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THE DIGITAL TRANSFORMATION OF MANUFACTURING INDUSTRY– A SCENARIO ANALYSIS FOR GERMANY

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Table of Contents

1 Introduction

Looking back in time, the economy has been exposed to fundamental changes and transformation each induced by different factors: introduction of mechanical production facilities (first industrial revolution), electronic energy (second industrial revolution) or internet technology (third industrial revolution). Currently, the economy might be at the edge of a similar drastic transformation through the introduction of cyber physical systems (CPS). What is called in Germany “Industrie 4.0” or Industry of Things (IoT), describes the fusion between physical and virtual world in the production process through interconnecting men, machines, products, objects and internet and communication technologies.

Until today, in Germany, IoT is not yet realized, still unknown to a majority of small and medium sized enterprises (DIE WELT 2014) and little evidence and expertise exist that is able to describe the impact of a digital transformation on the economy (BITKOM 2014, Reflex Verlag 2014, PWC 2014). In order to close this gap, this paper presents a first attempt to capture the economic effects of IoT on the economy in Germany in the long run.

A sophisticated scenario has been developed that addresses especially the following parameters: (i) cost structure, (ii) change in inventory (iii) gross fixed capital formation, (iv) supply chain and (v) private and state consumption, (vi) export. Using the macro-econometric input-output model QINFORGE (Interindustry Forecasting Germany), these parameters are altered according to inputs taken from the literature, expert interviews and own expertise. The scenario assumes a slow transformation process that is realized not before 2025. The results are compared to a baseline scenario with no IoT assumptions.

The results indicate that a digital transformation of the economy leads to a higher growth path. The growth impact is accompanied with a decline in imports which is a positive side effect for a commodity-poor country such as Germany. However, additional growth comes along to the disadvantage of employment. Until 2025, a total of 10,000 jobs are lost. Albeit this is a small number, the digitization supports sectoral change: Especially the agriculture and manufacturing sectors lose jobs, whereas employment is generated in service sectors.

2 Modelling Approach

This paper applies the econometric input-output-model QINFORGE that has been developed by the Institute for Economic Structures Research (GWS) in close collaboration with three other German labour market research institutions: Institute for Employment Research (IAB), Federal Institute for Vocational Education and Training (BIBB) and Fraunhofer Institute (FIT). Together, the four institutions form the QuBe-research consortium that is let by the BIBB and IAB. The aim of the QuBe-project (www.qube-projekt.de) is the long-term projection of labour demand and supply by occupational fields and qualification levels (Maier et al. 2014a, Zika et al. 2012).

The methodology is extensively described in Maier et al. (2014b). The most important aspects relevant for the analyses are repeated in this chapter.

The model belongs to the INFORUM family of modelling (Almon 1991) that rests on two basic fundamentals: Bottom-up construction and total integration. The former indicates that each industrial sector is modeled individually and that macroeconomic variables are calculated through explicit aggregation. This approach ensures that each individual sector is embedded within the economic context and that industrial interdependencies are explicitly incorporated and used to explain economic interaction. The latter describes a complex and simultaneous solution which takes into consideration inter-industrial dependence as well as the distribution of income, the redistribution effects of the state and the usage of income for goods. Thus, the input-output tables are fully implemented in the national accounts (Ahlert et al. 2009, Distelkamp et al. 2003). Both datasets are specified for improving the identification for gross fixed capital formation, private consumption, state consumption and foreign trade. Labour market specifics are consistently embedded in the macroeconomic context through output and unit costs. Macroeconomic indicators are determined by aggregation of 63 industries.

QINFORGE solves simultaneously, is dynamic over time and is described by non-linear functions. Its basic dataset consists of input-output-tables and national accounts. The applied model in this paper follows the school of evolutionary economics as features like technological change, imperfect competition and interdependencies, or partially sticky prices are standard characteristics. In QINFORGE, parameters and their elasticity values are estimated econometrically with given time series for a large number of variables.

3 Setting the Assumptions

This chapter describes the scenario assumptions. As in all other publications to the topic, the scenario assumes a slow but steady transformation towards a fully digitalized economy. The process is assumed to last until 2025. From 2025 onwards, the economy is fully transformed and remains at the level of development until the end of the projection horizon of 2030.

