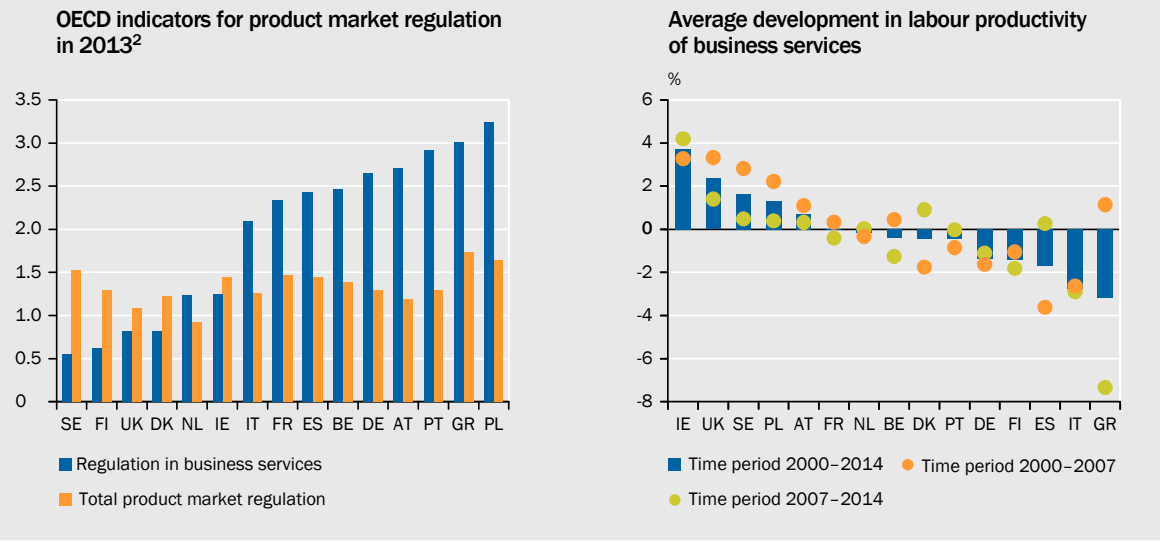
617. There are a number of explanations for the weak development in service sector productivity since the mid-2000s. Firstly, **labour market reforms** at the beginning of the millennium resulted in great numbers of less productive workers entering the market, primarily in the service sector. ↘ ITEM 600 Secondly, the weak productivity development – of business service providers in particular – was accompanied by the outsourcing of upstream production stages in the manufacturing sector. Former low-productivity activities in the manufacturing sector were outsourced to the service sector. ↘ ITEM 606FF.

618. Thirdly, developments of labour productivity in the service sector may have been underestimated due to **problems with regard to underlying data**. Measuring value added is far more difficult in this sector than in manufacturing, for example. Costs, wages and salaries are used to determine the value added of many service providers in the national accounts. Consequently, measuring increases in quality is very difficult; a hedonic price adjustment as for computer equipment is almost impossible. It is thus conceivable that quality increases in the service sector only materialise further downstream in the value chain, which means that the difference between manufacturing and service sector labour productivity is exaggerated.

619. Finally, the **high degree of regulation** and existing **barriers to competition** are likely to hinder advances in productivity. In an international comparison, the German service sector has an above-average degree of regulation, particularly in business services (OECD, 2014; European Commission, 2015). ↘ CHART 94 Regulatory obstacles that hamper competition persist in this sector, despite advances made to reduce them. According to economic research, competition is a key driver of productivity-boosting innovations.

↘ CHART 94

Indicators for product market regulation and labour productivity per hour of business services[1]



1 – Economic activities M and N from the German Classifiaction of Economic activities, Edition 2008 (WZ 2008): Professional, scientific, technical, administrative and support service activities. SE-Sweden, FI-Finland, UK-United Kingdom, DK-Denmark, NL-Netherlands, IE-Ireland, IT-Italy, FR-France, ES-Spain, BE-Belgium, DE-Germany, AT-Austria, PT-Portugal, GR-Greece und PL-Poland. 2 – Scale from 0 (non regulated) to 6 (highly regulated).

Sources: Eurostat, OECD

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620. A number of empirical studies in the literature have concluded that less red tape and a reduction in barriers to market entry have a positive effect on productivity. One strand of literature on this subject focuses on the **direct effects** deregulation has on productivity growth of companies, economic sectors and whole economies. The productivity effects under observation can be explained in economic terms by the elimination of barriers to market entry and increased competition. Companies streamline production processes, trim their cost structures, focus more strongly on customer needs and set incentives to harness economies of scope. This ultimately results in greater innovation activity, which leads to product improvements and price reductions.

621. Nicoletti and Scarpetta (2003), for example, find that reforms that raise competition increase productivity growth in 18 OECD countries, based on data for different economic sectors. Griffith et al. (2010) find for Europe, also based on data for different economic sectors, that the reforms to establish the EU domestic market have resulted in **more competition**, more investment in research and development and thus higher productivity growth. And finally, Aghion et al. (2004) analyse the impact of reducing market entry barriers through the establishment of the EU domestic market, based on corporate data for the UK. They conclude that more market entries by foreign firms have increased productivity of domestic companies and thus that of the overall economy.

622. In addition, market liberalisation can trigger **indirect effects** along the value chain. The central idea behind this assumption is that downstream processes benefit from cheaper and better products on deregulated intermediate product markets. This results in productivity gains in downstream production stages (Bourles et al., 2013; Forlani, 2010). As regards the significance of indirect effects, Dustmann et al. (2014) argue that a significant portion of the improvement

in German exporter's price competitiveness is due to the wage development in the service sector.

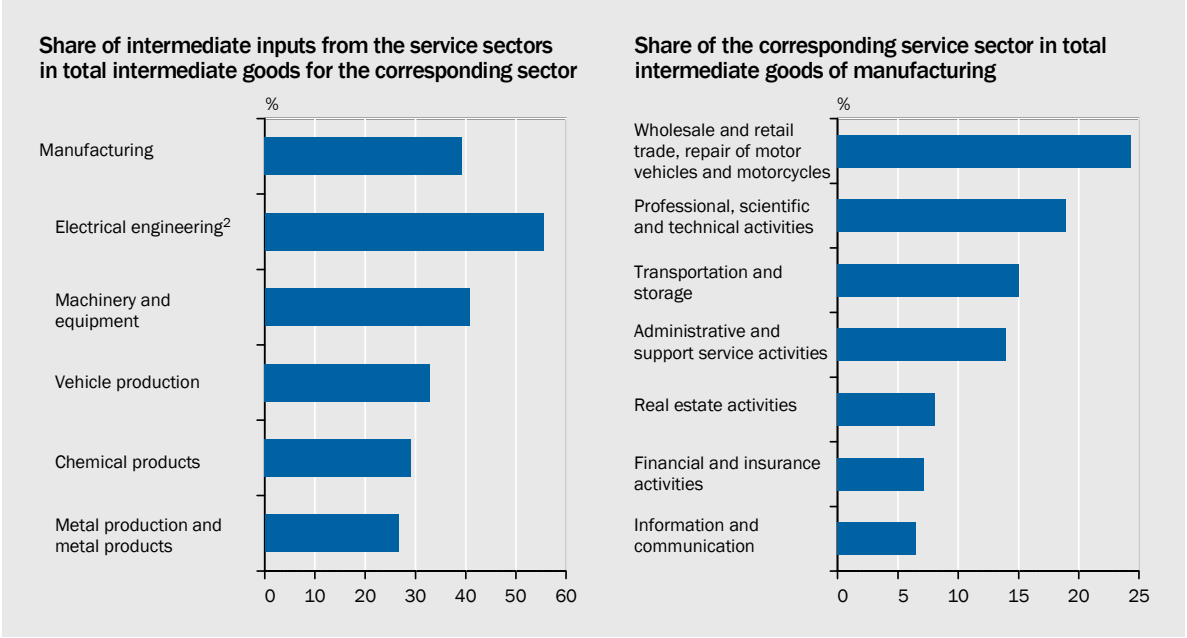
Services in Germany continue to constitute a significant portion of intermediate products for the manufacturing industry. ↘ CHART 95 The further reduction in existing regulations in the service sector could thus have positive effects on productivity in that sector and, by the same token, in the manufacturing sector.

623. International organisations (OECD, 2014; IMF, 2014, 2015b; Council of the European Union, 2015) and the Monopolies Commission have therefore called for the implementation of additional measures for **liberalisation of individual service sectors** in a number of reports for several years now. Overall, such liberalisation would have a noticeably positive impact on productivity development.

624. One reform proposal is aimed at further reducing **government stakes** in former state-owned companies such as Deutsche Telekom, Deutsche Post and Deutsche Bahn. These holdings could potentially create conflicts of interest and are thus a threat to competition (Monopolies Commission 2013a; 2013b, 2015a).

625. One such example is **freight and passenger transport**, in which Deutsche Bahn continues to have a dominant position. Several expert reports conclude that Deutsche Bahn's competitors are discriminated against via various channels (Monopolies Commission, 2013c, 2015a; OECD, 2014; European Commission, 2015). Discrimination results, for instance, from elements of the track pricing system that hinder competition, from more difficult access for competitors to the integrated ticket systems and from refused access to rail transport information and operating systems.

↘ CHART 95
Intermediate inputs from the service sectors into manufacturing in 2010[1]



1 – Direct and indirect intermediate inputs 2 – Manufacture of computer, electronic and optical products as well as electrical equipment.

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A **separation between infrastructure and transport operators** is called for in German rail transport to increase competition in freight and passenger transport (European Commission, 2013; Monopolies Commission 2013c, 2015a OECD, 2014). At least the regulatory authorities would have to be considerably reinforced to counteract discrimination against competitors (Monopolies Commission, 2015a).

626. Competition in the area of **postal services** is hampered by differing treatment of service providers' VAT. Whereas Deutsche Post is exempt from VAT due to its nationwide universal provision of postal services, regional providers are subject to VAT in full. The Monopolies Commission (2013b) advocates extending the VAT exemption to all universal providers in the short term, and to work towards a general elimination of VAT privileges in the long run.

627. In **mobile telephony**, the Organisation for Economic Co-operation and Development (OECD) points out that abolishing exclusive rights to issue SIM cards could unleash competitive potential (OECD, 2014). The crux of the criticism is that issuing SIM cards in Germany is currently restricted to network providers and that SIM cards cannot be reprogrammed to another mobile telephony provider once they have been issued.

