

The impact of wages on prices in Germany: evidence from selected empirical analyses

The impact of wages on prices has recently attracted a great deal of attention, both within academic circles and in the monetary policy debate. Despite the recent acceleration of wage growth, underlying inflation has risen only sluggishly, in Germany as well as in the euro area. This observation calls for a more precise analysis of the impact of wages on prices. In particular, the present investigation focuses not only on the scale of the impact, but also whether it might have diminished over time.

This article presents the results of selected empirical analyses examining the impact of wages on prices – a phenomenon known as pass-through – in Germany. On the basis of German firms' cost structure data for 2016, the percentage share of labour costs in the sales of goods and services that are contained in the Harmonised Index of Consumer Prices (HICP) is calculated. A comparable analysis is performed using input-output tables. Moreover, the impact of wages on prices is assessed based on a simulation using the Bundesbank's macroeconomic model. Lastly, a structural time series model is employed to address the question of how the relationship has evolved over the period since 1970. Overall, the analyses indicate that the elasticity of consumer prices to a change in wages is currently around one-third. This means that a 1% increase in labour costs would ultimately push consumer prices up by around 0.3%. The econometric studies additionally show that the pass-through of wage changes to consumer prices takes place gradually over several years.

Although the extent of the pass-through to consumer prices has diminished since the 1970s, there has been little change since the financial crisis of 2007-08 and, more recently, it has remained roughly stable. It must be taken into account, though, that such econometric studies of the pass-through typically focus on the cyclical component of inflation, i.e. deviations of the observed variables from their long-term trends.

The analyses indicate overall that the cyclical impact of wages on prices is still intact. Accordingly, the acceleration of wage growth in Germany over the past few years should, ceteris paribus, be reflected in a gradual rise in inflation.

The multidimensionality of the impact of wages on prices

Overview of impact of wages on prices

Wage dynamics are a central element in analysing and forecasting price developments. The macroeconomic elasticity of price changes to changes in wages, however, is affected by a large number of factors and also depends on which wage and price variables are being examined.

Relationship between unit labour costs and goods prices: mark-ups as buffers given imperfect competition

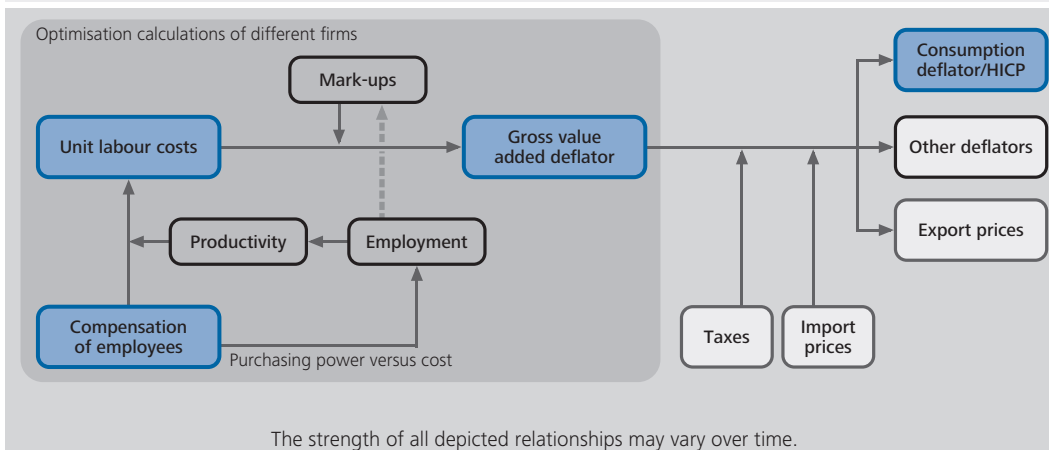
In the theoretical model of a closed economy with perfect competition, where goods prices are set in line with marginal costs, goods prices rise or fall at the same rate as unit labour costs.¹ However, in the real world, changes in unit labour costs are not necessarily passed through completely to price changes. This is because firms usually have a certain price-setting power and can set their prices somewhat higher than their costs. They therefore generally have the option of cushioning changes in unit labour costs by adjusting their mark-ups.² This is especially the case where changes in prices are costly for firms because, for instance, the adjustments themselves involve additional costs or they have reason to fear a decrease in their market share.