The digitalization process affects all industrial sectors, not only the manufacturing industries but also service sectors. However, this scenario only addresses the transformation process for the manufacturing industries. They are likely to be affected the most due to the production process and because they produce tools and equipment needed for the transformation process. The manufacturing industry is also interested to study because of their strong export dependency and the high employment intensity.

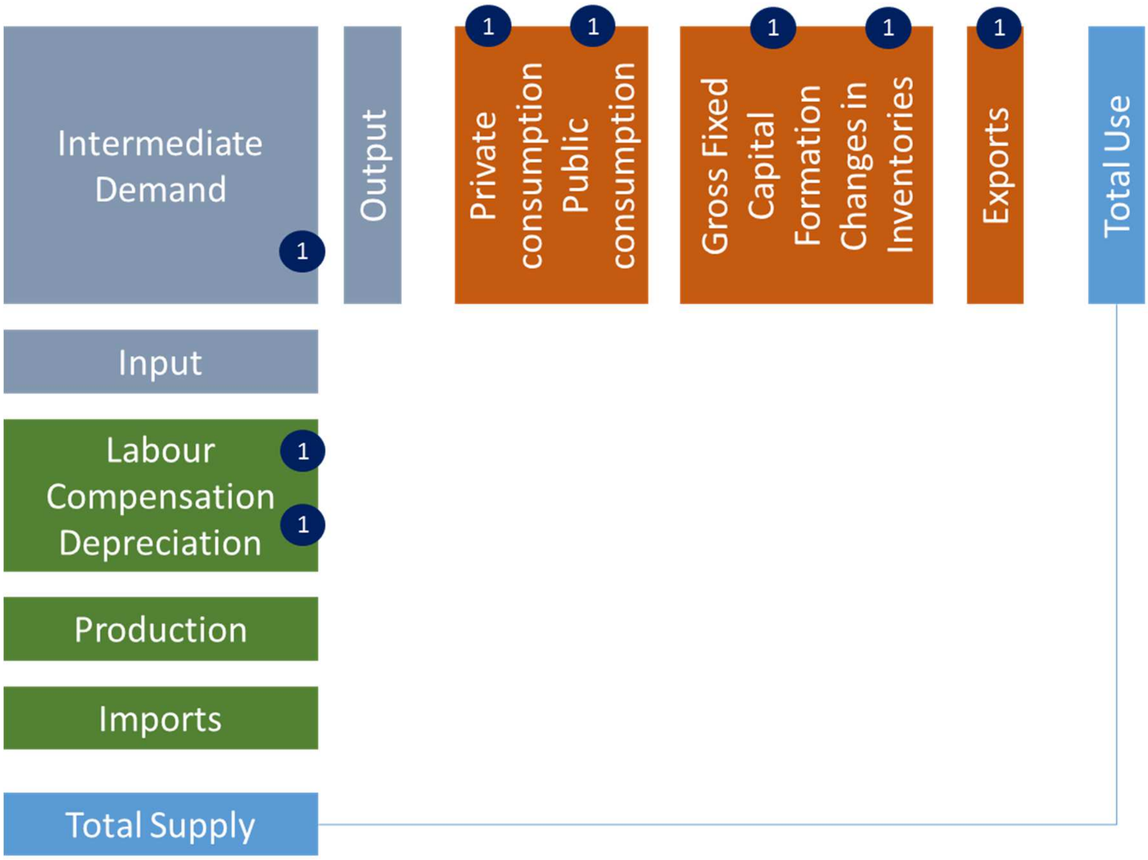
Due to the digital transformation process, new products and services are likely to be created. The extent to which they can be realized is unknown, yet. However, the effect of additional demand created by IoT is included in the analysis.

One consequent of the cost effects of IoT is to gain comparative cost advantages of products produced in Germany relative to products produced in other countries. This could lead to an insourcing process of production lines. This could lead to a lower import demand of intermediate goods and services. In this scenario, a reduction of intermediate import demand is not included because no clear indication could be found in the literature.

However, the scenario assumes a first-mover advantage for Germany. This implies that Germany is first in the adaptation of IoT technologies.

Figure 1 indicates the location of possible parameters of the IoT scenario. They are scattered along the IO table. The introduction of IoT first affects **investments** in equipment and construction. They affected by the need for additional, internet-ready machineries and the construction of high-speed internet lines.