In the first place, this prevents third-party providers, which could offer customers a variety of mobile telephony networks without changing SIM cards, from entering the market. Secondly, industrial customers, which install SIM cards in vehicles, are permanently tied to a single wireless network operator as changing providers would entail considerable cost. The OECD (2014) estimates that, in the automotive sector alone, abolishing exclusive rights could result in €1-2 billion in savings. This move would also significantly facilitate the installation of IT services in vehicles.

628. A further service sector criticised for excessive regulation is that of **professional service providers**. These include lawyers, tax consultants, engineers and architects. The first point of criticism is the existence of barriers to market entry that hinder competition. The OECD (2014) advocates, for example, reviewing compulsory memberships in professional and craft chambers to determine whether this creates barriers to market entry. Moreover, a new assessment should be undertaken to determine for which skilled crafts it is actually necessary to require a master craftsman diploma (Meisterbrief) in order to engage in that professional activity. The Monopolies Commission has actually advocated completely abolishing the requirement to hold master craftsman diplomas (Monopolies Commission, 2006). Other studies continue to justify such entry barriers on the basis of the hazardous nature of certain trades (Lageman et al., 2004).

The second point of criticism is directed at government **price regulation** for many professional services. Critics argue that consumer protection does not justify such price-setting, for instance, in the case of civil engineers and architects. Germany is the only country in the European Union that has official fee schedules for these professions. The OECD (2014) strongly calls for a market-based solution in this area.

629. In principle, the GCEE concurs in its assessment with the international organisations and the Monopolies Commission. For example, there are numerous barriers to entry in the service sector that prevent free competition and are detrimental to productivity advances. However, it is difficult to quantify how high the macroeconomic productivity gains could be if barriers to competition were reduced.

4. Interim conclusion

630. A sector-level analysis shows that the recent successful **integration of 3.4 million workers** into the German labour market was a major factor in significantly reducing labour productivity growth. It can be assumed that this kind of **composition effect** will play a lesser role in the macroeconomic labour productivity development in the next few years. Moreover, there continues to be considerable barriers to competition in the **service sector** that have a dampening effect on productivity growth.

631. In the manufacturing sector the **restructuring process** of the value chains seems to have come to an end since 2009. Companies in this sector achieved considerable productivity gains until 2008 by outsourcing labour-intensive value chain steps to other countries. There is no conclusive answer at this time regarding the causes of the development since the end of 2008.

II. PRODUCTIVITY AND INVESTMENT

632. Forecast regarding the productivity development are often accompanied by a discussion about **insufficient investment** in the Germany economy. High hopes are also pinned on productivity growth through **increasing utilisation of ICT** (Industry 4.0). However, it is evident that a significant expansion in fixed investment, especially in ICT, does not automatically result in higher productivity. A comparison with the US confirms that particularly the ICT-intensive sectors of the German economy have not been able to turn their ICT investments into productivity gains.

1. Discussion about symptoms

633. In the summer of 2014, the German government established a **commission of experts** to "boost investment in Germany". Their task was to develop policy recommendations to bolster private and above all public investment in Germany. In doing so, the commission should support economic policy in developing an **investment strategy** (BMWi, 2015a). The GCEE raised a critical voice in the public discussion on investment weakness (GCEE Annual Economic 2014 item 431ff.), mainly declaring that the discussion on "investments gaps" neither makes academic sense nor generates viable solutions for economic policy (GCEE

Annual Economic Report 2014 item 14ff., box 1). In particular, this discussion frequently created the impression that private investment volume can be arbitrarily controlled in a market economy by means of economic intervention, and does not result from rational decisions of private economic actors.

634. A central underlying assumption of the expert commission's work was that additional investment in physical capital creates the basis for productivity increases. In its final report dated April 2015, the expert commission diagnosed a **significant need to close the private investment gap** and cited the decline over time in the nominal investment ratio as one reason (Expert Commission, 2015). The expert commission also referred to international comparative studies that revealed an investment gap in Germany (DIW, 2013, 2014).

635. The focus on **investment ratios** can be explained by the fact that these are closely related to the growth rate of the real capital stock, which has a major impact on a country's potential output (GCEE Annual Economic Report 2014 box 10). By definition, the growth rate of the real capital stock in each period decreases by the depreciation rate and increases by the product of the investment ratio and the ratio of GDP to capital stock of the previous period. The latter number has amounted to 18 % since 2010, and, like the depreciation rate, fluctuates only negligibly over time. The investment ratio is thus the key driver for the growth rate of the capital stock.

Despite the major relevance of the investment ratio, direct **consequences for economic policy** can be drawn from neither an international nor an intertemporal comparison of investment ratios. On the one hand, there are considerable structural differences between individual national economies (GCEE Annual Economic Report 2014 box 2). On the other hand, and more importantly, capital formation is basically the sum of individual investment decisions. They are based on the prevailing conditions. The right benchmark for assessing the investment level can consequently only be an analysis of fundamental factors in the country in question. These include, for example, taxation of businesses ↘ ITEM 761FF., labour market regulation ↘ ITEM 566FF. and energy and climate policy. ↘ APPENDIX ITEM 696FF.

636. Moreover, the relationship between the aggregate nominal investment ratio and overall economic productivity is by no means trivial. Firstly, the analysis of investment ratios assumes that capital goods are **homogeneous goods**. Individual capital goods, however, differ considerably in terms of productivity and costs of utilisation. Technology-intensive investments in information and communications technologies as well as in research and development are likely to be more relevant for productivity than housing investments, for example. This could be one reason to explain why, despite high investments, no rise in labour productivity was observed in Spain in the first half of the 2000s.

637. Secondly, dramatic **price effects** are evident, particularly for ICT goods, which could result in misjudgements if the focus is directed purely at nominal investment ratios. ↘ ITEM 643 And thirdly, a focus on the investment ratio without taking account of the cost of human capital and other intangible expenditure (e.g. marketing and market research costs) has proven to be too narrow for a highly de-

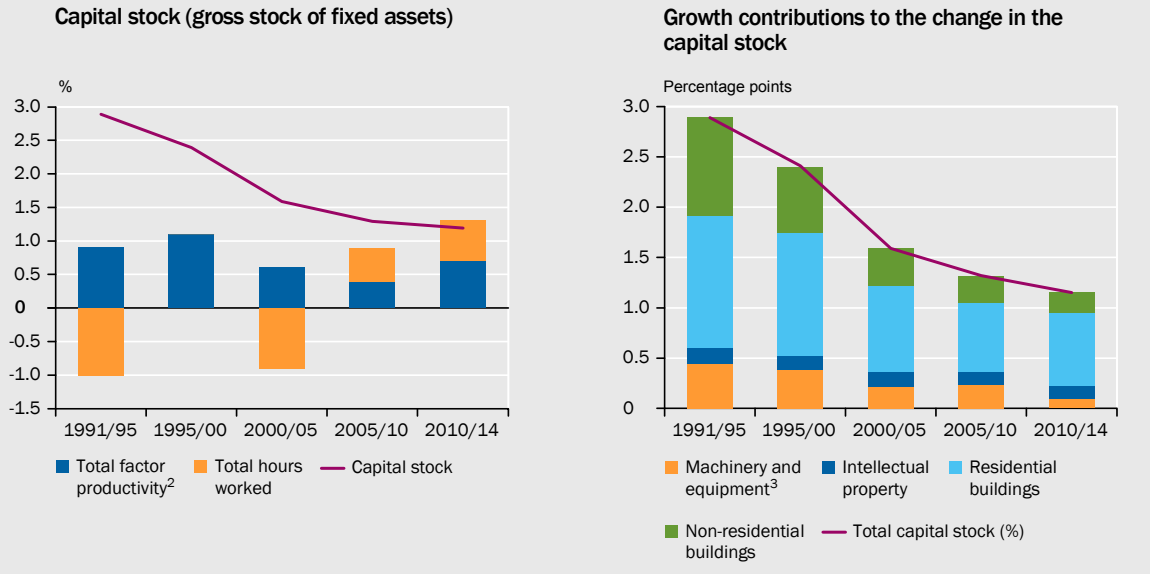
veloped country. This raises the question of whether an increasingly knowledge-driven economy still requires a high physical capital stock or whether other factors, primarily human capital (Lucas, 1988), are not much more important for long-term growth.

638. In terms of a potential investment weakness, an initial assessment of investment activity can be derived by employing the fundamental factors of **neoclassical growth theory**. This theory states that in a long-term equilibrium, the growth rate of the capital stock must be equal to the sum of the change rates of labour volume and total factor productivity. In Germany, the growth rate of capital stock has declined significantly over the past 25 years – most recently to around 1 %. However, for most of that period it was higher than the sum of the growth rates of labour volume and total factor productivity. ↘ CHART 96, LEFT

This decomposition also shows that **productivity development and investment development** are closely **interrelated**, but that the relationship is certainly not monocausal. The importance of labour supply to investment development also becomes clear. In light of demographic change the question whether a lack of workers, above all skilled workers, could cause the capital stock to decline will become more of an issue in the future.

639. In terms of **individual investment categories**, the expansion of the capital stock in Germany is largely due to gross fixed capital formation in construction. ↘ CHART 96, RIGHT A large portion of investments thus belongs to an investment category that is rather unimportant to labour productivity. On the other hand, a highly heterogeneous development has been observed among the "more productive" investment categories, notably since 2010. While investments in research and development have risen continuously since 1991, those in machinery and equipment have noticeably declined.

↘ CHART 96
Development of gross fixed assets[1]



1 – Average annual change. 2 – For calculation see Annual Economic Report 2014 Box 10. 3 – Including military weapons systems.

Source: Statistisches Bundesamt

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640. The **weak development of the real capital stock in machinery and equipment** is mainly due to the low investment in machinery. This development can be explained by cyclical and structural factors. Bleak sales prospects and the high uncertainty in recent years regarding euro-area economic growth likely put a damper on demand for machinery in the export industry. The change from a primarily industry-driven to an increasingly knowledge-driven economy is also likely to have caused a structural decline in machinery demand (Strobel, 2015).

2. Interdependence of investment and productivity

641. The relationship between investment and productivity is absolutely not monocausal. In the literature the discussion mainly focuses on **two channels** between investment and productivity advance (Greenwood et al., 1997; Fisher, 2006). The first is **neutral technological advance**, which reflects the changes in productivity given a certain input from factors such as labour and capital. This advance can result from changes in regulatory framework, better management, changes in corporate structures and product or process innovations (Syverson, 2011). Increasing neutral technological advances result in increasing demand for investment. In such case, causality moves from higher labour productivity to more investments.

