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Article

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Robert Lehmann, Stefan Linz and Timo Wollmershäuser

Structural Change in German Manufacturing: Hybrid Products and Production Processes Are Changing Industrial Business Models

KEY MESSAGES

- Growing discrepancy between output from national accounts and industrial production in German manufacturing
- Share in non-industrial activities of industrial enterprises is increasing
- Industrial products are becoming more hybrid as more goods are bundled with product-related services
- Production processes in German manufacturing are also becoming more hybrid
- Manufacturing firms outsource goods production and concentrate domestic activities on product development and commercialization

German manufacturing is in crisis. According to the monthly production index, approximately 13 percent fewer industrial goods were produced in manufacturing in 2024 than in 2018. The decline is therefore not only one of the sharpest in Germany's postwar history, but also by far the longest with a duration of six years (see Figure 1A). Against this backdrop, the end of the German industrial model and a gradual deindustrialization are often diagnosed in the public.

However, looking at the production index alone shows only one aspect of a fundamental structural

change in manufacturing. Since the mid-2010s, the economic activity of industrial enterprises, measured in terms of output in manufacturing calculated in the national accounts, has developed much more positively (see Figure 1B).¹ The production index correctly measures the development of the real value of the industrial goods produced. In contrast to output of national accounts, however, it does not take into account other activities such as turnover from other non-industrial activities, which have accounted for an increasingly large share of industrial business in recent years and have therefore had a lasting impact on the business activities of German industrial enterprises.

This expansion in industrial activity is also reflected in price-adjusted gross value added in manufacturing. It results from the difference between output and intermediate consumption in manufacturing and is central for the calculation of gross domestic product. The development of gross value added also indicates a weakness in the manufacturing industry in recent years. Compared to the production index, however, the decline of less than 3 percent since 2018 is significantly lower.

This article analyzes how structural change is reflected in the indicators of economic activity in manu-

¹ As all indicators developed largely in parallel in the years prior to 2013, this year was chosen as the reference in all figures in which the indices of all indicators are standardized to 100. All conclusions drawn in this article remain valid even if a different reference year is chosen.



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facturing. On the one hand, the increasing discrepancy between output in manufacturing and the production index shows a change in industrial production – away from the exclusive production of industrial goods toward hybrid business models. Hybrid products may have gained in importance, with an increasing proportion of turnover in manufacturing being generated from product-related services. But the production of enterprises themselves may also have become more hybrid, with an increasing share of turnover in manufacturing coming from revenues from outsourced production facilities, which, for example, are contracted to manufacture industrial products in sales markets or in lower-cost locations. Changes in the composition of the workforce and in business investment across industries provide preliminary indications of the adjustments associated with this structural change.

On the other hand, the increasing discrepancy between gross value added and output indicates a decreasing importance of external inputs in the production process. This could be due to a shortening of global value chains, which is accompanied by a reshoring of upstream production stages. But the change in industrial production could also have contributed to this. As services are labor-intensive, the increasing importance of hybrid business models goes hand in hand with falling input ratios. In this article, we show that gross value added in these manufacturing industries is developing more positively than output, where the discrepancy between output in manufacturing and the production index is greater, and thus the importance of hybrid business models is likely to increase.

INDICATORS OF ECONOMIC ACTIVITY IN MANUFACTURING

To contextualize the observed discrepancies, this section first explains the indicators used to measure economic activity in manufacturing. In particular, the key differences between the individual indicators are highlighted.

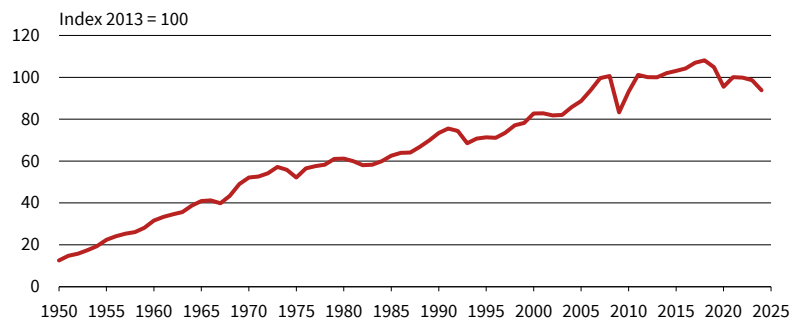
Production Index in Manufacturing

The production index in manufacturing indicates the price-adjusted development of the *value of industrial goods production* (see Table 1). The production index also includes the value of some quantitatively less significant industrial services accompanying production, such as installations, repairs, maintenance, and contract processing. The basis for the production index is the production survey in manufacturing, which is conducted monthly. This survey collects data on the sales value of industrial production. The results of the production index are presented for branches of economic activity (4-digit classes), where the economic branch indices compare the current price-adjusted value of production with the corresponding value of

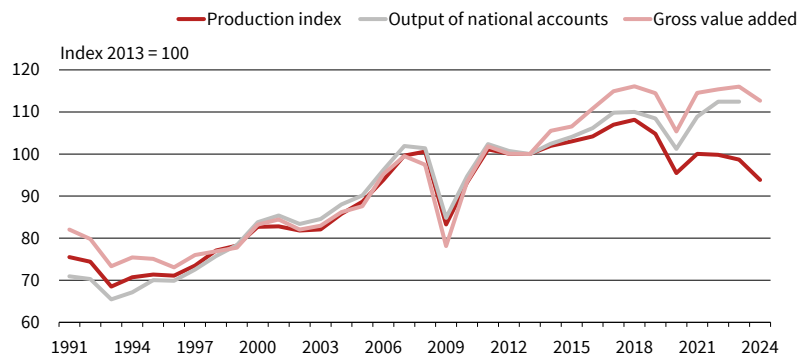
Figure 1

Price-Adjusted Indicators of Economic Activity in Manufacturing

A. Production index since 1950



B. Production index, output and gross value added since 1991



Note: Before 1991 manufacturing incl. mining and quarrying.

Source: Federal Statistical Office; Deutsche Bundesbank; authors' calculations.

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production of the base year (currently: 2021). The overall production index in manufacturing is then the weighted average of the branch indices, with weights representing the share of gross value added in the base year, updated at five-year intervals. Thus, the production index is a fixed-base index. The price adjustment of the value of production is also performed on a fixed-price basis using the index of producer prices of industrial products (domestic sales).