Figure 1: The Input-Output-Framework with indication for scenario parameters



Exports are likely to be positively affected because of the demand of qualitative better or relatively cheaper products. The same holds for the effects on private **consumption**. Additional demand can be induced either by prices or by new products. State consumption is mostly affected by an increasing demand in qualification and education measures.

Further, **intermediate demand** matrix informs about the cost structure and demand of products within the production process. The cost structure indicates which products and services are needed in order to allow production. The digital transformation will significantly alter this cost structure. It is assumed that material productivity emerges, reducing the need for raw material and intermediate products. At the same time, the demand for more services – especially ITK services – is likely to rise. Due to the identity between production and intermediates, value added is altered with changes in the cost structure.

Value added itself is determined among others through labour compensation and depreciation. The amount of labour compensation depends on numerous things: if production decreases, labour compensation is declining as well and produces less employment. This situation occurs, when due to the altered cost structure products are less required for production purposes. However, the change in labour productivity may also lead to a declining labour demand. Depreciation are directly influenced by investment decisions. For instance, the purchase of new machineries and are captured in the cost side.

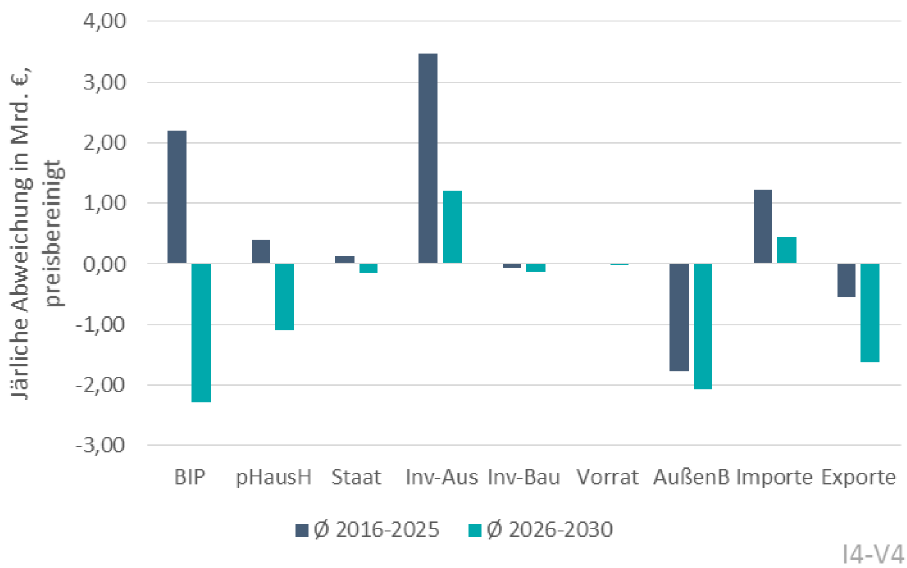
All other not mentioned elements of the IOT are indirectly affected by the parameters. That is for example the case for the imports or production which are affected by the supply via prices and demand.

4 Scenario setting

Additional **investment in equipment** due to IoT are likely to occur, however the machinery park is not going to change altogether. That is because already today, machineries are IoT-adjustable. The scenario assumes that all new purchased machinery (beginning in 2016) are IoT adjusted. This assumption means that additional investments as compared to the baseline scenario are only minor. The scenario assumes an additional investment of 0.5% to the baseline scenario (around 1 billion Euro more per annum). For the time 2016-2030 that implies an additional of 15 billion Euro of investment.