642. The second is the possibility that new investments comprise technical advances and thus raise labour productivity. The expert committee refers to this channel in particular, which reflects the **technological advance embodied in capital**. This can manifest in price declines of certain capital goods compared to other goods in the economy. This relative price shift results in greater demand for these capital goods and is accompanied by short to medium-term growth in labour productivity. In this case, causality moves from higher investment to higher labour productivity.

However, for such technological advance to be embodied in capital, innovation must have first taken place in the capital goods area. Moreover, technological changes embodied in capital may also cause neutral technological advances by serving as the basis for process innovations such as changes in company management.

643. The clearest example of technological advance embodied in capital is ICT. For example, computer equipment price drops until 2009 caused **a decrease in the deflator** for gross fixed capital formation in machinery and equipment until 2008. Machinery and equipment prices fell by around 9 % between 1991 and 2008. However, as computer equipment prices have not fallen as dramatically since 2009, machinery and equipment prices are, on the whole, rising again. One key reason for this is likely to be the recent decline in technological advance due to the production of new ICT goods.

This development is not restricted to Germany, but encompasses almost all industrialised nations. Several studies (Gordon, 2012; Fernald, 2015; IMF, 2015a)

refer to the fact that the major productivity gains resulting most notably from the production of new ICT goods and peaking in the US around the turn of the new millennium, are now coming to an end. Germany's weakening productivity development could therefore turn out to be normalisation.

644. It should be noted that both types of technological advance should in the long term go hand in hand with an increase in capital stock. In terms of cyclical effects, GCEE calculations show that **neutral technological advance** as well as the technological advance embodied in capital can explain most short to medium-term changes in German labour productivity in the past. ↘ APPENDIX ITEM 705FF.

At the same time, both technological advances boosted gross fixed capital formation in machinery and equipment, although the **technological advance embodied in capital** played a more important role. In sum, neutral technological advances as well as those embodied in capital can explain 25-30 % of the variation of gross fixed capital formation in machinery and equipment. This is in line with the findings of Altig et al. (2011) and Smets and Wouters (2003).

3. Interim conclusion

645. An assessment of investment activity in the German economy shows that the capital stock growth rate has been equal to the sum of the change rates of labour volume and total factor productivity most of the time since 2010. With regard to **individual investment categories**, the growth of capital stock is largely due to housing construction, which is likely to have little impact on labour productivity. A highly heterogeneous development has been observed among the "more productive" investment categories, notably since 2008. While investments in research and development have risen continuously, those in machinery and equipment have noticeably declined.

646. It is not tenable to assume that a rise in investment in physical capital in itself would be a significant contributing factor to a major improvement in labour productivity. As regards productivity development the core areas of the investment debate have to change. Economic policy should focus primarily on creating a **favourable framework** on the **factor and goods markets**.

III. DIGITISATION AND PRODUCTIVITY

647. Great hopes for future increases in labour productivity are pinned on **digitisation**, not least as a result of debates on Industry 4.0. The German economy, however, has exhibited major deficits in the past as regards efficient utilisation of information and communications technology, raising the question of what needs to be done in order to unleash the full potential of ICT.

1. Impact on the overall economy

648. It is not just the amount of investment that is central to the development of productivity in the overall economy, but also the composition of that capital formation (Stiroh, 2001). **ICT investment** plays a particularly important role in raising productivity. Policymakers believe that the increasing use of ICT to create value (digitisation) holds great potential for increasing productivity in the future (Federal Government, 2014). However, the nominal share of ICT investment in gross value added in Germany has actually been on a **downward trend** since the turn of the millennium. It fell from 2.6 % in 2000 to 1.6 % in 2014. The picture is somewhat more positive once price effects are taken into account.

Other countries such as the US have been investing more in ICT (Cardona et al., 2013; IMF, 2015c), particularly between 1992 and 2005. The lower level of ICT investment in Germany is therefore cited as a major cause of the weaker growth in the country's labour productivity from the mid-1990s compared to that seen in the US (Eicher and Röhn, 2007).

649. Investments in ICT increase efficiency in two ways. Firstly, they have a **direct effect** on companies' productivity level. This may be reflected in improved production infrastructure, for example, and in the development of complementary factors such as intangible capital (management skills or organisational structure). As a ubiquitous technology, ICT also has an **indirect spillover effect** on the wider economy, increasing efficiency in other areas of production. The interaction between R&D activity and ICT is an important factor in innovation. Examples include cloud computing and Industry 4.0. ↘ ITEM 656FF. Transferring information via the Internet in particular has become much easier and quicker in recent years.

650. A variety of empirical studies back up the claim that ICT investment makes a major contribution to productivity growth. The literature uses two methods of measuring the contribution of ICT investment on labour productivity growth. One approach is to use **econometric estimates**, normally at company level, to determine the elasticity of value added to a change in the ICT capital stock. Cardona et al. (2013) summarise a large selection of these studies and conclude that a 10 % increase in ICT investments leads to an increase in production of approximately 0.5 % to 0.6 %. They also find that this elasticity has trended upwards in recent years.

651. Alternatively, economists use **growth accounting** to determine ICT's contribution to the development of aggregate productivity. ↘ APPENDIX ITEM 710FF. Productivity growth is initially broken down at sector level into its three inputs: total factor productivity, capital and labour. The capital factor of production is then broken down again into ICT capital and non-ICT capital. In addition, a distinction is made between ICT-producing (approximately 5 % of total gross value added in 2013), ICT-intensive (around 39 %) and other sectors (around 56 %). ↘ TABLE 31 ICT-intensive sectors are those that have a relatively high level of ICT capital, but do not produce ICT themselves.

652. Older studies show that the ICT-producing and ICT-intensive sectors made relatively low contributions to the growth of labour productivity in the overall economy in Germany compared to the US (Eicher and Röhn, 2007). An updated analysis with data up to 2013 produced the following findings with regard to the importance of ICT to labour productivity in the economy as a whole:

– The contribution to productivity growth by the **ICT capital input** has **declined** since the period 1991-1995. ↘ CHART 97, LEFT

– **Technological progress in the economy as a whole** (total factor productivity) is driven primarily by the **ICT-producing sectors**, not by the ICT-intensive sectors. ↘ CHART 97, RIGHT Less than 5 % of total gross value added therefore explains almost half the increase in total factor productivity.

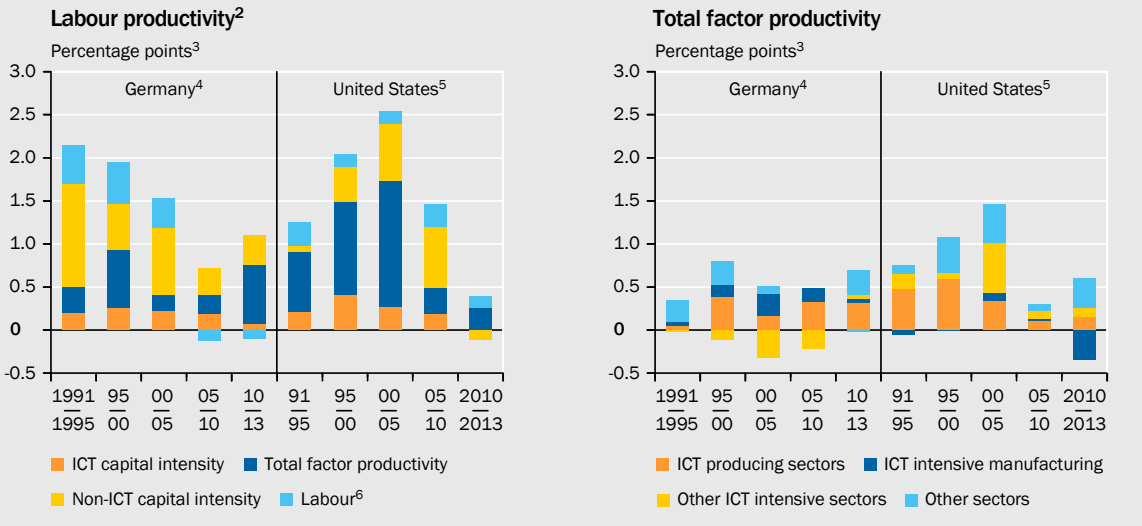
– In the **ICT-intensive sectors**, there has been only a **moderate increase** in total factor productivity. These sectors are thus far behind the ICT-producing sectors.

653. In the latter aspect in particular, the trend in Germany has been very different to that seen in the **US economy**, where major increases in total factor productivity in ICT-producing sectors were followed around the turn of the millennium by large increases in ICT-intensive sectors (Eicher and Strobel, 2008). In the US, neutral technological progress through product innovations at **ICT-producing companies** has, firstly, resulted in technological progress embodied in the capital used by ICT-intensive companies. This has led to a higher ICT capital intensity.

Secondly, new ICT goods have triggered innovations at **ICT-intensive companies**. These have led to an increase in total factor productivity at these com-

↘ CHART 97

Comparison of the contributions to labour productivity and total factor productivity between Germany and the United States[1]



1 – Data for United States: own calculations. 2 – Labour productivity per hours worked. 3 – Average annual growth contributions. 4 – Calculations based on the updated study of Eicher and Röhn (2007). 5 – Own calculations based on data for private economy transferred to total economy. 6 – Labour quality and reallocation of hours worked.

Sources: BEA, ifo

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panies (neutral technological progress). To that end, not only new products, but also more efficient structures of administration and production may have made a particular contribution. This development has primarily taken place in the service sector, primarily wholesale and business services. However, technological advances in ICT-intensive sectors have flattened out since the mid-2000s.

654. In **Germany**, ICT appears to have had **hardly any spillover effects** on ICT-intensive industries outside the manufacturing sector (ICT productivity paradox). However, this paradox applies only in the service sector. In manufacturing, by contrast, there have been efficiency gains. For the sake of future labour productivity, Germany should seek to identify the barriers to higher productivity in the ICT-intensive service sector.