It should also be noted that the impact of unit labour costs on prices is not identical to the impact of other wage variables, such as compensation per employee or collectively agreed wages, as unit labour costs already reflect the results of endogenous adjustment processes. If, for instance, compensation per employee increases, reducing mark-ups is not the only way for firms to cushion this rise in labour costs. Another option is to reduce labour demand, either by cutting the average number of working hours or by laying off employees. This would increase measured labour productivity, with unit labour costs either rising less strongly or even remaining unchanged.³ At the same time, lower labour demand could lead to a contraction in aggregate demand, which puts downward pressure on mark-ups and prices (purchasing power character versus cost character of wages).⁴ The impact of wages and unit labour costs on prices can thus be different.⁵

Wages versus unit labour costs and demand character of wages

¹ For more, see the Annex on pp. 32 ff.
² This holds, for instance, under monopolistic competition.
³ This holds wherever factors of production can be substituted, i.e. where labour input can be offset by higher capital input. Substitutability also depends on the scope of employment protection legislation.
⁴ In such a situation, mark-ups would behave pro-cyclically.
⁵ Gumiel and Hahn (2018) show, for instance, that wages and unit labour costs can respond differently to supply and demand shocks. For instance, following a demand shock, by the time the rise in unit labour costs peaks, growth in consumption per employee has already begun to contract.

The multidimensionality of the impact of wages on prices



Sectoral differences as a function of individual labour cost shares

In general, the more labour-intensive production is, the greater the impact of wages on prices.⁶ Since labour intensity of production can vary across sectors, the impact of wage changes on prices should vary by sector. Both the gross value added (GVA) deflator, which is often used in empirical studies to approximate the price of domestic production, and unit labour costs are therefore aggregates of industrial and services sectors with different wage structures and price-setting strategies.

HICP versus GVA deflator: import and export prices and sectoral differences

The macroeconomic GVA deflator, however, is not the target variable of monetary policy. In the euro area, the target variable is the HICP, which can be approximated relatively closely by the consumption deflator. Unlike the GVA deflator, this deflator also contains prices of imported consumer goods and inputs. These prices, however, are likely to be set largely independently of domestic labour costs, apart from those associated with domestic trading activities.⁷ The impact of domestic wages on consumer prices is accordingly likely to be smaller than that on the GVA deflator. In addition, part of the goods produced domestically are not sold domestically but exported. As a result, associated (labour) cost changes might not necessarily be passed through to consumer prices.⁸ As a result, depending on the size of the variation of sectoral wage and price movements, the pass-through of wages to the GVA deflator and to the HICP is likely to be different. The same conclusion holds for the pass-through to sub-components of the HICP.

Possible time variation of pass-through

Lastly, the impact of wages on prices and thus all the relationships described above are likely to be time varying, since the structure of the economy being studied is constantly changing.⁹ Examples of changing trends include (national and international) competitive pressure, the global commodity price cycle and technology transfer, labour force mobility, unions' bargaining power and firms' ability to offshore, the monetary policy strategy and thus possibly inflation expectations, as well as the fiscal policy framework. These factors are likely

to impact both on the pass-through of wages to prices and on their trend pattern.¹⁰

Against this backdrop, the present article examines the impact of wages on prices in Germany using a variety of wage and price variables as well as several different analytical approaches. Pass-through is in principle defined here as elasticity, i.e. the ratio of a percentage change in prices to a percentage change in wages. It is also important to distinguish between a static and a dynamic relationship between wages and prices. In the static context, price elasticity can be determined using statistical methods. By contrast, in a dynamic context, pass-through has to be estimated econometrically. This estimation can account for macroeconomic feedback effects. Such feedback effects are taken into account, for instance, in the Bundesbank's macroeconomic model, which is used for

Static versus dynamic relationship and interaction between wages and prices

⁶ If perfect competition is assumed, it can theoretically be shown that the pass-through of wages to prices corresponds to the labour cost share (see the Annex on pp. 32 ff.).