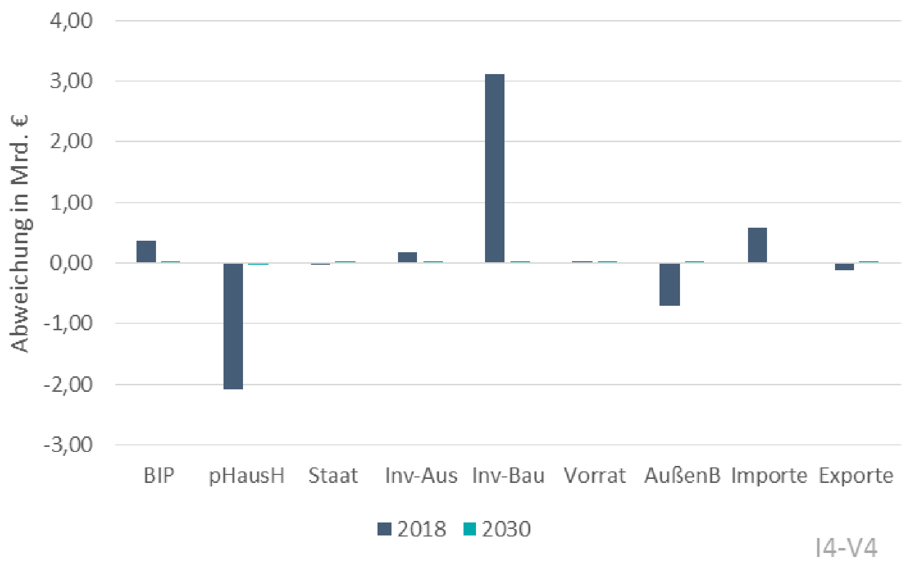
Usually, capital stock is renewed after a period of approx. 10 years. In the scenario we assume that only in the last 5 years, stock is change to IoT compatible machinery. In total, 30 billion Euro more are invested between 2016 and 2025. In the modelling surrounding, additional investments are induced. Figure 2 shows the effects on GDP and its components

Figure 2: Scenario Part 1: Investment in Equipment



Additional investments in **construction** are mainly dedicated to the infrastructure. According to TÜVRheinland (2013), the costs for development high speed internet may amount to 20 billion Euro. This aim shall be reached already in 2018. Due to this scarce time span and the high investment needed, only a 95% coverage is assumed. Hence, in the years until 2018 an additional investment of 4 billion euro are assumed per annum. The construction work is performed by underground working. Further, it is assumed that the state is financing this construction work. However, financed via taxes, households reduce consumption a little bit. The effects on GDP and its components are shown in Figure 3

Figure 3: Scenario Part2: Construction Investment



In order to change the cost structure, five changes are implemented:

- Increase in education in industry sectors (2.4 billion Euro additional)
- Increase of cost structure of industries for counselling services (plus 1.5% compared to baseline)
- Increase of IT services as input
- Decrease of material input
- Increase in labour productivity and accordingly lower cost for personnel

The impacts are shown in Figure 4.

Figure 4: Scenario Part 3: Cost structure

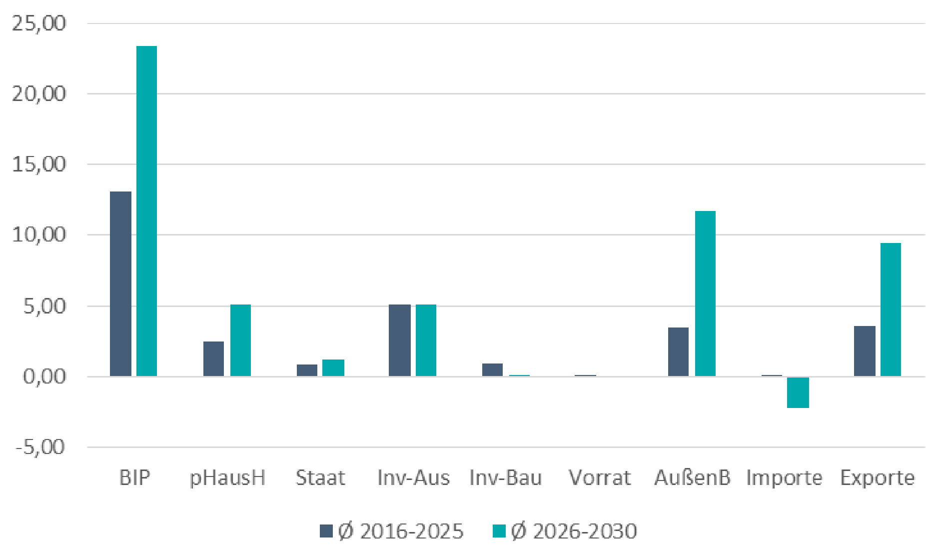


Figure 5 shows the combination of all effects in one single scenario. In total, the impact on GDP will start low but increase later in the projection horizon. Even without further assumptions on private consumption or exports, the scenario implies an increase in private consumption and exports due to income circulation and price competitiveness. Important is to notice the decline in imports which is the result of the lower demand for intermediate products. Between 2026 and 2030, GDP exceeds the baseline scenario by 0.8%.

