DEUTSCHE BUNDESBANK
EUROSYSTEM

Research Brief

65th edition – May 2024

Digital transformation and its impact on labour productivity

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Digital transformation creates scope to make workflows and production processes more efficient. To quantify the impact of digital transformation on labour productivity, research often focuses on investments in digital technologies. This perspective neglects the fact that digital intermediate inputs, such as microchips or integrated software, also represent an important transmission channel for the efficiency gains from digitalisation. Our analyses based on a multi-sectoral model show this for Germany, France and the United States. Cumulative labour productivity growth in these countries over the period from 1996 to 2020 would only have been about half as high without the efficiency gains from the digital sectors.

Previous work on the impact of digitalisation on labour productivity has often focused on the role played by investments in digital goods. This includes, for example, the acquisition of computers for commercial purposes. Digital products, though, are used not only as capital goods but also represent important intermediate inputs, such as microchips and integrated software. In Germany, France and the United States, around half of the goods produced in the digital sectors serve as intermediate inputs. Besides the information and communication sector, the digital sectors also comprise parts of the manufacturing industry such as the "manufacture of computer, electronic and optical products". The latter includes, for example, the production of graphics cards, microprocessors and the like.

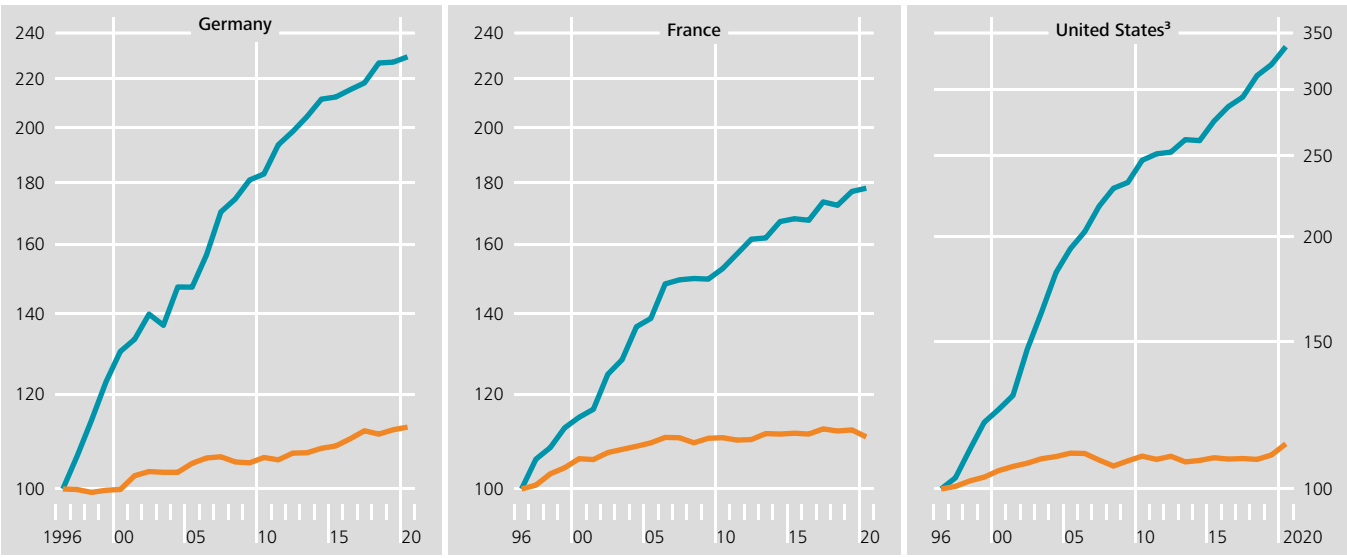
Use of digital goods* — Table 1

	Germany	France	United States
Consumption	0.31	0.26	0.24
Investment	0.16	0.17	0.25
Intermediate inputs	0.53	0.57	0.51

Source: World Input-Output Database, data for the year 2000.
* Use of goods produced in the digital sector (share of gross output). The digital sector consists of NACE divisions C26 and C27 and NACE section J.

Total factor productivity in digital and non-digital sectors*

Figure 1



Source: Bundesbank calculations based on EU KLEMS and European Commission data. * Total factor productivity (TFP) was calculated using a Solow decomposition and adjusted for changes in utilisation using survey data about capacity utilisation. **1** NACE divisions C26 and C27 as well as NACE section J. **2** NACE sections C (excluding C26, C27 and C19), D-I, K, M-N, R-S. **3** For the United States, changes in average weekly hours worked are used to approximate changes in utilisation.

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Analysis of sectoral efficiency changes in a macroeconomic model with a production network

Our study takes this into account and examines how efficiency gains in the digital sectors have impacted on labour productivity in Germany, France and the United States via production linkages. Efficiency gains in a given branch of economic activity are measured here in terms of total factor productivity (TFP) growth rates. The latter reflect the part of sectoral output growth that is not attributable to changes in the inputs used. Estimates show that TFP growth in the digital sectors was exceptionally high in recent decades (see Figure 1).

To quantify the aggregate impact of these efficiency gains, we use a multi-sector dynamic general equilibrium model in which the economic sectors are interconnected through production linkages: products from one sector are not only used for consumption or investment but also serve as intermediate inputs for production in other sectors. The various intermediate inputs have only limited substitutability. Production flows between individual branches of economic activity are calibrated based on macroeconomic input-output tables. The latter provide information on production linkages in an economy.