655. One possible explanation could be the low level of **complementary investment**. This includes spending on further training of staff, intangible expenditure (for example on corporate restructuring), and investment in product design and market research. An alternative explanation for the ICT productivity paradox could be the different management structures of the two countries. In Germany, management has a greater reliance on rigid employment structures rather than flexible components of remuneration as in the US. High regulation of product and labour markets may also be a factor (Bloom et al., 2012; Bartelsmann et al., 2010). Moreover, it can be assumed that the acceptance of new technologies and the new business models associated with them will tend to decline in an ageing society.

2. Industry 4.0 – the fourth industrial revolution?

656. "Industry 4.0" has become one of the buzzwords of the public debate on the digital revolution. The term refers to the complete digitisation and networking of value chains in the manufacturing sector using **information and communication technology**. The process has been triggered by enormous improvements in IT hardware. The rapid increase in processing power and storage capacity have enabled large volumes of data to be analysed quickly with the help of intelligent algorithms (Bertschek, 2015).

Industry 4.0 essentially describes an increase in total factor productivity in the manufacturing sector, which is made possible by innovations in products and processes and triggered by greater use of ICT. Compared to the US, Germany has had few problems in using ICT efficiently in this sector of the economy. ↘ ITEM 652FF.

657. The technological innovations resulting from Industry 4.0 primarily affect activities in the manufacturing sector via three channels: firstly, progress in ICT means that physical objects such as robots, machinery and components can communicate with one another directly via the Internet. These **"cyber-physical systems"** can help to make production processes flexible and customised, which reduces set-up costs when changes to production processes are necessary. This means that average costs are lower and no longer fall as the pro-

duction volume increases. In other words, economies of scale lose their significance and mass production loses its advantages over customised manufacture.

In the medium term, this type of process innovation could even have an impact on the international division of labour. A fall in domestic costs due to greater capital intensity would mean that stages of production no longer need to be outsourced to other countries. However, this is unlikely to explain the recent increase in vertical integration observed in manufacturing. ↘ ITEM 605FF.

658. Secondly, businesses hope that the improved data available will **stimulate innovation for new products**. Communicative interaction between product and producer enables the creation of new, larger datasets. Companies will now be able to draw on experience and data collected on products as customers use them throughout their useful lives.

659. Thirdly, the customer data collected can be used to provide particular **services by producers** in the manufacturing sector. This could change existing business models, giving a greater role to ICT-supported services. Digitisation is therefore likely to unleash new growth potential in the service sector. All in all, there are a wealth of opportunities for achieving greater product differentiation and tapping new markets.

Value added is likely to shift increasingly towards information technology in the future. High-quality machinery in the manufacturing sector will still be needed, but linking it to ICT and IT services will become increasingly important.

660. There is already public debate on the potential that digitisation of manufacturing could unleash the **fourth industrial revolution**. The first three industrial revolutions involved mechanisation using water and steam power (first), mass production using electrically powered assembly lines (second) and the use of electronics and information technology to further automate production (third). However, there is no general consensus as to the precise timings of previous industrial revolutions or even as to their number.

661. One of the main reasons for this is likely to be that there is no **generally accepted definition** of an **industrial revolution**. However, the largely uncontested aspects are likely to include major increases in labour productivity and substantial upheavals in labour and goods markets (Gordon, 2012). This leads to the emergence of new professions and products, as well as the disintegration of old business models and social structures. Traditional occupations, working models and products come under pressure, meaning considerable adjustment costs are possible on the labour market in particular. These are usually manifested in changing requirements for employee training and skills.

662. Company surveys have not indicated much in the way of a tangible fourth industrial revolution to date. According to a study by the Centre for European Economic Research (ZEW), only around one in five companies are familiar with the term Industry 4.0 and only 4 % of the companies are currently implementing or planning Industry 4.0 projects (ZEW, 2015). Familiarity with the term Industry 4.0 depends greatly on the size of the company. Half of the companies with more

than 500 employees were aware of Industry 4.0 and a quarter are planning or already implementing Industry 4.0 projects. Such planned or existing Industry 4.0 projects are most widespread in the ICT sector (21 % of the companies), electronics (15 %) and mechanical engineering (14 %).

A survey of mechanical and industrial engineering firms by the Cologne Institute for Economic Research (IW) conclude that the **digital transformation** is **not yet of particular importance** to many companies. Three-quarters of the businesses surveyed in these sectors had not yet taken steps to implement ideas related to Industry 4.0 or had only done so sporadically (IW, 2015).

Past industrial revolutions differed from political revolutions in that they took place over a relatively long period of time. In a sense they were evolutionary rather than revolutionary. Company surveys indicate that we can expect the same from Industry 4.0 (Hüther, 2015).

663. The quantitative **effects** of increasing digitisation through Industry 4.0 on aggregate **labour productivity** are extremely difficult to assess. Studies published in the past are unconvincing in their methodological approach and should only be interpreted as rough estimates at best. The German Association for Information Technology, Telecommunications and New Media (BITKOM), for example, expects cumulative productivity gains of up to 30 % by 2025 in certain sectors of the economy (Bauer et al., 2014).

However, BITKOM's conclusions about the potential for change through Industry 4.0 are based on interviews with just eight experts and the sector-specific value chains linked to them. Although the future consequences of Industry 4.0 cannot be reliably quantified, there is no doubt that the integration of ICT in automation processes in the manufacturing sector has the potential to substantially improve labour productivity.

3. Role of economic policy

664. The digital transformation offers a great potential for increasing labour productivity. It is already making its mark in today's labour market, bringing changes to the professional landscape, forms of employment and the employee skill structure in demand. ↘ ITEM 545FF. Policymakers must create a **suitable framework** to ensure that businesses can implement this transformation successfully. This means addressing regulatory issues such as data protection, norms and standards. It is particularly important to focus on the European level rather than simply seeking national solutions.

665. The digital revolution should not be hindered at national level by overly rigid regulatory barriers. The **high level of regulation** on the product and labour markets suggests that there are obstacles to productivity (Bloom et al., 2012; Bartelsmann et al., 2010). Making remuneration more flexible and labour markets less rigid is likely to boost competition between innovative companies, give businesses more freedom and thus unleash potential for higher productivity.

666. **Expanding broadband networks** also has the potential to raise productivity. Czernich et al. (2011) have shown that increasing broadband coverage across the population is capable of lifting economic growth. The commission of experts tasked with bolstering investment in Germany is calling for a major expansion of very high-speed (up to 1 Gbit/s), but also very expensive fibre optic connections (Expert Commission, 2015). However, as Falck et al. (2013) found, **demand for high-speed Internet connections** is not keeping pace with supply. Few households seem to be requesting broadband speeds of more than 50 Mbit/s to date (Dialog Consult and VATM, 2014).

667. The German Federal Government aims to make **broadband networks with download speeds of at least 50 Mbit/s available across the board**. However, the costs and benefits of potential public subsidies must be weighed up carefully, especially in rural areas. Furthermore, given the rapid development of the technologies involved (e.g. wireless technology), it would be premature to convert the majority of broadband infrastructure to fibre optics. The relatively high cost of fibre optic connections in comparison to other technologies might subsequently prove to be an expensive mistake (TÜV Rheinland, 2012). Extensive public subsidies for widespread expansion of the fibre optic network should therefore be rejected.

668. **Education and training policy** is another area for political action in relation to digitisation. It plays an important role in enabling all parts of society to participate in technological advances, and in raising average individual productivity. Education policy should aim to teach people essential IT skills at an early stage, especially in secondary schools. This means better equipping schools with IT infrastructure and developing digital teaching strategies for staff and pupils (OECD, 2015).

Further education programmes should also be available to help adults gain IT skills. Taking advantage of the potential offered by digitisation and technological change ultimately depends to a large degree on complementary investment in human capital. This can help to increase acceptance of new technologies and the new business models they bring with them – a highly relevant issue in an aging society.

IV. INNOVATION IN GERMANY

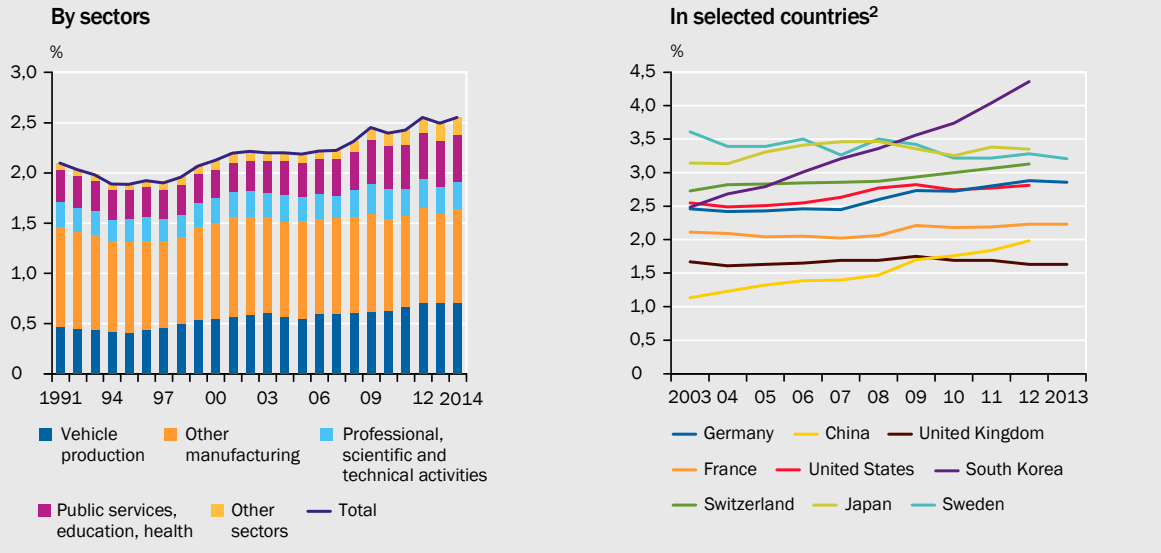
669. An economy's **level of innovation** is of great importance for the development of aggregate productivity. Particularly, the relevant question is to which extent existing and new companies are able to develop novel products or to reduce their production costs by improving the technologies used.

1. Assessing innovation

670. Efforts to increase innovation in an economy can be assessed with the help of figures on **R&D investments** and the **number of patent applications**. While these can both be measured in objective terms, it should be noted that they only provide a rough indication of innovation. High R&D spending, for example, does not necessarily guarantee marketable products in return. When it comes to patent applications, one difficulty is that many process and product innovations, large and small, are not included in the figures as they are either not patented or not patentable. Moreover, patents are increasingly being used as a strategic tool and do not always reflect increased innovation activity.