⁷ By the same token, the cost situation of foreign firms and their price-setting strategies can be expected to play a stronger role.

⁸ The same holds for the prices of goods produced domestically, which are classified as investment or government consumption. Although these are contained in the GVA deflator, they only feed into the consumption deflator via inputs, if at all.

⁹ For the United States, Peneva and Rudd (2017) find a decrease in the impact of wages on prices, whereas for the euro area (including Germany), Bobeica et al. (2019) generally find an unchangingly strong pass-through, which, however, is likely to be somewhat more moderate owing to the existing low inflation environment. Possible changes in the relationship between wages and prices are also very relevant to the monetary policy debate. To substantiate this point, at their press conference in March 2019 Draghi and de Guindos (2019a), for instance, pointed out that "we've got to be patient in terms of pass-through [from wages to prices] (...) because the mechanism whereby increasing the cost, wages and also other parts of the cost components are transferred into prices, has changed structurally in the last few years. You've seen this in the United States and you're seeing this in Europe now". They were referring there to the following statement in Yellen (2015): "movements in labor costs no longer appear to be an especially good guide to future price movements" and: "the wage-price spiral no longer seems to provide a useful description of the U.S. inflation process". At the same time, at their press conference in July 2019 Draghi and de Guindos (2019b) emphasised that "over the medium term underlying inflation is expected to increase, supported by (...) stronger wage growth".

¹⁰ In other words, the relationships could also depend on the position of the business cycle and on the type of shock driving the wage change.

Various analytical approaches using different price and wage variables

preparing the macroeconomic forecasts for Germany that feed into the Eurosystem's projections (see also the box on pp. 19 ff.).

In the first analysis, the share of labour costs in goods and services contained in the HICP is determined for 2016 based on various firms' cost structure data. This is used to derive conclusions on the pass-through of wage changes to changes in consumer prices. The second analysis presents the results of econometric analyses for the period since 1970. It addresses not only the pass-through of hourly wages to the consumption deflator but also the effects on the GVA deflator. In addition, to facilitate comparison with various academic studies, the pass-through of unit labour costs to these two price variables is examined. This article also investigates whether the estimated pass-through has diminished over time.

Firms' labour cost shares as a proxy for the impact of wages on prices

Labour cost share as a proxy for pass-through

A comparison of a firm's labour costs with total sales provides an initial proxy for the pass-through of wages to prices. It is, in fact, possible to demonstrate theoretically that, under certain conditions, labour cost shares correspond to the pass-through of wages to prices (for more, see the exposition in the Annex on pp. 32 ff.). At the macroeconomic level, it must be noted here that – as mentioned in the preceding section – not all goods and services produced domestically are intended for private consumption. This means that, to start with, labour cost shares are calculated for individual firm and services sectors whose products are contained in the HICP.¹¹ These shares are then weighted in accordance with the HICP basket of goods in order to ultimately determine the labour cost share of headline HICP. This share can then be understood as an indicator of pass-through of wages to consumer prices.¹²

Data on the cost structure of firms in Germany are published annually by Germany's Federal Statistical Office for some 70 sectors of the economy. The reporting entities range from those which manufacture prepared meals and dishes via furniture manufacturers to catering services providers. They mostly provide, on an annual basis, data about their expenditure on individual production components, such as purchased goods, raw materials used or wages.¹³ This wage expenditure and all other expenditure can be expressed as a percentage of total sales in that respective economic sector in order to determine labour cost shares and shares of other expenditure at a disaggregated level. At the same time, the difference between sales and the sum of all expenditure provides an approximation of the mark-ups tacked on to costs in the respective business sectors.¹⁴

Data on firms' cost structure for around 70 economic sectors

The sectors of the economy for which cost data are available, however, are subject to a different statistical classification than goods and services, which are contained in the HICP basket of goods.¹⁵ In order to calculate the labour cost share of the HICP, economic sectors have to be assigned to HICP components at the

Assigning business sectors to HICP components: two-thirds of HICP covered

¹¹ In an ideal scenario, firm-level microdata would be used here; however, such data are not available.