Output of National Accounts

The annual output of national accounts is calculated within the output approach and measures the *total value of all goods and services produced domestically within a given period*.² Output is broadly defined and includes not only the turnover from own products of industrial enterprises but also turnover from goods for resale and commissions from commission trade (see Table 2). The data basis for the output of national accounts in manufacturing is provided by annual structural statistics, including the cost structure survey and the structural survey of small enterprises (see Table 1). These statistics record the requested output positions in detail. Adjustments are made to account for conceptual differences between struc-

² In the German national accounts, gross domestic product is originally calculated from both the production and the expenditure sides. A reconciliation is then carried out between the two resulting calculations, leading to the published gross domestic product results and its aggregates (Federal Statistical Office 2016).

Table 1

Production Index, Output, and Gross Value Added in Official Statistics

Statistics	Features
Production index in manufacturing	<ul style="list-style-type: none"> – Secondary statistics – Input data: surveys of production, supplemented by other primary statistics – Periodicity: monthly – Representation: price adjusted value of production in the reporting month in relation to the respective value in the base year, fixed-base index on base 2021 – Breakdown of results: industry branches (4-digit classes) according to the statistical classification of economic activities in the European Community (NACE Rev. 2) – Aggregation: overall index as weighted average of the branch indices, weights: share of gross value added in the base year (update at five-year intervals) – Additionally, calculation of a quarterly production index (local units with 20 or more persons employed), adjustment of the monthly production index to quarterly results – Price adjustment: adjustment using the index of producer prices of industrial products, domestic sales, fixed price base – Input for other statistics: quarterly update of annual gross value added in national accounts – GENESIS Code: 42153
Production survey in manufacturing	<ul style="list-style-type: none"> – Primary statistics, full coverage survey with cutoff limit – Respondents: local units with 50 or more persons employed (monthly) and with 20 or more persons employed (quarterly): (monthly: approx. 20,000 local units, quarterly: approx. 24,000 local units) – Survey variables: (i) quantity produced for sale, weight; (ii) sales value in euros (excluding goods for resale); (iii) quantity produced for further processing; (iv) repair, installation, and processing under contract – Breakdown of results: product types according to the product classification for production statistics, 2019 edition (GP 2019) – Aggregation: summation of nominal values – Periodicity: monthly and quarterly – Input for other statistics: calculation of the production index in manufacturing – GENESIS Codes: 42121, 42131
Output and intermediate consumption of national accounts, data for manufacturing	<ul style="list-style-type: none"> – Secondary statistics – Periodicity: yearly, quarterly – Data basis: cost structure survey and structural survey of small enterprises, other statistics and documents, intra-annual update according to the development of the production index etc. – Breakdown of results: industry branches (mainly two-digit divisions according to the statistical classification of economic activities in the European Community, NACE Rev. 2), output including and excluding goods for resale – Aggregation: summation of nominal values – Price adjustment: adjustment using the index of producer prices of industrial products, domestic sales (output) or the index of producer prices of industrial products for intermediate consumption, domestic sales, and index of import prices for intermediate consumption, previous year's price base – Input for other statistics: derivation of gross value added as the difference between output and intermediate consumption – GENESIS Codes: 81000–0100, –0103, –0101
Gross value added of national accounts, data for manufacturing	<ul style="list-style-type: none"> – Secondary statistics – Data basis: output and intermediate consumption of national accounts – Calculation as the difference between output and intermediate consumption – Price adjustment: difference between price-adjusted output and price-adjusted intermediate consumption (double deflation) – Goods for resale: goods for resale are included in both output and intermediate consumption, by using the net value of goods bought for resale (use of goods for resale), only service charges from the sale of goods for resale are included – Input for other statistics: derivation of the gross domestic product under the production approach of national accounts
Cost structure survey in manufacturing	<ul style="list-style-type: none"> – Primary statistics, stratified sample survey – Respondents: approx. 18,000 enterprises with 20 or more persons employed – Survey variables e.g. total turnover from own production, from goods for resale and from other non-industrial/non-craft activities of enterprises, material and goods received; gross output as total turnover plus changes in stocks of work in progress and finished products plus own production of fixed assets, intermediate consumption as material consumption plus input of goods for resale plus cost of contract work plus other services and costs – Breakdown of results: industry branches (4-digit classes) according to the statistical classification of economic activities in the European Community (NACE Rev. 2) – Aggregation: summation of nominal values – Periodicity: yearly – Input for other statistics: calculation of the annual output of national accounts – GENESIS Code: 42251
Structural surveys of small enterprises in manufacturing	<ul style="list-style-type: none"> – Primary statistics, stratified sample survey – Respondents: approx. 6,000 enterprises with under 20 persons employed – Survey variables e.g. total turnover, costs by type, shorter questionnaire for small enterprises compared to the cost structure survey – Breakdown of results: industry branches (4-digit classes) according to the statistical classification of economic activities in the European Community (NACE Rev. 2) – Aggregation: summation of nominal values – Periodicity: yearly – Input for other statistics: inclusion of smaller enterprises in the calculation of the annual output of national accounts – Publication discontinued in 2021

Source: Federal Statistical Office (2016, 2018, 2019, 2022a, 2024b and 2024c).

tural statistics and national accounts to ensure completeness, including differences in the treatment of taxes, subsidies, and the shadow economy. However, output derived directly from structural statistics and output of national accounts generally follow a very similar pattern.

Output of national accounts is expressed in euros, with results presented primarily for economic branches (two-digit divisions) according to the statistical classification of economic activities in the European Community (NACE Rev. 2). By concept, output of national accounts is also reported excluding goods for resale. The price adjustment is performed using the index of producer prices of industrial products, and the price-adjusted output of national accounts is expressed in previous year's prices and as a chain index with base year 2020. When structural surveys are not yet available for current time points, output of national accounts in manufacturing is projected along with gross value added (see next section).

Gross Value Added of National Accounts

Gross value added of national accounts represents the *value created in the production process* and is derived as the difference between output and intermediate consumption.³ Intermediate consumption includes costs of materials (raw materials, intermediate products, energy) as well as costs for goods for resale,

³ In the output approach of national accounts, gross value added is the key measure for deriving gross domestic product. The transition from gross value added to gross domestic product is marked by net product taxes, defined as product taxes minus product subsidies. Adding net product taxes to gross value added allows the transition from basic prices to market prices, which is what gross domestic product is expressed in.

Table 2

Derivation of Gross Value Added in National Accounts (Simplified Version)

Output	= Turnover from own products and goods for resale
	+ Commissions from commission trade and turnover from other activities
	+ Own consumption of own-account products and products consumed
	+ Changes in inventories of finished products and work in progress
	+ Own work capitalized (own-account production of fixed assets, etc.)
- Intermediate Consumption	= Cost of materials (raw materials, intermediate products, energy)
	+ Cost of goods for resale
	+ Cost of services (services purchased)
	+ Repair and maintenance
	+ Other intermediate consumption (rent, etc.)
= Gross Value Added	

Source: Federal Statistical Office; authors' compilation.

repairs, or rent (see Table 2).⁴ For the calculation of intermediate consumption, the structural statistics mentioned earlier are used. The cost structure survey contains detailed information on the enterprises' costs, allowing for the derivation of intermediate consumption used in production. Once again, adjustments are applied to align with the national accounts framework.