Efficiency gains in the digital sectors are important but so, too, is their diffusion via digital intermediate inputs

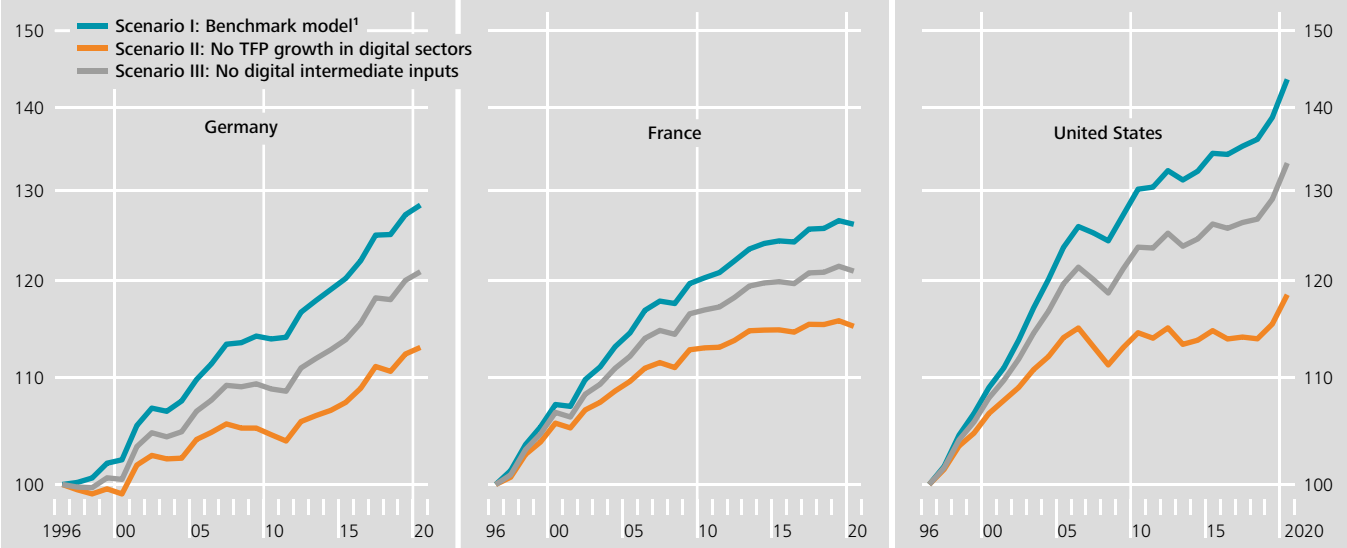
Specifically, we start by feeding observed TFP growth rates of all economic sectors into the model. We then compare the simulated path of aggregate labour productivity with that of a counterfactual scenario. In the counterfactual scenario, it is assumed that there was no TFP growth in the digital goods-producing sectors of the economy during the period under review. The comparison reveals that TFP growth in the digital sectors had a considerable impact on aggregate labour productivity growth. Without the efficiency gains in these branches, US labour productivity growth would have been about 25 percentage points lower between 1996 and 2020, despite the comparatively small share of the digital sectors' production in total gross value added. Similar results were found for Germany and France, where productivity growth would have been around 15 percentage points and 11 percentage points lower, respectively. Digital transformation has thus been a major driver of labour productivity in recent decades.

In a second scenario, we show that digital intermediate inputs are a key transmission channel for efficiency gains in the digital sector. Here, we assume that digital products can be used only for consumption or investment purposes, but not as intermediate inputs. Figure 2 shows that productivity growth would be significantly lower without digital intermediate inputs.

Importance of digital sectors for aggregate labour productivity*

Figure 2

1996 = 100, log scale



Source: Bundesbank calculations based on EU KLEMS data and the World Input-Output Database. * Digital sectors comprise NACE divisions C26 and C27 as well as NACE section J. Other sectors covered are NACE sections C (excluding C26, C27 and C19), D-I, K, M-N, R-S. 1 Plots the development of labour productivity based on the sectoral TFP paths and a model with eight sectors.

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The simulation scenarios described above can also be conducted for other sectors of the economy. That exercise reveals that the non-digital sectors of manufacturing as well as the trade and transportation sectors have also made significant contributions to labour productivity growth. However, these economic sectors are significantly larger than the digital sector in terms of their share of total gross value added. Relative to its size, the digital sector has a disproportionally large impact on aggregate labour productivity growth.

Conclusion

The digital transformation has exerted a strong impact on aggregate labour productivity growth in recent decades. Our analyses based on a multi-sectoral macroeconomic model reveal that, absent the efficiency gains in the digital sectors, labour productivity growth in Germany, France and the United States between 1996 and 2020 would only have been about half as high. Production linkages play a key role in this regard. These ensure that the remarkable efficiency gains made in the digital sectors are passed on to end consumers via value chains. The extent to which this happens depends not only on the magnitude of the digital efficiency gains but, crucially, also on the relative importance of digital intermediate products. To increase the latter, continued efforts should be made to expand the digital infrastructure and digitalise businesses on a broad scale.

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News from the Research Centre

Publications

"Direct, Spillover and Welfare Effects of Regional Firm Subsidies" by Nils Wehrhöfer (Deutsche Bundesbank), Sebastian Siegloch (University of Mannheim) and Tobias Etzel (Deutsche Bundesbank) will be published in the *American Economic Journal: Economic Policy.*

"Nowcasting GDP with a pool of factor models and a fast estimation algorithm" by Sercan Eraslan (Deutsche Bundesbank) and Maximilian Schröder(BI Norwegian Business School) will be published in the *International Journal of Forecasting*.

Events

26 – 27 June 2024
8th Annual Macroprudential Conference, jointly organized by Deutsche Bundesbank, De Nederlandsche Bank and Sveriges Riksbank, Eltville am Rhein

04 – 05 July 2024
International Conference on Payments and Securities Settlement, Eltville am Rhein