Figure 5: Total Scenario

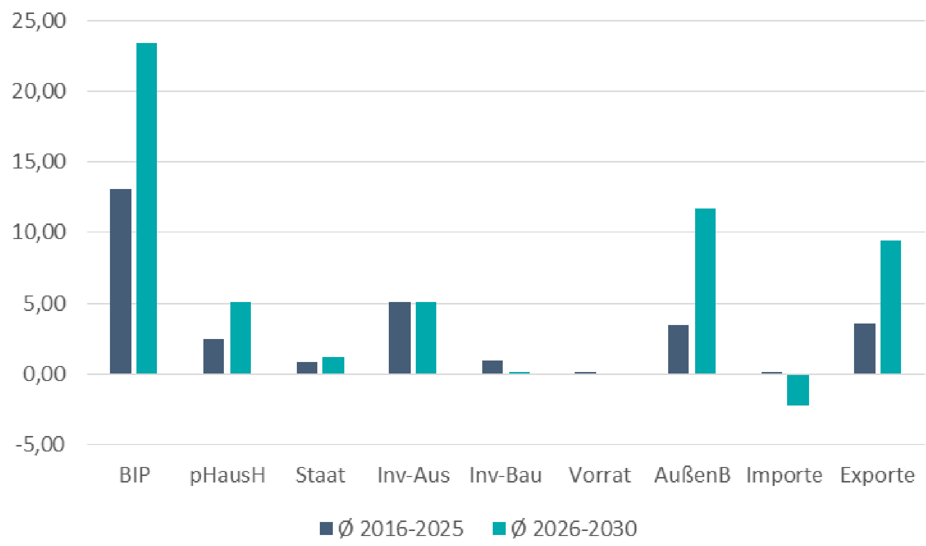
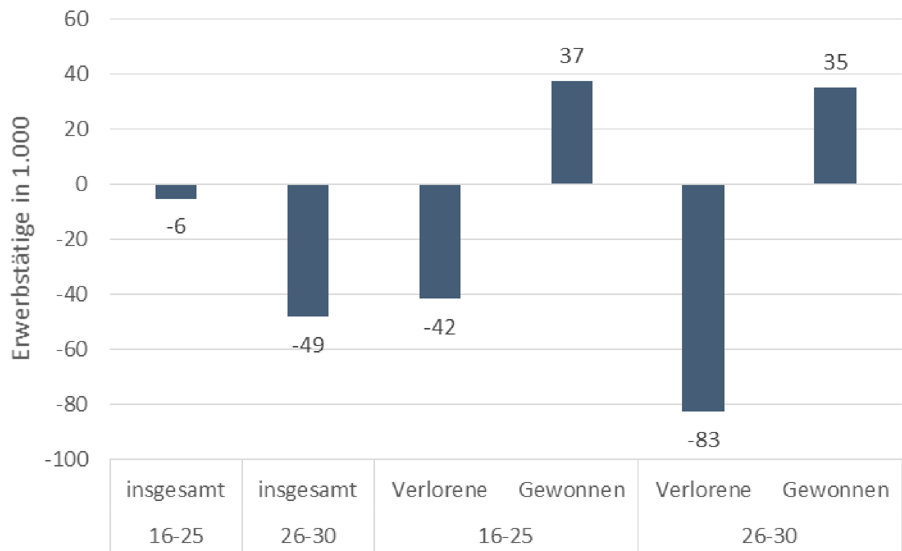


Figure 6 shows the employment results of the total scenario. In some industries, additional jobs are created, in other industries or service sectors, jobs are reduced. The net effect is a decline in employment by 6.000 persons between 2016 and 2025.

Figure 6: Total Scenario: Employment results



5 Conclusions

The scenario has shown, that the digital transformation process leads the economy to a higher growth path. But during the transformation, employment is declining. Altogether, the results are modest. Parallel to the increase in labour productivity, a loss in employment can be observed. The job losses are likely to be mainly in routine-jobs. At the same time, jobs are created especially in high-skilled areas.

The results may alter if additional demand is implemented in the scenario – assuming that IoT is creating new products and services and provokes additional demand. The negative impact on the labour market may then be smaller.

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