Gross value added is expressed in euros, with results presented for two-digit divisions of the statistical classification of economic activities in the European Community (NACE Rev. 2). The price adjustment for intermediate consumption is based on two weighted indices (Federal Statistical Office 2017): prices of domestic outputs (domestic intermediate consumption) and import prices (foreign intermediate consumption).⁵

⁴ Regarding goods for resale, gross value added includes only the difference between turnover from resale goods and the corresponding expenses, meaning the "service charge" from the sales of resale goods.

⁵ The Federal Statistical Office points out that relying on already-used price indices is in line with European statistical guidelines, provided that certain conditions are met. This is ensured for Germany (Federal Statistical Office 2017).

Table 3

Turnover in Official Statistics

Statistics	Features
Monthly report on local units in manufacturing	<ul style="list-style-type: none"> Primary statistics, full coverage survey with cutoff limit Respondents: approx. 22,000 local units with 50 or more persons employed Survey variables, e.g., turnover from own products (turnover of kind-of-activity units), other turnover (e.g., from the sale of goods for resale and other non-industrial activities) Breakdown of results: industry branches (4-digit classes) according to the statistical classification of economic activities in the European Community (NACE Rev. 2), sales markets (domestic/euro area/non-euro area), differentiation by turnover of kind-of-activity units and total turnover (including other turnover) (see aggregation) Aggregation: turnover of kind-of-activity units: summation of the turnover from similar activities performed by kind-of-activity units to obtain homogeneous results for industry branches; turnover of local units: summation of the total turnover of entire local units allocated to industry branches based on their main activity Periodicity: monthly Input for other statistics: calculation of the turnover index in manufacturing GENESIS Codes: 42111, turnover of kind-of-activity units: -0024, turnover of local units: -0002
Turnover index in manufacturing	<ul style="list-style-type: none"> Secondary statistics Input data: monthly report on local units in manufacturing Periodicity: monthly Representation: turnover of kind-of-activity units in the reporting month in relation to the respective turnover in the base year, fixed-base index on base 2021 Breakdown of results: industry branches (4-digit classes) according to the statistical classification of economic activities in the European Community (NACE Rev. 2) Aggregation: overall index as weighted average of the branch indices, weights: turnover in the base year (update at five-year intervals) Price adjustment: adjustment using the index of producer prices of industrial products (domestic sales), index of export prices (non-domestic sales), fixed price base GENESIS Code: 42152

Source: Federal Statistical Office (2022b and 2024a).

The price-adjusted gross value added in manufacturing is obtained as the difference between real output and real intermediate consumption (double deflation method).⁶ Both components are deflated using the previous year's prices. In the framework of quarterly national accounts, the gross value added in manufacturing, measured in nominal and real terms, is projected using the year-on-year growth rate of the quarterly aggregated production index (Federal Statistical Office 2024c). The intermediate consumption ratio remains constant in the projection, meaning that the output of national accounts is implicitly determined and develops at the same rate as gross value added.

Turnover of Local Units

In addition to production data, the Federal Statistical Office also publishes monthly turnover data for local units in manufacturing. This turnover data is useful for interpreting the increasing discrepancy between the production index and the output of national accounts. The monthly report on local units in manufacturing (see Table 3)⁷ collects data on the turnover from sales of own-produced goods and repair and maintenance work. The survey differentiates between turnover in domestic markets, the euro area, and non-euro area countries. Enterprises producing goods in multiple industry branches (e.g., automotive components and machinery) are classified based on their main branch of activity. Besides turnover from own-produced goods, enterprises also report other turnover from goods for resale or services beyond repair and maintenance, such as rental income, license fees, commissions, and revenues from the sale of patents (referred to as "other turnover").

The total turnover reported in the monthly report represents the sum of turnover from own-produced goods and other turnover, expressed in euros. Turnover figures are not adjusted for price changes. For this analysis, a simplified price adjustment was applied to the aggregated turnover in manufacturing, using the index of producer prices of industrial products (domestic sales).

Turnover Index

The turnover index is derived from the monthly report on local units in manufacturing. It tracks the devel-

opment of price-adjusted turnover from kind-of-activity units. These units are homogeneous operational segments within enterprises that belong to the same industry branch. Regardless of the enterprise's main classification, all turnover from kind-of-activity units within the same industry branch is aggregated. The other turnover from industrial enterprises is excluded from the index; only turnover from sales of own-produced goods and repair/maintenance services is considered.

The subindices for individual industry branches are calculated as the ratio of the current turnover sum to the corresponding turnover sum in the base year (currently: 2021). The overall turnover index in manufacturing is determined – analogous to the production index – as a weighted average of the subindices, based on turnover shares in the base year, updated at five-year intervals. The price adjustment of the turnover index is carried out by industry branch using the index of producer prices of industrial products (domestic sales) and export price indices.

Comparison of Indicators

The analysis is based on the following data: All monthly indicators (production index, turnover index, turnover of local units) are available up to and including December 2024. The indicators from the national accounts have different publication delays. The quarterly gross value added in manufacturing, which is updated during the year using the production index, is available up to and including the fourth quarter of 2024. Annual data on the output of national accounts in manufacturing ends in 2023. Only real (price-adjusted) time series are considered. All data was standardized to the year 2013 (see also Footnote 1).

The four output indicators – output of national accounts, production index, turnover index, and turnover of local units – basically follow similar patterns (see Figure 2A). However, they show increasing discrepancies in their dynamics, especially from 2020 onward. While output of national accounts rose in 2021, 2022, and 2023, the production index fell in 2022 and 2023 compared to previous years, which hints at structural shifts. The additional consideration of the turnover indicators makes these shifts particularly clear. While the turnover index tends to follow the course of the production index, the development of the turnover of local units is more similar to that of output of national accounts.⁸ A closer analysis of the turnover of local units reveals that other turnover has increased significantly during this period. Other turnover, which, as mentioned above, is not generated by the sale of own products but by services provided by industrial enterprises or the sale of merchandise, is not included in the turnover index. The strong in-

⁶ The method of double deflation is considered advantageous compared to the method of single deflation (Oulton et al. 2018). Sturgess (2017) documents for eight countries that, with the single deflation method, the growth rate of real gross value added deviates by 3 to 4 percentage points upward or downward, with persistent deviations—a positive deviation is followed by another positive deviation, and so on. This results not only in differences in trends but also on the level of price-adjusted values. Therefore, among other significant reasons, the double deflation method is recommended (United Nations Department of Economic and Social Affairs 2018).