671. Both of these indicators give a **positive picture** of **innovation in the German economy**. ↘ CHART 98 Innovative activity, measured using R&D investment and the number of patent applications, shows an upward trend and is above average internationally (EFI, 2015). Private sector R&D investment made up more than 2 % of GDP in 2014.

↘ CHART 98
Investment in research and development[1]



1 – In relation to nominal GDP. 2 – Sources: OECD, Eurostat. Calculations of Lower Saxony Institute for Economic Research (NIW) in Schasse and Leidmann (2015).

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The majority of R&D investment is attributable to the manufacturing sector (almost 64 %), with automotive manufacturing largely driving the increase in R&D spending since the early 1990s. At €20 billion, R&D spending makes up more than half of all investment in the automotive sector. The positive picture painted by R&D investment must, however, be relativised by the future challenges of demographic change and the comparatively modest development of new companies.

672. R&D investment in recent years has shifted towards research-intensive industries and larger companies (Eickelpasch, 2015). In contrast to large companies, **small and medium-sized enterprises** (SMEs) have considerably reduced investment in innovation as a share of revenue compared to 1995 (EFI, 2015). There remains major uncertainty regarding the causes of this trend. They could lie in poorer financing conditions for R&D activities after the financial crisis and expiry of the support offered by the government stimulus packages. The trend may also be the first effects of the demographic change (EFI, 2015).

2. Challenges of the demographic change

673. In the medium term, demographic change is set to have an increasingly detrimental effect on the German economy's potential to innovate. There are two reasons for this. Firstly, the **supply of young people** available to enter innovative professions – mathematicians, engineers, scientists and technicians – will decline. This will have a negative impact on both the potential for innovation and labour productivity.

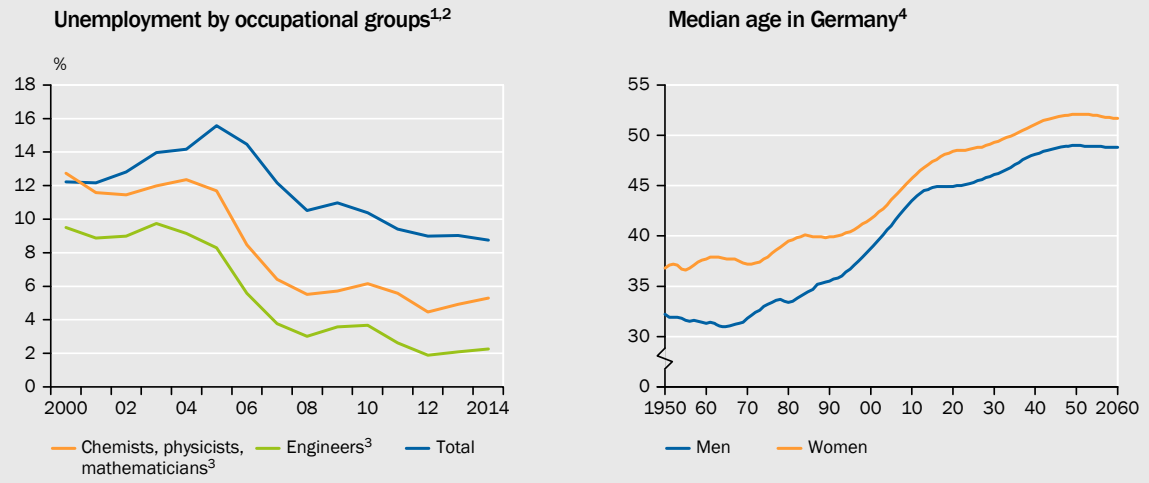
Fewer people will complete vocational training, which will reduce the ability to innovate in the long term. In the short term, moreover, potential for innovation will not be fully exploited if the demand for innovative talent cannot be met. As recently as the turn of the millennium, unemployment among engineers was at around 10 %, only slightly lower than the rate in the wider economy. Today, there is almost full employment in this occupational group. ↘ CHART 99, LEFT

A **shortage of engineers** is expected in the next few years, particularly given that there are now already two engineering vacancies for every unemployed engineer (VDI and IW, 2015). This situation is not expected to change in the medium to long term due to the decline in the working-age population over the coming decades. On a macroeconomic level, this scarcity is likely to result in higher wages for engineers in a trend that will be further fuelled by the retirement of the baby boomer generation from 2020 onwards.

674. Secondly, it is likely that an **ageing society** will tend to reduce the **average level of innovation per worker**. The median age for men and women began to increase substantially in the mid-1990s. ↘ CHART 99, RIGHT This trend is set to continue. Between 2010 and 2050, the median age for men is expected to increase by five years from 44 to 49, and for women by six years from 46 to 52.

↘ CHART 99

Demographic change and potential for innovation



1 – Unemployment rate is calculated as officially registered unemployment divided by the sum of employment subject to social security contributions and officially registered unemployment. 2 – Since 2005, data for unemployment are incomplete as local municipalities attend to some unemployed persons who receive the basic support for job-seekers according to the Second Book of the Code of Social Law (SGB II). 3 – Due to changes in the job classification, data from 2012 onwards are not fully comparable to previous years. 4 – 1950 to 1989: former Federal Republic of Germany and German Democratic Republic combined, since 1990: Germany. As of 2011, calculations are based on the preliminary results of the population projection based on the Census 2011. As of 2014: results of the 13th coordinated population projection for Germany, variant 2: continuity with higher migration (long-run net migration of 200 000 persons per year).

Sources: IAB, Statistisches Bundesamt, VDI

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675. However, **individual labour productivity** is not only a product of the ability to innovate, but also of experience. The German Council of Economic Experts has discussed the link between labour productivity and age in detail in its Expertise on the challenges of demographic change (GCEE Expertise 2011 item 156ff.). The **"labour productivity curve"** describes the relationship between the age and individual productivity of a worker. Age affects productivity through two opposing factors:

- The so-called **fluid intelligence**, including the ability to grasp unfamiliar concepts, solve problems in original ways and a willingness to learn, declines with age. These skills are key to innovation.
- Meanwhile, **crystallised intelligence**, including linguistic dexterity, an eye for the big picture and breadth of knowledge, increases with age (Paqué, 2012).

Researchers are divided as to the extent to which an individual's loss of fluid intelligence is compensated by crystallised intelligence as they get older (GCEE Expertise 2011).

676. However, **fluid intelligence** has much greater potential than crystallised intelligence to spill over to other individuals and companies through innovations. This makes it the more important form of intelligence to the economy as a whole. A decline in the proportion of young workers therefore has a negative impact on innovation. Feyrer (2007) has shown the extent of the **macroeconomic impact** of demographic change on labour productivity for the United States. The number of people in the 40-49 age cohort increased by roughly 5 % in the US between 1980 and 1990. This cohort makes the greatest contribution to productivity growth. The 5 % increase in size resulted in an annual increase in

productivity of 1.5 % p.a. Aksoy et al. (2015) predict that Germany will see a decline in annual per capita GDP growth of 0.6 percentage points between the last decade and the present decade as a result of demographic change.

677. In the years following the turn of the millennium, the **considerable increase in the average age** of the labour force was not yet fully noticeable as it was relatively easy to replace those retiring with unemployed skilled workers. This will become more difficult in the years ahead as there are ever fewer skilled workers available in the labour market. Companies can nonetheless be expected to find ways of tackling the future shortage of young people. Corporate structures may change, for example, to allow younger workers to concentrate on tasks in which they can contribute their fluid intelligence.

678. A willingness and ability to adapt to changing requirements as a result of structural and technological change will be particularly important to integrating people into the labour market sustainably throughout their working lives. This may mean that workers have to complete a second round of vocational training later in their career. Retraining and further education are likely to play a major role in the future and can be organised with the help of **flexible working time models**. Traditional remuneration structures are also likely to change in response to a shortage of workers with fluid skills. The wages of more innovative, younger employees may thus increase disproportionately in the future.

679. **Wage-negotiating parties** within companies should support and encourage this **structural change**. Policymakers should actively promote the mobilisation and continuing education of older workers and avoid creating regulations that hinder the flexible adjustment of corporate structures. Increased participation of women in the labour market, mobilisation of young people without training qualifications and an influx of young, skilled workers may also help to increase the potential for innovation.

3. Young companies and start-up financing

680. Young companies are **very important** for an economy. International studies show that, measured by their R&D intensity, they are more innovative than companies that have been in existence for longer (Acemoglu et al., 2013). In addition, due to the competition they create established companies increase their innovation activity and labour productivity, particularly in technology-intensive areas (Aghion et al., 2009). Young businesses also play a key role in job creation (Criscuolo et al., 2014).

681. Among young companies, **start-ups** likely make a particularly large contribution to increasing productivity in the overall economy. Start-ups are characterised by innovative ideas and strong revenue and employment growth (Ripsas and Tröger, 2015). But they only represent a minority of new companies founded. The proportion of newly founded companies with regional or nationwide innovations was just 16 % in 2014 (Metzger, 2015). The total number of founders was roughly 900,000.

682. **Entrepreneurial momentum** in Germany has decreased in the past few years and is now only average in European terms (EFI, 2015). The possible causes of this trend include **demographic change** and the **healthy labour market situation**. During times of high unemployment, the lack of adequate job opportunities in paid employment can be a motive for founding a business; many potential founders are likely to avoid entrepreneurial risk at times of high employment (Bersch, 2015).

683. The just average level of company foundings compared to other countries could also be a result of the **education system**. For example, a large number of founders of companies told Deutscher Startup Monitor (DSM) that they see numerous deficits in entrepreneurial skills imparted in the university system and particularly in the school system (Ripsas and Tröger, 2015). It would therefore be interesting to evaluate the extent to which education policy could contribute to a better entrepreneurial culture (Falck and Fichtl, 2013). Furthermore, many successful high-tech start-ups have been set up around excellent research universities (Stanford, Berkeley, MIT, Harvard).

684. The poor entrepreneurial momentum is often discussed in relation to a lack of **start-up financing**. The relatively low availability of venture capital (VC) compared to other countries is noted as one factor. Venture capital is a category of equity financing (private equity) where venture capitalists provide funding to young companies for a limited period and at the same time in some cases additionally provide advice. The return on venture capital does not typically take the form of a regular dividend, because young companies generally make losses in the early stages; instead it comes in the form of profit on the later sale of shares in the company (**exit**).