¹² Since the data are not available for all sectors and labour cost shares in inputs and the share of imported goods can only be estimated, the result should be understood as a proxy.

¹³ See Federal Statistical Office (2019a) to (2019c). Wage expenditure includes remuneration and social security contributions along with, where available, data on temporary work and wage labour.

¹⁴ The impact of foreign trade is largely excluded in this study. One factor omitted here is that part of the goods contained in the HICP is imported. With regard to these goods, which, directly and indirectly, account for around one-fifth of consumer spending, domestically paid wages are likely to matter only for trade. Another factor omitted here is that certain goods produced domestically are primarily destined for export. The proxy for the pass-through of wages to prices was thus calculated under the assumption that the labour cost share of the goods in a sector destined for sale domestically corresponds to the labour cost share of the goods of the same sector destined for a foreign market.

¹⁵ Whereas firms and service providers are classified according to the Nomenclature statistique des activités économiques dans la Communauté européenne (Statistical classification of economic activities in the European Community (NACE)), HICP components fall under the classification of individual consumption by purpose (COICOP).

Transmission of wage changes to prices in the Bundesbank's macroeconomic model

A wage shock not only has a direct impact on goods prices through the changed cost situation resulting from the shock, it also has indirect effects. These include, in particular, the impact of higher wages on the labour market and the real economy. Amongst other things, these are relevant for the development of productivity and are therefore significant with regard to the adjustment process of prices to a new wage level.

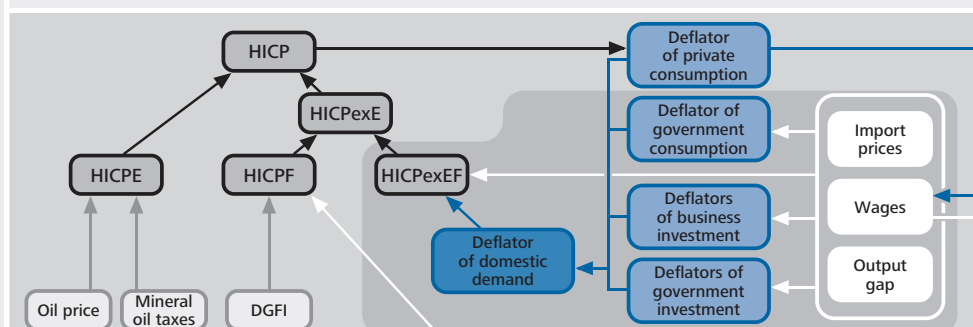
Structural models, such as the structural vector autoregressive model (SVAR) in the main text, or semi-structural macroeconomic models, such as the Bundesbank's macroeconomic model, are suitable analytical instruments for taking account of these repercussions. For the long term, the central behavioural equations in this model are derived from neoclassical theory. In the short term, prices do not fully adjust, and the model behaviour is determined to a greater extent by the demand for goods. This model serves not only as a core instrument for producing macroeconomic projec-

tions for Germany – which feed into the semi-annual euro area forecasts by Eurosystem experts that are published by the ECB in June and December¹ – but it is also regularly used for scenario analyses and policy simulations. This allows, for example, the effects of an assumedly exogenous rise in wages on consumer prices to be estimated. Here, in addition to the direct effects that are evident from the price variable behavioural equations, the impact of wages on the labour market and components of aggregate demand – which in turn have repercussions on price development – can also be taken into account in the context of the full model.

In the price block of the econometric model, both the deflators of the expenditure components as well as various components of the Harmonised Index of Consumer Prices (HICP) are explained. Here,

¹ In this context, the model is chiefly responsible for merging the projections for the sub-aspects of the German economy into a coherent overall macroeconomic picture.