⁷ The monthly reporting of local units in manufacturing allows for a comparison between German federal states and is also available monthly, whereas production surveys are only published for a limited number of federal states. Lehmann (2025) presents long time series of price-adjusted turnover of local units by federal state.

⁸ However, in recent years there has also been a growing discrepancy between the production index and the turnover index, which is discussed in the next section.

crease in other turnover relates to the development in the “Manufacture of motor vehicles and parts” industry branch and is strongly influenced by business between industrial enterprises in Germany and foreign countries outside the eurozone.

Gross value added and output of national accounts also follow a similar trend (see Figure 2B). However, the stronger increase in gross value added in the 2010s compared to output is striking; still, this discrepancy has not widened any further since 2020.

DISCREPANCY BETWEEN THE PRODUCTION INDEX AND OUTPUT OF NATIONAL ACCOUNTS

This section discusses possible causes for the increasing discrepancy between the production index and output of national accounts. The influence of measurement errors in the calculation of the production index is discussed first. It is shown that the exclusion of small enterprises and the characteristic of a fixed-base index do not appear to play a central role, and that different price developments for domestic and foreign sales can possibly understate the production index. Subsequently, the increasing other turnover from industrial enterprises, which is not achieved with the pure sale of (physical) goods from own production in Germany, is discussed. The main driver of the increasing discrepancy between the output indicators is likely to be the other non-industrial activities, which are becoming increasingly important as industrial enterprises change their business models.

On the Influence of Measurement Errors in the Calculation of the Production Index

Possible Underestimation of Production in the Production Index

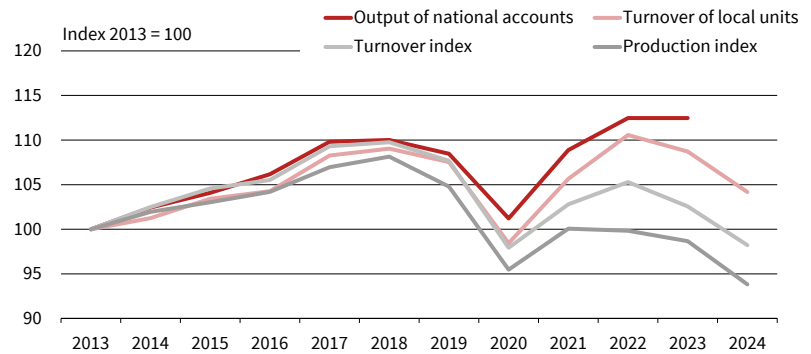
In addition to the quantities produced, the enterprises also report the respective sales value of their production in the production surveys, based on the sales price achieved in the reporting period or the sales price achievable at the time of sale. While the reporting enterprises are generally able to indicate whether the turnover was achieved with domestic or foreign customers when collecting turnover data, it is more difficult to provide information on production.⁹ A particular problem arises when the development of domestic and foreign sales prices differs greatly. In 2021, domestic prices increased significantly more than export prices. In this situation, the convention of deflating the production index with domestic sales prices may lead to an underestimation of the production index. This fact is likely to play an important role in the discrepancy between the production index

⁹ The share of turnover from countries outside Germany in the turnover index is around 50 percent.

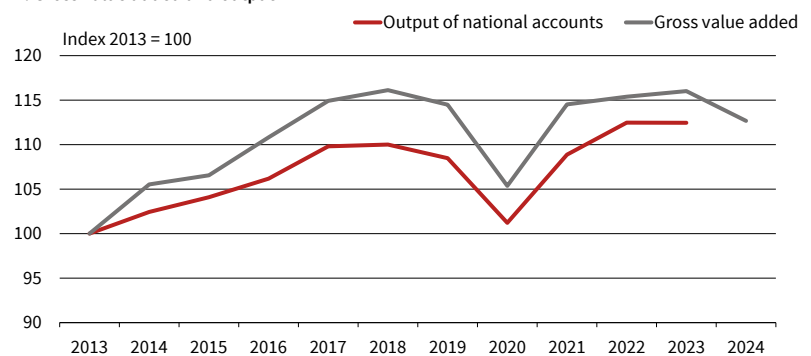
Figure 2

Price-Adjusted Indicators of Economic Activity in Manufacturing

A. Production and turnover



B. Gross value added and output

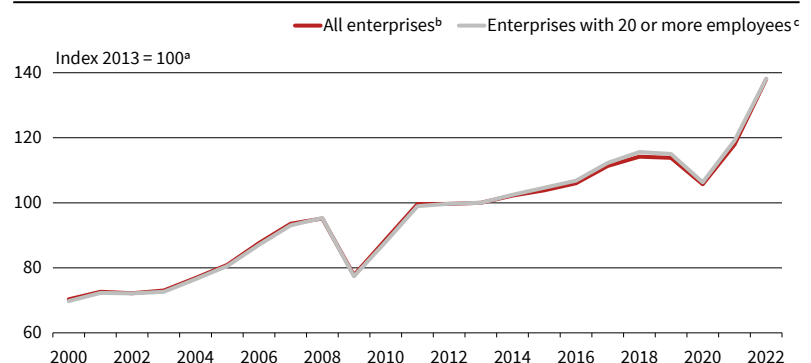


Source: Federal Statistical Office; authors' calculations.

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Figure 3

Output in Manufacturing from Structural Surveys



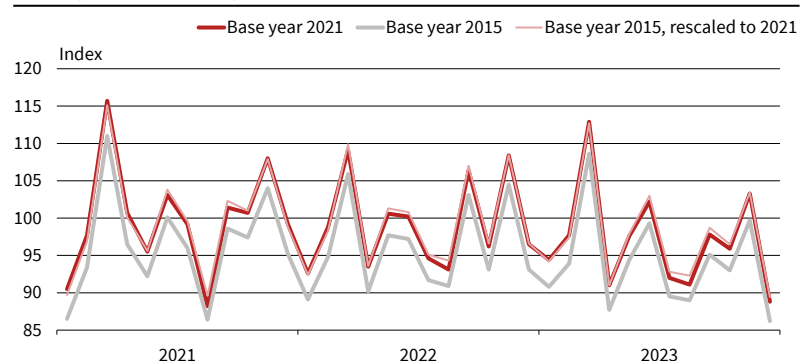
Note: ^a In current prices. ^b Structural survey and cost structure survey. ^c Cost structure survey. Source: Federal Statistical Office.

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Figure 4

Production Index in Industry Excluding Construction

Price-adjusted, but including calendar and seasonal patterns



Source: Federal Statistical Office; authors' calculations.