685. Venture capital totalling €646 million was invested in Germany in 2014, which is equivalent to 0.02 % of gross domestic product (BVK, 2015). A clear **home bias** can be seen here. According to DSM's survey results, a good 77 % of venture capital comes from German investors (Ripsas and Tröger, 2015). At the same time, the investment volume of private equity companies based in Germany was only €563 million. It can be concluded from this that only a small amount of German venture capital has flowed into foreign start-ups.

686. The **funding of companies** differs **across their life cycles** (Berger and Udell, 1998), depending on the mechanisms available at each point to overcome problems of asymmetrical information. In the early stage, young businesses typically have no option other than to finance themselves with their own funds (including funding through family or friends) or through business angels, as they have no track record or collateral. At this stage, the risk that profitable investments will not be made due to a lack of funding is particularly high (Scholtens, 1999). It is not until later that funding channels open up via financial intermediaries, in the form of either venture capital (VC) or borrowing (bank loans).

687. In order to increase the supply of private venture capital for young companies in Germany, the state has set up **numerous lending support programmes**. There are three key public programmes for start-ups depending on the company's stage of development:

– Funding in the pre-foundation stage (**seed financing**): public funding is provided through the High-Tech Gründerfonds (high-tech founder fund). The Federal Ministry for Economic Affairs and Energy and the Kreditanstalt für Wiederaufbau (KfW) participate in the fund.

– The **start-up phase**: KfW is investing €400 million in private venture capital funds through the ERP Venture Capital Fund in the next five years, thereby attempting to mobilise a total volume of €2 billion. In addition, KfW has established the ERP Start-up Fund, which invests directly in start-ups taking holdings of up to 50 %. KfW provides €225 million for this.

– The ERP/EIF growth fund of €500 million is used for growth financing (**follow-up financing**) (BMWi, 2015b). The aim is to mobilise funding in the two-digit million range for each start-up in collaboration with private venture capital providers. The specifics of how this will be implemented are still unknown.

688. **Public financial support** for start-ups – for instance in the form of tax subsidies and subsidised lending programmes – is justified by **positive external effects** on innovation activity and economic growth. The fundamental problem of any public financial support is, however, that this could **crowd out** private funding, or that funding would go to **projects** considered **unprofitable** in economic terms and there would thus be a misallocation of capital. Comprehensive financial support of young businesses can therefore not be justified.

689. The empirical evidence on the efficiency of public financial support is limited. Brander et al. (2014) show a **complementarity** between private and state-supported VC projects on the basis of a global data set. Joint funding by private and state-supported VC increases the funding volume relative to a VC project with just private funding. VC projects funded entirely by the state rank lowest in terms of volume. The evidence also suggests that the probability of a successful exit is higher in the case of joint funding. Promoting VC can thus have a notable positive impact. General crowding out does not occur. In view of this evidence, **co-funding models** where the state does not assume the first loss tranche alone could be a good idea, meaning that market signals guide the selection of projects.

690. At the same time, empirical evidence shows that the design of the financial system and particularly the **institutional framework** of a country are key factors for explaining the hurdles in corporate financing (Beck et al., 2006). Promoting a start-up-friendly environment can also make an important contribution to improving the funding of young companies.

In Germany, for example, there is a lack of **exit prospects** for venture capital providers, which is partly due to the generally weakly developed capital market (Beck et al., 2015). Selling shares in as yet unprofitable young businesses on the secondary markets or the stock exchange frequently proves difficult. This problem could be handled by creating a pan-European stock exchange segment for growth-oriented companies (EFI, 2015). This is a core component of the **European Capital Market Union**. ↘ ITEM 435FF.

691. In addition, the **tax framework** may explain the lack of willingness to provide more equity. German corporate tax law penalises equity financing. The GCEE has for a number of years, therefore, been suggesting an **allowance for corporate equity** in order to remove this distortion (GCEE Annual Economic Report 2012 item 385ff.). ↘ ITEM 728FF.

However, policymakers are trying to make venture capital funding more attractive through an **investment subsidy**. This refunds 20 % of their equity investment tax-free to private investors (up to €250,000 a year) if they invest at least €10,000 in young, innovative companies and hold the investment for at least three years. The effectiveness of this programme is, however, doubtful. **Removing tax distortions** would appear much more sensible than creating new areas of subsidisation.

V. CONCLUSION

692. Two structural developments have contributed to the significant decline in German productivity growth in the past few years. Firstly, more than 3 million people have been **successfully integrated into the German labour** market since 2005. Many of these employees exhibit comparatively low productivity. Secondly, the **process of restructuring** the value chains in the manufacturing sector may have come to an end. The vertical integration in manufacturing has not decreased any further since the recession in 2009.

However, it is still too early to make a final assessment of this latest development because there is **high uncertainty** as regards the causes. For example, improved labour market conditions in Germany could have induced multinational companies to bring some of their production back into the country. However, it is also conceivable that the vertical integration rebound was due to the impact of the financial crisis or an increase in protectionism.

693. There is a close relationship between developments in labour productivity and **prosperity** in an economy. An important task of economic policy is therefore exploiting unused potential and creating **suitable conditions** for facilitating sustainable productivity increases. For example, there are numerous barriers to entry in the service sector that prevent free competition and therefore impede productivity advances. Excessive regulation of the product and labour markets could explain why investments in ICT cannot fully exploit their productivity-increasing potential.

694. In addition, expanding **technological knowledge** in the economy is an important source for increasing labour productivity. Harnessing the full potential of the German innovation system is therefore a core task of economic policy. This requires the provision of comprehensive infrastructure for innovations covering the aspects of education, research and transfer of knowledge (GCEE Annual Economic Report 2009 item 380ff.). In the next few years, the question of

how the still high number of innovative employees in Germany can be retained or even increased through, for example, **education and training** despite the demographic change will become more prominent (GCEE Annual Economic Report 2009 item 441ff.).

695. Successfully implementing innovative ideas through start-ups is very important for productivity advances. However, there may be problems in **start-up financing**, as the availability of venture capital for young companies is relatively low compared to other countries. A suitable institutional framework could help to improve the financing of young businesses. This includes further developing the European stock exchange segments for start-ups and removing tax distortions, particularly by introducing an allowance for corporate equity. This is always preferable to creating new areas of subsidisation.

APPENDIX TO THE CHAPTER

1. Energy policy: Economically viable climate protection

696. According to a broad academic consensus, economic activities are now exhausting the limits of what the planet can take or have already exceeded these limits (Enquête Commission, 2013). The climate change is one of the most urgent challenges. This is made plain by the imminent **climate summit in Paris**, where once again a global climate treaty will be on the agenda (Cramton et al., 2015). The global warming we face can likely only be limited if a global alliance for effectively reducing the emission of greenhouse gases is successfully forged (GCEE Annual Economic Report 2011 item 403ff.; acatech et al., 2015).

The European Union has resolved to play the pioneering role in this endeavour and is therefore seeking a comprehensive **restructuring of the energy sector** in Europe, which is – as specified in the targets of the Federal Government's energy concept (2010) – technologically efficient and low emission and largely relies on renewable energies. However, simply having introduced this restructuring will not suffice. Climate change cannot be effectively limited through purely national or regional efforts to limit emissions in Europe, nor is it very promising to rely on other countries taking similar action merely due to Europe's pioneering role (Academic Advisory Council to the German Federal Ministry of Finance, 2010).

697. In fact, **economic efficiency** should not be ignored in this comprehensive project that is expected to take decades. This is because from an economic perspective, this restructuring represents an investment with considerable costs already arising today that must be borne by households and businesses in the present, but with largely uncertain rewards that will be reaped in the future. Current energy policy decisions will decide how high the costs are. This will only be copied

in the international community if these costs can be demonstrated not to lead to major economic disadvantages.

With the Renewable Energy Act (Erneuerbare-Energien-Gesetz – EEG), which is designed as a measure of **national industrial policy**, policymakers have given unconditional priority to the technology-specific expansion of renewable energies in a manner not limited by the integration capability of the system (GCEE Annual Economic Report 2011 item 422ff., Monopolies Commission, 2011). This strategy has been maintained thus far despite considerable criticism by academics and without further consideration of constructive alternative models with non-technology-specific support for renewable energies, such as consideration of the quota model presented by the German Council of Economic Experts (GCEE Annual Economic Report 2011 item 431ff., Monopolies Commission, 2011). None of the attempts to curb the cost explosion associated with the EEG have produced a decisive reversal (GCEE Annual Economic Report 2014 item 35). On the contrary, the recent major expansion of wind farms off the German coast and particularly on shore is likely to cause costs to rise further.

698. The EEG has meant that the proportion of renewable energies has risen sharply in Germany in the past few years. This development has also led to a **rising renewable energy surcharge** that has in particular caused the retail price of electricity to rise. The surcharge will climb to a record level of 6.345 cents/kWh next year. However, because electricity spot market prices have fallen, the retail electricity price is likely to stay largely flat at a high level next year (electricity spot market price plus renewable energy surcharge).

699. This purely national strategy is not very convincing from a climate policy viewpoint, because the EU has already had an effective instrument for climate protection in the **Europe-wide Emissions Trading System (EU-ETS)** in the energy and industry sectors since 2005. This could serve as an effective steering mechanism for a European climate protection strategy (GCEE Annual Economic Report 2011 item 432). European countries aim to jointly lower their CO_2 emissions by 40 % by 2030 compared to 1990 with the EU-ETS. In particular, the EU-ETS enables countries outside the EU to join the system and thus gradually extend the alliance against climate change (EU Directive 2009/29/EC; Ellerman et al., 2014). The EU-ETS would also be an excellent instrument for economically efficient European energy policy if future climate protection agreements were to agree on a global price target instead of a volume target (Cramton et al., 2015).

700. The EU-ETS is conceptually convincing as a support tool for the European energy transition, because it **leaves** the specific implementation of the **measures** needed to avoid emissions to **market players**, but nevertheless effectively caps emissions: compliance with the emission cap will certainly be maintained. This cap can also be reduced further and further over time. For example, the plan is to lower the cap by 2.2 % per year from 2020 onwards. Emission trading ensures cost-efficient climate protection; by trading certificates, the most cost efficient measures for avoiding emissions are implemented while expensive measures are omitted. Measures for avoiding emissions will not amount to anything more

than the expansion of renewable energy capacity. The EU-ETS does not micromanage what renewable energy capacity is created and where. The gradual reduction of the emission allowances issued tends to increase their price and thus makes investment in climate-friendly technologies more attractive (Diekmann, 2012).