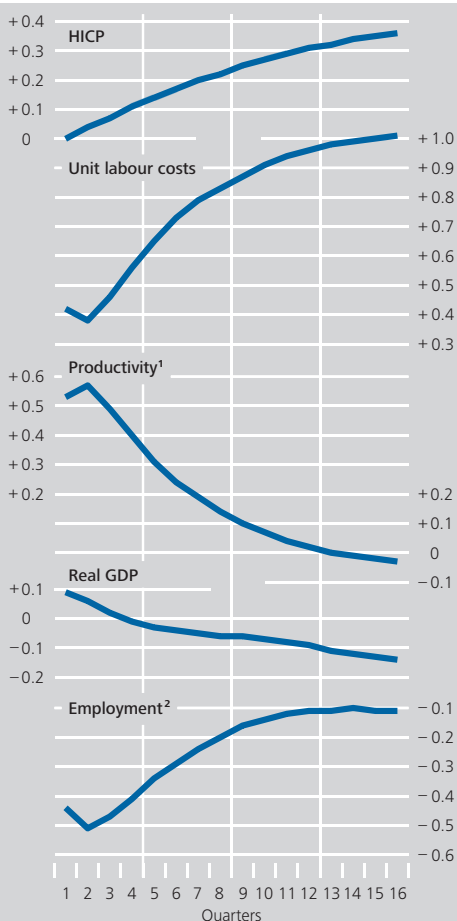
Schematic illustration of the price block in the Bundesbank's macroeconomic model*



* In the model, the role of value added tax is also factored in to the modelling of individual price variables. HICP = Harmonised Index of Consumer Prices. HICPE = HICP energy. HICPF = HICP food. HICPexE = HICP excluding energy. HICPexEF = HICP excluding energy and food. DGFI = agricultural producer prices in the EU.

Response of selected model variables to a wage shock*

Percentage deviation from the baseline



* Exogenous and persistent rise in gross hourly wages of 1%.
 1 On an hourly basis. 2 Total number of hours worked.
 Deutsche Bundesbank

wage variables feed in as determinants to varying degrees in each case. With regard to HICP, the more volatile components of energy and food as well as the HICP core components of services and industrial goods excluding energy are considered separately.² Crude oil prices and agricultural producer prices in the EU are the respective key influencing factors for the energy and food components of HICP. To explain the HICP core components and the deflators for investment and government consumption, Phillips curve equations³ expanded with estimated long-term relationships are used. In this long-term relationship, the impact of

key cost components on prices is captured through import prices (P_t^m) as well as unit labour costs (ULC_t):

$$\ln(P_t) = \alpha_1 + \alpha_2 \ln(ULC_t) + \alpha_3 \ln(P_t^m) + \varepsilon_t.$$

In this modelling framework, it is therefore assumed that wage inflation will not have an effect on prices over the long term provided that productivity rises to the same extent, so that the wage costs per unit produced remain unchanged.

Over the short to medium term, alongside the changes in import prices and unit labour costs, the level of aggregate capacity utilisation (X_t) also affects price development. If required, additional explanatory variables (Z_t), such as the interest rates on commercial or residential mortgages as a measure of user cost of capital, are included:⁴

$$\Delta \ln(P_t) = \beta_1 \varepsilon_{t-1} + \beta_2 \Delta \ln(ULC_t) + \beta_3 \Delta \ln(P_t^m) + \beta_4 X_t + \beta_5 Z_t + u_t.$$

Within the price block, a link between consumer price movements according to HICP and the general domestic price trend is achieved first by including the deflator of aggregate domestic demand as a determinant of the HICP core component. Second, in the behavioural equation for the deflator

² When modelling the individual price variables, an adequate degree of homogeneity is desired on the one hand so that the price variables move largely in parallel in simulations over the long term. On the other hand, individual influencing factors should also be given sufficient consideration.

³ A detailed description of the Phillips curve approach and its application within the price projection can be found in Deutsche Bundesbank (2016).