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and the turnover index (see Figure 2A).¹⁰ However, the effects of the different price developments on the production index still need to be analyzed and quantified in more detail.

No Significant Distortion Due to Exclusion of Small Businesses in the Production Index

The production index includes data for enterprises with at least 20 employees. Output of national accounts, however, is based on a combination of the cost structure survey for enterprises with 20 or more employees and the structural survey of small enter-

¹⁰ In the turnover index, however, domestic and foreign sales are deflated separately using domestic and export price indices.

prises, meaning that no cutoff threshold is relevant here. However, a comparison of the development of output from the cost structure survey of enterprises with 20 or more employees with the development of all enterprises (cost structure survey and structural survey of small enterprises) shows only very slight deviations (see Figure 3). Therefore, the underreporting of small enterprises cannot be used to explain the discrepancy.

No Underreporting of New Products in the Short-Term Statistics

In Lehmann and Wollmershäuser (2024), it was argued that the discrepancy between output of national accounts and the production index could be caused by a composition effect. A composition effect can occur if the weighting of industrial products differs between output and the production index. This happens when new product groups become established over time but are not adequately reflected in the weighting scheme (e.g., electric vehicles). Consequently, new product groups may be underrepresented, while older product groups may be overrepresented in the production index. The data available at the time from Lehmann and Wollmershäuser (2024) showed the production index with the base year 2015. Linz and Flores (2024) have illustrated the influence of the change in the base year (from 2015 to 2021) and thus the weighting on the development of the production index. The result shows only a negligible influence on the production index (see Figure 4).¹¹ It can therefore be concluded that the composition effect cannot be used to explain the discrepancy between the production index and output of national accounts.

Increasing Share of Turnover from Goods for Resale

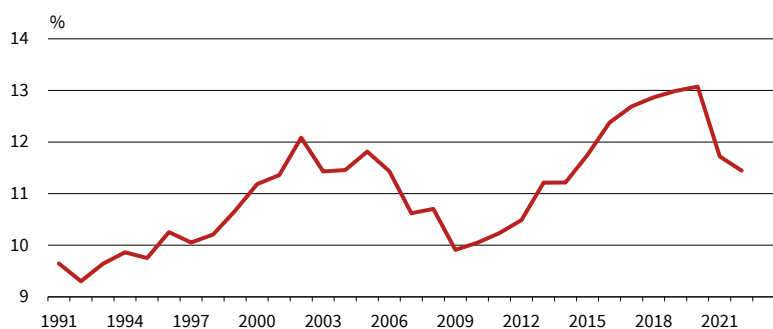
As the turnover index – like the production index – primarily measures the sales value of own goods products, and as the turnover of local units and output also include turnover from goods for resale and other non-industrial activities, these additional activities must account for an increasingly large proportion of the turnover of industrial enterprises. The influence of turnover from goods for resale can be illustrated using national accounts data, which report output with and without goods for resale, at least in current prices. As no suitable deflators are available for industrial goods for resale, only nominal figures can be considered. The rising trend in the share of turnover from goods for resale in total output (including goods for resale) indicates the increasing importance of this

¹¹ The composition effect is generally offset by an opposing normalization effect. The normalization effect is based on the fact that the index for new product groups rises sharply if these show significant growth (Linz and Flores 2024). It is impossible for new product groups not to be mapped at all because the entire production of goods is always recorded.

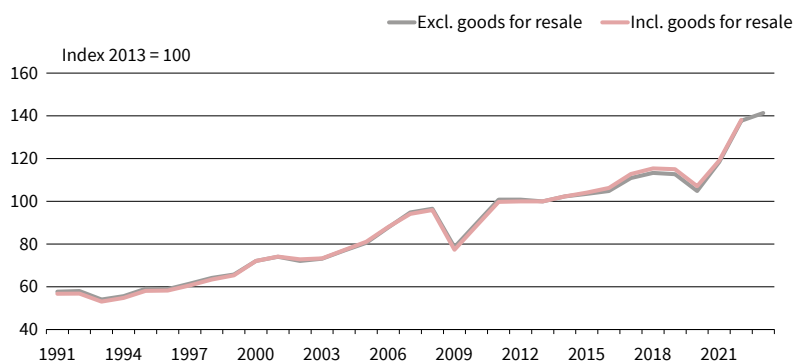
Figure 5

Turnover from Goods for Resale

A. Share of turnover from goods for resale in total output (including goods for resale)



B. Output of national accounts (in current prices)

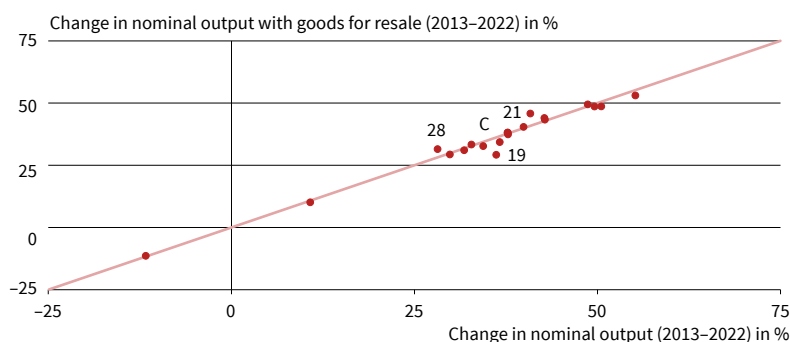


Source: Federal Statistical Office; authors' calculations.

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Figure 6

Goods for Resale in Industry Branches



Source: Federal Statistical Office; authors' calculations.

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non-industrial activity (see Figure 5A). However, this increase is so small that it makes only a small contribution to explaining the increasing discrepancy in economic indicators in the manufacturing sector (see Figure 5B). Output with goods for resale increased by just 0.4 percentage points more than without goods for resale in the period from 2013 to 2022. There was also no marked heterogeneity between the industry branches in the same period (see Figure 6). It can therefore be concluded that turnover from goods for resale is not the main reason for the increasing discrepancy between the production index or the turnover index on the one hand and the turnover of local units or output on the other.

Increasing Share of Turnover from Other Non-Industrial Activities

It is therefore obvious that the main driver of the increasing discrepancy between the turnover index and the turnover of local units must be other non-industrial activities. The Federal Statistical Office's database does not contain any further information on the exact nature of these activities, which account for a growing proportion of turnover in manufacturing. For this reason, an overview of the changes to the business model of industrial enterprises discussed in the literature is provided below. On the one hand, hybrid products may have gained in importance, with an increasing proportion of turnover in manufacturing being generated from product-related services. On the other hand, the production of enterprises may have become more hybrid and, as a result, an increasing share of turnover in manufacturing may be attributable to income from outsourced production facilities that are commissioned to manufacture industrial products in sales markets or at lower-cost locations, for example. We then examine whether the implications of this structural change are reflected in the adjustments to the employment structure and corporate investment in the individual industry branches.