701. In practice, however, the EU-ETS has yet to meet expectations. When **defining the path** for the emission cap, neither the major financial and economic crisis of recent years nor the enormous expansion of renewable energy capacity in electricity generation was foreseen. In addition, credits from international projects that are granted as part of clean development and joint implementation measures are particularly responsible for the current large surplus of emission certificates (Andor et al., 2015). The decrease in price of emission allowances resulting from the sum of these influences triggered a controversial debate in the EU, and appeared to corroborate the views of supporters of additional national support schemes for renewable energies. Ultimately the only way to establish the EU-ETS as a climate policy steering mechanism in the EU will likely be to extend it to more sectors than the ones already covered, i.e. particularly to the fields of transport and heating, and to **stabilise the price signal** (Böhringer and Lange, 2012).

The European Parliament has decided to introduce a market stability reserve (MSR) to stabilise prices. This adjusts the annual supply of allowances to be auctioned by temporarily taking certificates out of the market. The effect of the MSR is, however, not likely to be felt for several years (Gibis et al., 2015). In addition, there are doubts about its effectiveness because the system still includes an excess of certificates. More promising are suggestions to introduce a price corridor for emission certificate auctions (Fell and Morgenstern, 2010; Wood and Jotzo, 2011; acatech et al., 2015) or to reduce the number of excess certificates through an one-off intervention (Andor et al., 2015).

702. In order for the EU-ETS to take full effect as a steering mechanism, **distortions as a result of national support programmes** must also be removed, for example the EEG's support for renewable energies in Germany. This is because managing the volume of emission allowances at EU level means national programmes only lead to a redistribution of emissions (Monopolies Commission, 2015b). To achieve the target of global CO_2 reduction cost-efficiently, however, the expansion of renewable energies should be pursued in the countries with the most suitable sites.

In addition to ending the national support programmes and market integration of renewable energies, the **European internal electricity market** can be strengthened by increasing cross-border transmission capacity. This would avoid electricity shortages and further harmonise electricity prices in Europe (Schaber et al., 2012). The introduction of capacity markets to guarantee security of supply should be rejected, at least as long as overcapacity still exists in the short to medium term. Interventions in the generation capacity of power stations ("redispatch") and the introduction of regional, cross-border electricity price zones can be used to reduce regional electricity shortages and electricity

overcapacity. This would create incentives to expand generation capacity in regions with greater supply insecurity.

703. The Federal Government still has the option of putting global climate protection at the heart of its efforts in the context of the energy transition and thus giving this important social project a greater chance of success. This kind of about-face in energy policy would, however, require a considerable shift of focus to the **European perspective** embodied in the outlined expansion of the EU-ETS, while firmly moving away from the national industrial policy that has thus far been followed in the area of renewable energies. The upcoming reform of the EEG in 2016 could be used to this end. The national support for renewable energies should be ended completely in future, or at least, if the political power in this arena dominated by vested interests is not sufficient to do this, be made technology-neutral (GCEE Annual Economic Report 2014 item 36, acatech et al., 2015).

If the Federal Government decided on this route, it could in future avoid repeatedly having to create **new areas of subsidisation**, which the currently prevailing national focus compels it to make, and which needlessly make the energy transition more expensive. An example of this is the dispute vehemently fought in 2015 between the Federal Ministry for Economic Affairs and Energy and the major energy suppliers about the electricity sector expanding its involvement in emission reduction. This is now to be achieved by means of transferring older lignite power stations into a reserve at an expected cost of €230 million per year, and later decommissioning them (BMWi, 2015c). It is irrelevant for climate protection how emissions are saved, it only matters that their volume is systematically reduced – which the EU-ETS achieves.

704. Similar considerations apply to the costs associated with ending the use of nuclear energy in Germany. According to a recent expert report, the €38 billion in provisions created by the energy sector for **dismantling nuclear power stations** and disposing of the fuels is enough to fulfil their legal obligations (Warth & Klein Grant Thornton, 2015). However, the question as to whether these provisions will remain sufficient when needed is under discussion. For example, an expert opinion commissioned by Alliance 90/The Greens, suggests that the corporate groups' assets are insufficient to cover these long-term costs and will, moreover, continue to decrease (Irrek and Vorfeld, 2015). The groups' provisions should therefore also be transferred into a fund regulated by public law, as should not only securities and cash, but the ownership of tangible assets and holdings in the grid and energy distribution sector, in order to be available for future payments and long-term liabilities.

This is the wrong approach in the view of the GCEE. Instead, drastic state interventions in the private property of companies should be limited to cases of actual insolvency of utilities providers operating nuclear power stations. We are still a long way away from that though. Currently, policymakers should instead concentrate on energy and climate policy that puts **economic efficiency** at its core and does not neglect it as a sideshow. This is the only way in which Germany can successfully play a pioneering role in global climate protection.

2. The cyclical effects of changes in technology

705. The question of how changes in technology will impact macroeconomic variables in the short term is disputed in **current business cycle research**. On the one hand, there are the supporters of real business cycle theory (Kydland and Prescott, 1982; Long and Plosser, 1983), who believe that technology shocks are the driving force in economic cycles. On the other hand, there are authors such as Galí (1999), who see technological changes as playing an insignificant role in macroeconomic fluctuations. There are also studies (e.g. Smets and Wouters, 2003), that fall between these two positions.

706. A vector autoregressive (VAR) model is estimated to get an impression of the influence that neutral technological productivity shocks and technological productivity shocks embodied in capital have on **German labour productivity** and investment activity. The VAR model has four variables: logarithmised labour productivity measured as gross domestic product in relation to labour volume, the logarithmised relative price between the deflators of gross fixed capital formation in machinery and equipment and gross domestic product, capacity utilisation in the manufacturing sector and the logarithm of real gross fixed capital formation in machinery and equipment.

The first two variables are necessary to be able to distinguish between a neutral productivity shock and a productivity shock embodied in capital. Taking capacity utilisation into account is intended to serve the purpose of checking for demand effects, which also impact labour productivity. The model is estimated in differences for the quarters from the beginning of 1970 to the beginning of 2015. The estimation also includes looking for a trend in the differences.

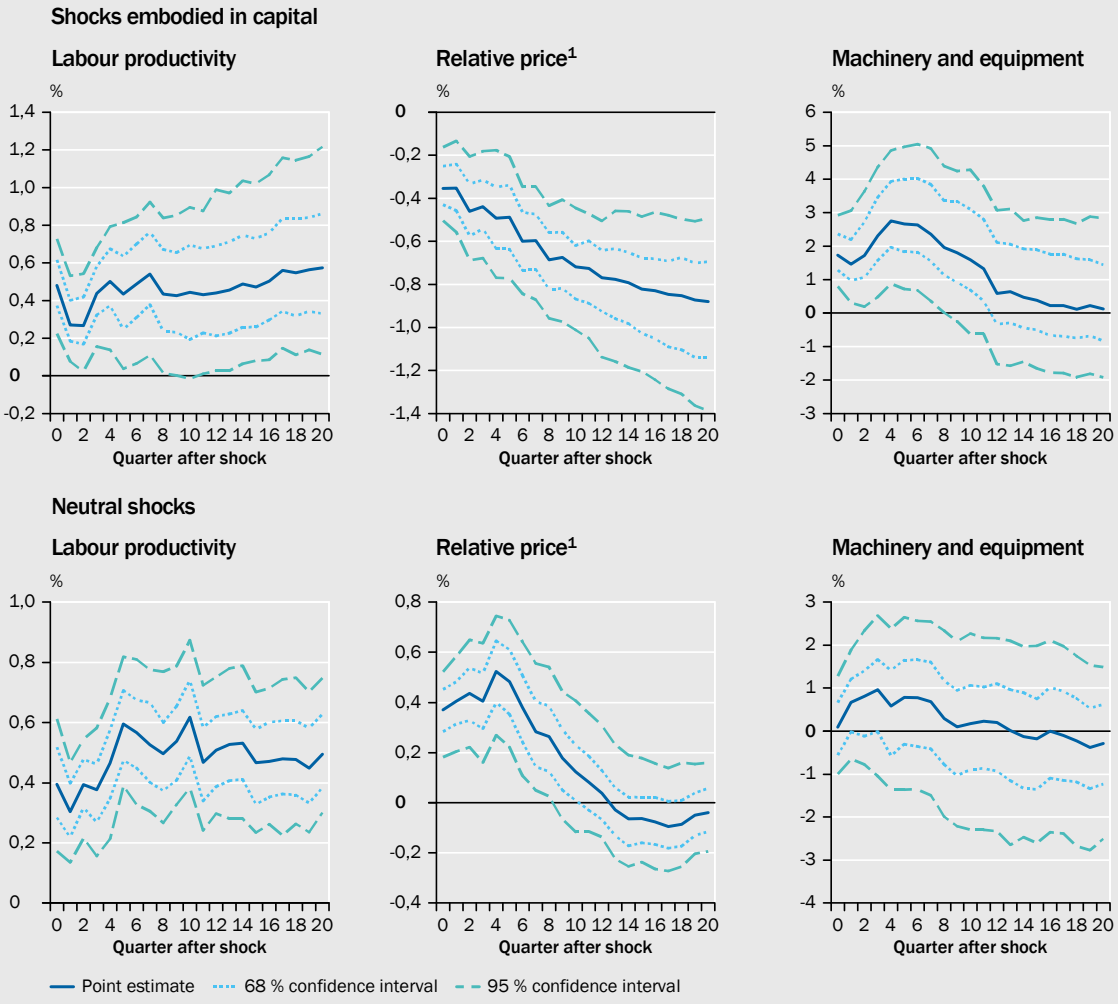
707. The **identification** of neutral technological progress and technological progress embodied in capital is carried out based on Fisher (2006) and Altig et al. (2011). Both studies assume that only technological changes influence labour productivity in the long run. In order to distinguish between the neutral productivity shocks and the productivity shocks embodied in capital it is also assumed that only the latter have a permanent influence on the relative price between the deflators of machinery and equipment and of GDP.

The assumption that only productivity shocks influence labour productivity in the long run is disputed. For example, endogenous growth theory holds that factors other than productivity shocks can also lead to a long-term rise in labour productivity (Uhlig, 2004). In addition, changes in the taxation of investment income or shifts in preferences regarding working hours can result in permanent changes to labour productivity.