⁴ The specification presented here is purely for illustrative purposes. Any delays or modifications to the different variables are not shown. In order to factor in any dependencies between the equations in the price system consisting of the deflators of investment, the HICP core components and the deflator of government consumption, the short-term relationships are estimated using a system approach.

of private consumption expenditure, it is ensured that, in simulations, it develops broadly in line with aggregate HICP, comprising food, energy and the core component.⁵

In order to investigate the degree of transmission of wage changes to prices within the context of the model, a permanent exogenous rise in effective gross hourly wages paid⁶ of 1% over their baseline level was simulated.⁷ Here, no consideration is taken of the extent to which this wage inflation is reflected in negotiated wage rates and what proportion, if any, is attributable to wage drift, or of the causes of the rise in wages.⁸ Instead, the analysis focuses on the macroeconomic impact of an increase in wages paid by employers and on the transmission channels that are relevant to price development.⁹

If the price block of the model is viewed in isolation, the higher gross hourly earnings lead to a rise in prices, which, according to the estimation of the behavioural equations, is subdued at first but gradually intensifies over a number of years. At the same time, however, the simulations of the overall model account for employers responding to the higher wage costs by adjusting their demand for labour.¹⁰ The results show an immediate decline in total number of hours worked compared with the baseline level without the wage shock. However, as this response to higher wage costs itself lags behind the growth in hourly earnings, households' disposable income initially rises. For a time, households use the additional purchasing power to increase their consumption expenditure, with a portion going into savings. With the transmission of the wage shock to prices progressing in the second and third years of the simulation period, however, rising consumer price inflation has a dampening effect on real earn-

ings. The domestic price level, which increases as a result of the wage shock, reduces price and cost competitiveness, causing exports to increasingly fall below their baseline level. In principle, the increased wage costs also constitute an incentive for enterprises to substitute labour with capital. Overall, however, this is outweighed by the impact of macroeconomic activity on investment, so the reaction is muted. Imports become more price competitive compared with domestic production on the one hand,

⁵ It is also taken into account that fluctuations in energy prices are generally reflected to a lesser degree in the consumption deflator than in HICP.

⁶ There is no noteworthy effect on the outcome of the simulation if a rise in hourly employee wages that also include employer social contributions is implemented instead.

⁷ Here, it is assumed that wages rise due to an exogenous shock. Accordingly, possible causes for the increase in wages are not taken into account, and potential repercussions on wages resulting from the responses of other macroeconomic variables following the wage shock are not factored in to the analysis. The role of different structural shocks in the transmission of wage changes to prices in the euro area was, for instance, analysed on the basis of simulations using the ECB's New Area-Wide Model (see European Central Bank (2018)).

⁸ In principle, it would be possible to use the central wage equation in the macroeconomic model to trace the root causes of a rise in wages negotiated by the bargaining parties. The specification used to model negotiated wages largely corresponds to the one presented in Deutsche Bundesbank (2018). In the model, it is assumed that effective gross wages and salaries paid move in line with negotiated wages over the long term, but deviations above the estimated behavioural equation are possible over the short to medium term. If effective wages experience stronger growth than negotiated wages – referred to as positive wage drift – this can, within the context of the model, be attributable to the labour supply being more heavily utilised compared to the long-term observed average.

⁹ Furthermore, this analysis assumes that the macroeconomic effects of higher wages in Germany in the observation period do not cause any response in European monetary policy and that there is no reaction in bilateral exchange rates vis-à-vis the euro. This is in line with the analytical framework that is generally used for projections, in which interest rate and exchange rate movements are predetermined in the technical projection assumptions.