Hybrid Products: Product-Related Services

Traditionally, industrial enterprises process raw materials and intermediate products with the aim of producing higher-quality goods. As a result of increasing digitalization and greater competitive pressure, enterprises are increasingly offering hybrid products to differentiate themselves from other manufacturers (Leimeister and Glauner 2008; Metzger 2023). Hybrid products (product-service systems) are solutions that are tailored to the needs of the customer, combining a tangible product (i.e., an industrially manufactured good) with product-related services to form a product bundle (Lay et al. 2010).

In 2012, the Fraunhofer Institute for Systems and Innovation Research ISI surveyed almost 1,600 industrial enterprises as part of the "Modernization of Pro-

duction" survey, which has been conducted regularly since 1993 (Lerch et al. 2013). According to the survey, 85 percent of the enterprises offered one or more services, with small enterprises having a lower share than medium-sized and large enterprises. However, the survey revealed that many enterprises had difficulties in the commercial exploitation of services. For example, 17 percent of all enterprises offering services stated that they were unable to generate any turnover from them. And a further 20 percent were unable to put a concrete figure on the turnover generated by services. At 22 percent and 23 percent respectively, these proportions were significantly higher for enterprises that only offered traditional product-related services such as planning, consulting, project planning, technical documentation, assembly, commissioning, training, maintenance, and repair. By contrast, these shares were significantly lower at 8 percent and 15 percent respectively for enterprises that offered at least one advanced and also less common product-related service, such as software development, leasing, rental, financing, or operator models.

In 2014, a study by the Bavarian Industry Association, which was carried out by IW Consult GmbH, surveyed almost 800 German enterprises in manufacturing and industry-related service sectors as part of the IW Future Panel (Bahrke and Kempermann 2015). Almost 25 percent of the companies surveyed that had an industrial focus and that generated revenue from industrial goods offered hybrid products and thus a certain number of product-related or supplementary services in the pre-production phase and in the post-production utilization phase. The most frequently mentioned services in the pre-production phase included the design for implementation of the product in the customer's systems, training, engineering, and development, as well as consulting services for the specifications, configuration, and design of the product. In the utilization phase, services were primarily offered in the areas of maintenance and repair, training, material and spare parts management, ongoing optimization, assembly, and logistics.

In addition to describing product-related services and their importance for the manufacturing industry, both studies also looked at the drivers of this development. Bahrke and Kempermann (2015) emphasize the influence of digitalization and the associated increasing knowledge intensification and networking of processes and production chains. They distinguish between three development stages of hybrid products. While traditional product-related services primarily relate to the industrial core product (maintenance, repair, and disposal), process- and data-related services are primarily aimed at the further production process and new data-based business models. At the same time, the degree of complexity of the underlying business models increases with the development stages. In their survey, Lerch et al. (2013) concluded that manufacturers of complex products offer prod-

uct-related services more frequently on average than manufacturers of moderately complex or simple products, and that additional revenue is generated with product-related services, particularly for complex products. In addition, Bahrke and Kempermann (2015) find that manufacturers of hybrid products conduct more research and development and have introduced new products or processes more frequently.

Hybrid Production: Production Relocation and Contract Manufacturing

In addition to the products, production processes may also have changed. Traditionally, all stages of production take place in one company and usually at one location. Nowadays, however, more and more enterprises are separating product development and commercialization from product manufacturing. In the case of complete separation, the literature speaks of a factoryless goods producing firm, whose goods production is completely outsourced as contract manufacturing services to an external company, e.g., on the sales market (Bernard and Fort 2015 and 2017). Examples of this can be found in the semiconductor industry, which often does not have its own production facilities and is reliant on foundries.

Of course, hybrid forms are also conceivable, which are classified as hybrid manufacturing firms (Kamal 2018). They continue to have their own production facilities in the domestic market but outsource parts of production to external enterprises abroad. There are examples of this in the German automotive industry, which produces some of its vehicles destined for the German market as part of joint ventures in other European countries or in China. For Danish manufacturing firms, Bernard et al. (2020) were able to show that enterprises reduced their domestic production after relocating production and, at the same time, increased imports of goods that were previously produced domestically. The factoryless or hybrid industrial enterprises mainly generate income from their intellectual property. While contract manufacturers generally quantify the value of production with the manufacturing costs, contractors sell the products purchased from contract manufacturers with markups on the manufacturing costs (Xing 2021). In contrast to licensed production, where the licensor receives fees from the licensee for the use of intellectual property (software, patents, brands, design), in contract manufacturing the intellectual property rights and thus the intangible value of the goods remains with the contracting company.

In their study, Bernard et al. (2020) were also able to show that enterprises reduced their overall domestic employment after relocating production. However, the employment structure also shifted from production-related to research-related occupations. Compared to traditional industrial enterprises, investment expenditure on research and development is

therefore likely to play a greater role, as material investments (in machinery, equipment, and production halls) were outsourced with production, and domestic activity is concentrated on processes related to product development.

Statistical Evidence for Structural Change

Data from the Federal Statistical Office does not provide more detailed information on the type and scope of activities with which industrial enterprises increase their turnover from non-industrial activities. Therefore, the empirical relevance of the changes in the business model of industrial enterprises described above can be analyzed only indirectly. For this purpose, the great heterogeneity between the branches of manufacturing with regard to the discrepancy between output and the production index is exploited (see Figure 7A). As industrial enterprises have shifted their business activities away from the exclusive production of industrial goods toward hybrid business models, the structure of their workforce and of corporate investment may also have changed. This is because both the increasing complexity of products and the increasing concentration of domestic production on intangible goods, which goes hand in hand with production relocations, should be accompanied by rising employment and increasing expenditure on research and development.