708. The findings show that labour productivity rises immediately after a positive technology **shock embodied in capital**. ↘ CHART 100 As a result of such a shock, prices for machinery and equipment fall in comparison to the GDP deflator. Gross fixed capital formation in machinery and equipment also increases. After the capital stock has adjusted, it falls again and reaches its original level after around 16 quarters. This is in line with the predictions of a neoclassical growth

↘ CHART 100

Effects of technology shocks on various economic indicators



1 – Deflator of machinery and equipment in relation to GDP deflator.

Source: own calculations

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model. A rise in labour productivity can also be observed for a **neutral technology shock**. However, this causes prices for machinery and equipment to rise in relative terms. In addition, the effects on gross fixed capital formation in machinery and equipment are positive but not significant.

709. **Variance decomposition** can be used to quantify the roles that the two types of technological progress play for gross fixed capital formation in machinery and equipment. It can be seen that neutral technological progress and technological progress embodied in capital together explain 25 % to 30 % of the variation in gross fixed capital formation in machinery and equipment, although technological progress embodied in capital plays the more important role. This is in line with the findings of Altig et al. (2011) and Smets and Wouters (2003).

3. Growth analyses: Study of causes at sector level

710. The findings of the **growth analysis** in the main body of the chapter are based on an update of the study by Eicher and Röhn (2007). For a detailed description

of the calculations see this source. Only the most important points underlying the findings in the text are discussed below. The growth analysis is performed at **economic sector level** and unbundles labour productivity, measured as gross value added per hour worked, into its input components. Accordingly, macroeconomic labour productivity is equivalent to the weighted total of these input components; the weightings for each economic sector reflect their relative share of macroeconomic output.

711. In detail, the **growth rate of labour productivity** for the individual industry i, $\Delta \ln y_i$, results from the rate of change of the total factor productivity, $\Delta \ln A_i$, the change in the average skill level of the labour force, $\Delta \ln E_i$, and the percentage adjustment of ICT capital intensity, $\Delta \ln c_i^{ICT}$, and non-ICT capital intensity, $\Delta \ln c_i^{NICT}$. Instead of capital stock, the concept of capital intensity (effective use of the capital, capital services) is used. Capital intensity is the product of capital stock and productivity of the relevant capital goods (measured by the user cost of capital).

712. The information regarding ICT and non-ICT capital intensity can be determined from the ifo Investment Database (Strobel et al., 2013). This database enables differentiation between three ICT and nine non-ICT capital goods groups at sector level. The three ICT capital goods groups are (i) office machinery, computer equipment and devices, (ii) telecommunications, radio and television sets, electronic components and (iii) software. All economic sectors that manufacture these goods are classified in the group of ICT-producing sectors of the economy. It is also possible to use the data to differentiate between ICT-intensive and other sectors of the economy. Those sectors whose ICT share of overall capital intensity is higher than the median of all sectors of the economy are labelled ICT-intensive sectors. ↘ TABLE 31 summarises the classification of the industries into the relevant groups.

713. The **growth equation** for a single sector can be defined as follows:

$$\Delta \ln y_i = \nu_i^{ICT} \Delta \ln c_i^{ICT} + \nu_i^{NICT} \Delta \ln c_i^{NICT} + \nu_i^{L} \Delta \ln E_i + \Delta \ln A_i .$$

The individual rates of change of the input variables of capital intensity and quality of work are each multiplied by their share of the sector's total costs (factor income shares) – ν_i^{L}, ν_i^{ICT} and ν_i^{NICT}. The aggregated contributions to growth for labour productivity in the overall economy can be derived from the weighted totals of the individual input components across industries. The results are shown separately for ICT-producing sectors, ICT-intensive sectors and other sectors of the economy. ↘ TABLE 30

↘ Table 30

Growth contributions to labour productivity by economic sectors

Percentage points

	1991 – 1995	1995 – 2000	2000 – 2005	2005 – 2010	2010 – 2013
Labour productivity (%)[2]	**2.2**	**2.0**	**1.5**	**0.6**	**1.0**
Reallocation of hours worked	**0.3**	**0.5**	**0.1**	**– 0.3**	**– 0.1**
Labour quality	**0.1**	**– 0.0**	**0.3**	**0.1**	**– 0.0**
ICT capital intensity	**0.2**	**0.3**	**0.2**	**0.2**	**0.1**
ICT producing sectors	0.1	0.0	0.0	0.0	0.0
ICT intensive sectors	0.1	0.1	0.1	0.1	0.0
other sectors	0.0	0.1	0.1	0.1	0.0
Non-ICT capital intensity	**1.2**	**0.5**	**0.8**	**0.3**	**0.3**
ICT producing sectors	0.1	0.0	0.0	0.0	0.0
ICT intensive sectors	0.5	0.2	0.1	0.0	– 0.0
other sectors	0.5	0.3	0.6	0.3	0.4
Total factor productivity	**0.3**	**0.7**	**0.2**	**0.2**	**0.7**
ICT producing sectors	0.1	0.4	0.2	0.3	0.3
ICT intensive sectors	0.0	0.0	– 0.1	– 0.1	0.1
other sectors	0.3	0.3	0.1	– 0.0	0.3

1 – Deviation in total sum can be due to rounding. 2 – Average annual change. Calculations based on the updated study of Eicher and Röhn (2007).

Source: ifo

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↘ Table 31

Development of labour productivity by economic sectors in %[1]

	Share of gross value added (2013)	1991 – 1995	1995 – 2000	2000 – 2005	2005 – 2010	2010 – 2013
ICT producing sectors						
Computer, electronic and optical products	1.3	4.7	11.4	10.0	9.4	5.7
Telecommunications	1.0	11.4	16.3	5.1	12.6	6.0
IT and information services	2.6	0.0	4.5	1.0	5.3	9.3
ICT intensive sectors						
Chemical products	1.6	8.2	4.9	3.9	2.2	– 4.2
Pharmaceutical products	0.9	9.0	4.3	8.2	1.4	1.0
Electrical equipment	1.7	3.2	3.2	0.1	2.1	– 2.2
Machinery	3.5	4.0	1.8	1.8	– 1.2	– 0.9
Motor vehicles, trailers and semi-trailers	4.0	1.8	– 2.4	4.0	6.1	2.6
Other transport equipment	0.5	– 2.4	10.5	5.3	4.4	– 2.9
Furniture and other goods	0.9	– 0.4	1.9	1.0	1.2	1.8
Rep. a. installation of machinery a. equipment	0.6	6.4	7.5	7.8	– 4.2	0.0
Wholesale (excluding motor vehicles)	4.6	2.0	3.1	7.8	– 0.7	2.1
Retail (excluding motor vehicles)	3.3	0.7	0.7	– 0.2	2.0	– 0.1
Water transport	0.3	12.2	15.4	14.5	6.3	4.4
Air transport	0.2	11.6	4.7	– 5.2	0.9	–11.5
Postal and courier activities	0.5	– 0.5	2.8	– 1.2	0.4	1.2
Publishing, audiovisual and broadcasting	1.3	3.8	3.4	– 0.2	0.8	1.9
Financial services	2.6	0.6	4.6	– 1.2	0.7	2.5
Insurance and pension	1.0	4.4	– 7.1	–28.8	1.9	– 1.9
Activities auxiliary to financial and insurance services	0.6	– 1.1	–11.7	– 7.1	– 3.3	–10.7
Professional, scientific and technical services	6.1	– 0.1	– 2.7	– 2.2	– 2.8	– 1.0
Other business services	4.8	– 0.2	– 0.8	0.1	– 2.3	0.9
Repair of computers a. personal a. household goods	0.1	5.1	4.4	– 3.5	– 0.8	– 0.1
Other sectors						
Agriculture, forestry and fishing	0.8	– 5.1	5.4	2.8	1.8	2.2
Mining and quarrying	0.2	7.5	– 0.9	– 2.0	6.8	– 3.6
Food, beverage and tobacco processing	1.6	– 0.9	0.5	– 1.2	– 1.1	3.7
Textiles and apparel industry	0.3	6.0	3.4	3.8	2.0	– 0.1
Wood, cork, except furniture; straw, plaiting materials	0.2	5.8	3.2	2.5	– 0.7	– 2.5
Paper and paper products	0.4	0.3	4.6	1.7	2.5	3.0
Printing and reproduction of recorded media	0.3	1.8	2.3	2.0	3.0	2.4
Coke and refined petroleum products	0.2	–30.1	6.5	– 1.1	– 4.3	–21.2
Rubber and plastic products	1.0	3.4	2.0	3.5	2.3	0.5
Other non metallic mineral products	0.6	5.7	2.2	2.3	0.2	2.3
Basic metals	0.8	7.2	4.4	– 0.2	– 1.6	3.5
Structural metal products	2.0	1.2	2.9	1.1	1.0	1.4
Electricity, gas, steam and air conditioning supply	2.0	5.2	8.0	3.4	2.1	– 3.1
Water collection, treatment and supply	0.2	3.8	3.4	1.0	0.0	1.1
Sewerage, waste treatment; materials recovery	0.8	– 8.8	– 5.5	1.5	– 0.4	2.5
Construction	4.5	– 1.0	0.4	0.4	– 0.4	0.2
Wholesale, retail trade, repair of motor vehicles	1.6	– 2.5	1.5	5.5	0.0	1.6
Land transport and transport via pipelines	1.9	5.5	3.3	0.6	1.3	1.2
Warehousing and support activities for transportation	1.8	1.3	1.4	8.8	0.2	1.3
Accommodation and food service activities	1.5	– 2.7	– 1.3	– 1.2	– 2.5	2.7
Real estate activities	11.2	2.0	– 0.2	3.6	1.4	2.7
Public administration; compulsory social security	6.2	3.4	2.0	1.3	1.8	2.7
Education	4.5	0.7	– 0.3	– 1.2	– 1.8	– 1.8
Human health and social works activities	7.4	1.7	1.9	1.0	1.3	1.4
Arts, entertainment and recreation	1.4	– 1.7	– 0.7	– 1.7	– 0.8	1.4
Activities of membership organisations	1.1	3.7	2.3	0.1	0.6	1.2
Other personal service activities	1.3	1.9	– 2.6	– 0.0	– 1.0	– 2.0

1 – Average annual change. The calculations are based on an update of the study by Eicher and Röhn (2007).

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