¹⁰ The higher potential earnings also incentivise households to expand their labour supply. This would have implications for labour force participation, the unemployment rate and thus feedback loops to wages, too. However, these do not feed into this assessment, as the higher wage level is assumed as given.

yet, on the other hand, are dampened by declining aggregate demand. As a whole, the simulation outcomes obtained using the macroeconomic model initially show an increase in gross domestic output as an immediate reaction to the wage shock. However, this drops below its baseline level as early as the second year.¹¹ Since the decline in the total number of hours worked is greater, productivity per hour rises at first.¹² This limits the impact of higher gross wages on unit labour costs and thereby on prices. This effect expires over the medium term, however, and unit labour costs exceed their benchmark to a similar degree as effective hourly earnings. In accordance with the elasticities in the behavioural equations for the individual price variables estimated for the macroeconomic model, the consumer price level is, after four years, only around 0.3% higher than its baseline level without the wage growth. Consequently,

price elasticity in relation to a wage shock would be only around 30%. In the event of a 1% wage shock, the annual rate of inflation would thus be around 0.1 percentage point higher than in the baseline scenario in each year of the four years.

11 A monetary policy response to the higher inflation rate would amplify the decline in gross domestic product compared to the baseline scenario. See Deutsche Bundesbank (2013).

12 The extent to which the reduced total number of hours worked would be accompanied by employment losses is dependent on whether and how the average number of hours worked per employee responds to the altered circumstances. If it falls as a result of lower demand, the response in the number of employees would be less pronounced than that accounted for in the total number of hours worked. The possibility of compensating by adjusting working hours is more likely in cases of temporary shocks and/or good cyclical positions, for example.

deepest possible level of disaggregation. It should be noted that, for goods in the HICP (food and non-energy industrial goods), the cost structure in both the production sector and in retail trade is relevant since this index reflects final consumer prices in retail trade.¹⁶ Information on the labour cost share is available, on the whole, for more than half of the HICP basket of goods. Therefore, the coverage of goods, at four-fifths, is considerably greater than that of services, at one-third.¹⁷ If it is assumed, moreover, that the wage expenses are likely to be relatively low¹⁸ with regard to rents and energy, which together account for around one-fifth of the HICP, and these components are factored into the analysis, HICP coverage of data on the cost structure rises to around two-thirds.

Thanks to the above classification of the labour cost shares of individual economic sectors, in keeping with the Federal Statistical Office's cost structure survey, to the components of the

HICP basket of goods, direct labour cost shares of the HICP and the HICP special aggregates¹⁹ can be identified; however, these do not contain the wage expenses resulting from inter-

16 To this extent, the labour cost share in the various subsectors of retail trade is relevant. In addition, production sector goods, which likewise contain labour cost shares that can be derived from the production sector's cost structure, also feed into retail trade's "services purchased".

17 On the whole, suitable economic sectors can be found for more than 80% of the food products contained in the HICP and for even as much as around 90% of the non-energy industrial goods contained in the HICP. In retail trade, which is downstream from production, a suitable classification can be found for a large share of industrial goods; however, the aggregate "retail sales of food products" must be used for all food products. In the case of services, the fact that data on "other services" are collected only every four years reduces the quantity of useful data. Assuming no distinct change in cost structures in two years, data for 2014 are used in this analysis for some services subsectors (laundry and dry-cleaning, hairdressing salons and funeral parlours) in order to achieve a greater degree of coverage.

18 Data on wage expenditure in these areas are patchy and indicate very small values, such as, for instance, 4% in the manufacture of refined petroleum products or electric power generation.

19 These encompass energy, unprocessed and processed food, non-energy industrial goods and services.

Cost structure data of selected firms and service providers in 2016

€ million

Economic sector ¹	Expenditure					
	Use of or spending on merchandise or materials	Spending on raw materials, consumables and supplies, energy consumption	Wages ²	Social security contributions	Rental and leasing activities, operating leasing	Other costs ³
Manufacture of furniture WZ08-3100	9,099	232	4,918	755	387	2,923
Retail sale of household furniture WZ08-47591	15,804	399	3,474	727	1,614	4,581
Food and beverage service activities WZ08-56	643	18,034	14,729	3,409	5,355	7,592

Sources: Federal Statistical Office (2019) and Bundesbank calculations. Structural data of firms in the manufacturing sector, in the wholesale and retail trade and in the services sector. **1** Economic sectors (WZ) based on the Statistical classification of economic activities in the European Community (NACE Rev. 2). **2** Sum of gross wages and salaries as well as temporary employment and wage labour or other industrial/craft trade services (where data on the latter are available). **3** Including operating taxes and levies as well as purchased merchandise and services.