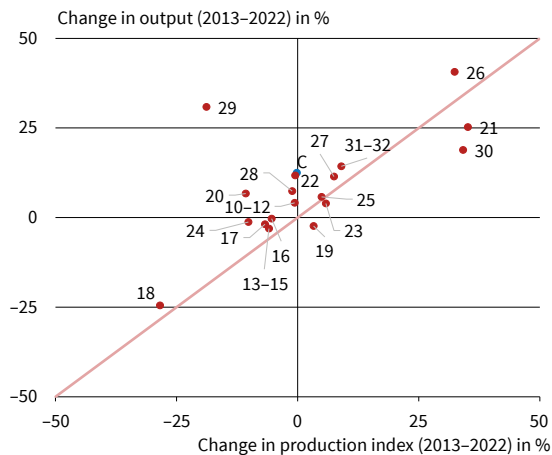
The proportion of employees in the area of in-house research and development in relation to total employment is recorded as part of the annual cost structure survey. In the manufacturing industry as a whole, this share increased from 5.5 percent to 6.2 percent between 2013 and 2022. Expenditure on research and development as well as on software and databases is reported in the national accounts as other fixed capital formation. Their share in overall gross fixed capital formation in the manufacturing industry as a whole rose from 46.0 percent to 54.2 percent between 2013 and 2022. A look at the individual industry branches shows that the discrepancy between output and the production index, and thus the importance of hybrid business models, increases with a rising share of employees in research and development and with a rising share of expenditure on other fixed capital formation in overall gross fixed capital formation (see Figure 7B and 7C).

This relationship is particularly pronounced in the important automotive industry (division 29 according to the statistical classification of economic activities in the European Community, NACE Rev. 2), where a discrepancy of 50 percentage points has built up between the rate of change in output and the rate of change in the production index in the years from 2013 to 2022. In the same period, the shares of employees and investments in research and development increased by 2.1 and 13.6 percentage points respectively. But even without the automotive industry, the

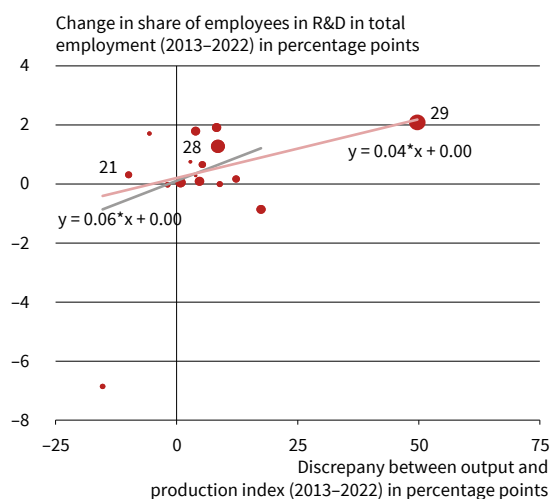
Figure 7

Change in Industrial Production by Industry Branch

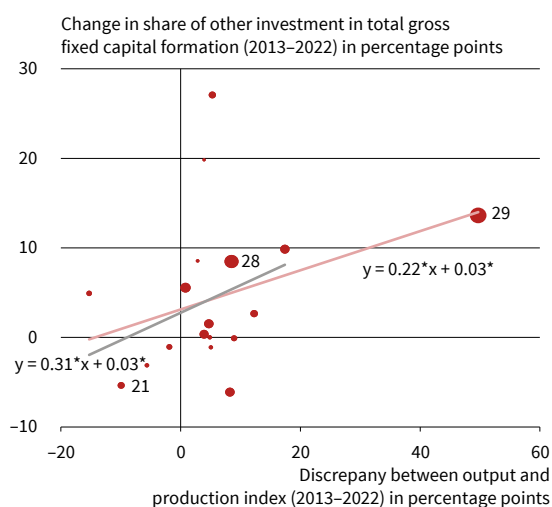
A. Change in non-industrial activities



B. Relationship to employees in research and development



C. Relationship to expenditure on research and development



Note: For the analysis, the industry branches 10 to 32 according to NACE Rev. 2 are considered. In the regressions in Figures B and C, the number of observations per branch was adjusted in proportion to its respective value added share in 2022. A * indicates significance at the 5% level. The gray line is the result of the regression without manufacturers of motor vehicles, trailers and semi-trailers (division 29 according to NACE Rev. 2).

Source: Federal Statistical Office; authors' calculations.

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correlation remains. In mechanical engineering (division 28), for example, turnover from other non-industrial activities increased in line with employment and expenditure on research and development. In the pharmaceutical industry (division 21), on the other hand, where the proportion of employees in research and development increased only slightly in the period under review and the proportion of other fixed capital formation declined, output increased less than the production index. Overall, the changed composition of the employment structure and corporate investment in the individual industry branches thus provides initial indications of the adjustments associated with the structural change in manufacturing.

DISCREPANCY BETWEEN OUTPUT AND GROSS VALUE ADDED OF NATIONAL ACCOUNTS

Gross value added has increased more strongly in recent years than output. As a result, fewer external inputs were required for the production of the same quantity of industrial goods.¹² The decline in the real intermediate input ratio (calculated as the share of price-adjusted intermediate consumption in price-adjusted output, in each case in chained volume data for the base year 2020) took place primarily in the 2010s (see Figure 8). Prior to this, it had been trending upward since the second half of the 1980s and reached a level at the end of the 1990s at which it remained largely unchanged until 2010.

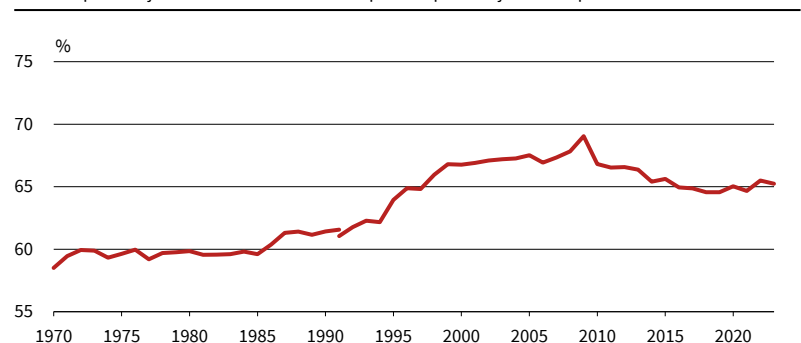
One possible cause of declining real intermediate input ratios could be a gradual reduction in the international division of labor and the associated shortening of value chains. When, during increased globalization in the 1990s, German industry increasingly imported intermediate goods and thus outsourced parts of its production abroad, the intermediate input ratio rose, and gross value added in Germany grew more slowly than output. If this offshoring process

¹² Measurement errors, for example due to different survey groups, can be ruled out as the cause of the discrepancy, as both the intermediate consumption and the production value are determined as part of the same cost structure survey.

Figure 8

Real Intermediate Input Ratio

Share of price-adjusted intermediate consumption in price-adjusted output

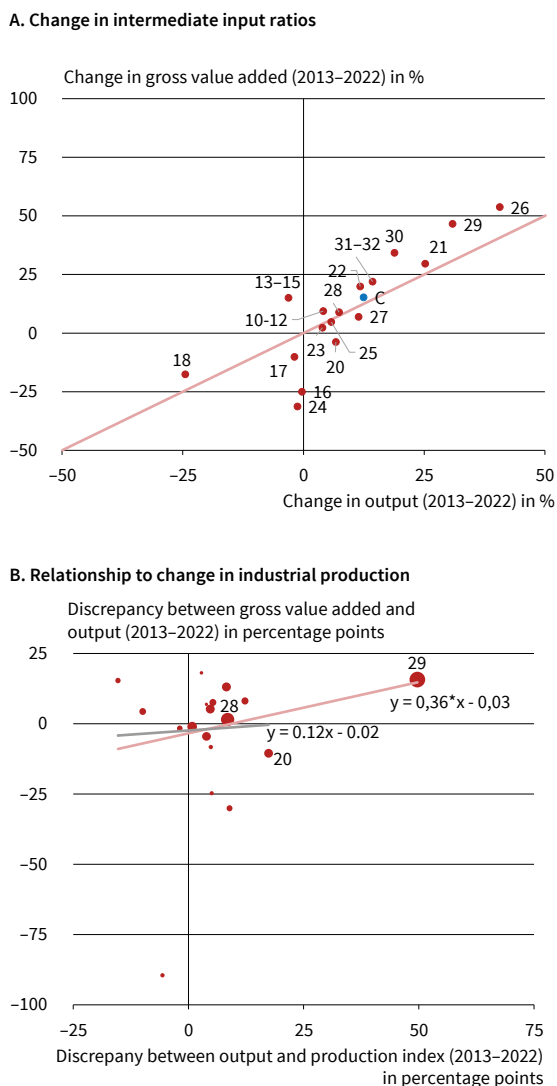


Note: Until 1990 West Germany.

Source: Federal Statistical Office; authors' calculations.

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Figure 9
Change in the Industrial Production Process by Industry Branch



Note: For the analysis, the industry branches 10 to 32 according to NACE Rev. 2 are considered. In the regressions in Figure B, the number of observations per branch was adjusted in proportion to its respective value added share in 2022. A* indicates significance at the 5% level. The gray line is the result of the regression without manufacturers of motor vehicles, trailers and semi-trailers (division 29 according to NACE Rev. 2).
Source: Federal Statistical Office; authors' calculation. © ifo Institute

was reversed, the same output would be produced today as before, but with less recourse to external (imported) inputs and more domestic production. Increasing automation in the production process could have contributed to this, reducing the advantage of low labor costs in the former target countries of the production relocations. Moreover, reshoring is likely to reduce the risk of value chains breaking down and production processes being disrupted as a result.

Another reason for falling input ratios could be the increasing importance of hybrid business models. As the services associated with product development and utilization are predominantly labor-intensive, the share of intermediate inputs, which play a role primarily in the production of goods, is likely to decline on

its own. To investigate this correlation, the heterogeneity in the development of real intermediate input ratios between the manufacturing sectors was again exploited. While price-adjusted gross value added increased more strongly than the price-adjusted output in most industry branches between 2013 and 2022 and thus the real intermediate input ratios decreased, the opposite trend was particularly evident in the manufacture of wood, plaiting, basketry, and cork products (division 16 according to NACE Rev. 2) and in metal production and processing (division 24) (see Figure 9A). Part of this different development can be attributed to the change in manufactured industrial goods. The discrepancy between the price-adjusted gross value added and the price-adjusted output is increasing more strongly in those industrial sectors in which hybrid business models (and thus the discrepancy between the output and the production index) have become more significant (see Figure 9B).

CONCLUSION AND POLICY RECOMMENDATIONS

The manufacturing industry in Germany is undergoing profound structural change. While the quantity of manufactured industrial goods measured by the production index has been following a downward trend since 2019, the price-adjusted total turnover of industrial companies, which is measured by the more comprehensive annual output in manufacturing, continued to trend upward until 2023. According to the monthly turnover statistics, a decline is likely to have occurred only in 2024. The price-adjusted gross value added in manufacturing also followed this trend.

The conceptual differences between the production index and output in manufacturing allow different interpretations of the results. Depending on the objective of the study, it may make sense to use one economic indicator versus another. On the one hand, the extent of goods production measured by the production index is relevant for the development of imports and exports, the hours worked directly in production and the employment there, material consumption, energy consumption, or transport activity in Germany. Output in manufacturing, on the other hand, is a measure of total economic output. After deducting intermediate consumption, it shows how much economic value has been added, which can be distributed in the form of wages and salaries or corporate profits.

The article shows that, in contrast to gross value added and output, the production index does not take into account turnover from other non-industrial activities, which have accounted for an increasingly large share of industrial business in recent years. On the one hand, the increasing discrepancy between output and the production index shows a change in industrial production – away from the exclusive production of industrial goods toward hybrid business models. Hybrid products are likely to have gained in impor-

tance, with an increasing proportion of turnover in the manufacturing sector being generated from product-related services. But the production of enterprises themselves is also likely to have become more hybrid and, as a result, an increasing proportion of turnover in the manufacturing sector is likely to be attributable to revenues from outsourced production facilities that are commissioned to manufacture industrial products in sales markets or at lower-cost locations. On the other hand, the increasing discrepancy between gross value added and output indicates a decreasing importance of external inputs in the production process. The change in industrial production may also have contributed to this. As services are labor-intensive, the increasing importance of hybrid business models goes hand in hand with falling input ratios.

This shift in the business activities of German industrial enterprises – away from the exclusive production of industrial goods toward hybrid business models – must be taken into account when assessing the current situation of German manufacturing. The changing composition of employment and corporate investment in the industry branches provides initial indications of the adjustments associated with this structural change. We have shown that the share of employment and expenditure on research and development increased more in those industries where the discrepancy between output and the production index was greater.

However, there is still a lack of detailed information on the type and scope of activities with which industrial enterprises are generating increasing turnover from other non-industrial activities. Only the growing quantitative importance of these activities can be deduced from the Federal Statistical Office figures presented here. Two surveys conducted at the beginning of the 2010s provided the first interesting indications of service activities in industry. However, as the importance of these activities has increased noticeably over the past decade and hybrid business models are likely to have changed in the line of technological developments, a follow-up project will collect up-to-date information on non-industrial activities using the ifo Business Survey.

It seems reasonable to assume that the observed structural change will gain momentum in the future. The German economy is facing major challenges. Digitalization, decarbonization, demographics, and deglobalization are putting the established German business model under pressure and making it necessary to modify existing production structures. Economic policy can help improve Germany's competitiveness by lowering the tax burden, reducing bureaucratic and energy costs, improving the digital, energy, and transport infrastructure, and providing intensive support to strengthen the labor supply. The success of this strategy is uncertain, but if economic policy remains silent, the result will be accelerated deindustrialization.

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