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Share of labour costs in sales of selected firms and service providers in 2016

%

Economic sector ¹	Share of expenditure in sales			
	Wages ²	Other expenditure	Total	Mark-up ³
Manufacture of furniture WZ08-3100	29	67	96	4
Retail sale of household furniture WZ08-47591	15	80	95	5
Food and beverage service activities WZ08-56	31	54	85	15

1 Economic sectors (WZ) based on the Statistical classification of economic activities in the European Community (NACE Rev. 2). **2** Wages and social security contributions (see the uppermost table). **3** Derived from sales minus expenditure.

Deutsche Bundesbank

Direct labour cost share around one-fifth for goods, one-quarter for services

mediate products (see the chart on p. 24). In 2016, these direct labour cost shares for both groups of goods (non-energy industrial goods and food) accounted collectively for around one-fifth²⁰ and were slightly higher in the production sector than in retail trade.²¹ The labour cost share of sales is somewhat greater for services, at one-quarter.²²

Labour cost shares of HICP components vary between 5% and 50%

The distribution of wage expenditure by HICP special aggregates ranges from 5% to over 30% for food and from just over 10% to just under 50% for non-energy industrial goods²³ (see the chart on p. 25). The range of wage expenditure between the individual HICP com-

ponents, especially for non-energy industrial goods, is relatively small. Only the production

²⁰ For Australia, D'Arcy et al. (2012) find a labour cost share of one-fifth only for trade.

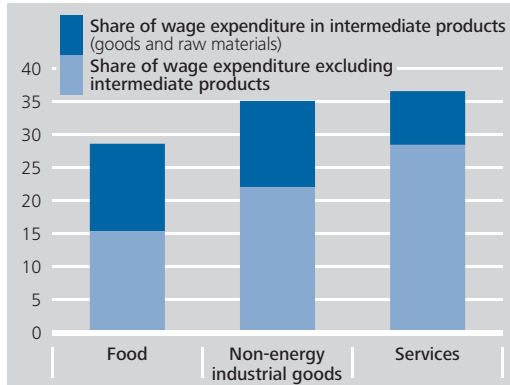
²¹ In the case of food and non-energy industrial goods, the production and retail trade sectors are aggregated by using the cost share for goods in retail trade as a weight of the production sector.

²² For services, where available, cost structure data for large firms (total sales of €250,000 and up) are used since, in this case, small firms can affect the overall data. Small firms are often run by the proprietors themselves or family members, who are not being paid for their work and whose "wages" therefore do not show up as part of wage expenses.

²³ For goods, only the matches at the industrial producer level are taken into account, as fewer matches can be created at the retail trade level. For instance, for the HICP food sub-index there is only one single match at retail trade level.

Wage expenditure by selected HICP special aggregates in 2016

As a percentage of sales



Source: Bundesbank calculations based on data from the Federal Statistical Office.
 Deutsche Bundesbank

of goods such as boats shows a significantly higher labour cost share; the importance of this product for private consumption, however, is marginal. For services, the labour cost shares in the individual HICP areas are vastly more different, ranging from 10% to over 50%. This reflects the highly diversified nature of the components for services covered in the HICP. High labour cost shares are to be seen particularly in labour-intensive services such as hairdressing or dry-cleaning, yet these only make up a small portion of the basket of goods. By contrast, the labour cost share for services with a distinct weight in the HICP, such as telecommunications, amounts only to a little more than 10%.

However, the wage expenses directly contained in the HICP that have been calculated in the analysis thus far using cost structure data are likely to understate the actual figure. This is because firms purchase commodities and other resources in order to produce the final goods or services offered to the consumer. These intermediate inputs also entail wage expenses, which must be added to those already calculated. According to cost structure data, the labour cost shares of intermediate goods producers usually account for around one-quarter of sales. Significantly lower or higher values are rare. This labour cost share can be weighted by the expenditure on goods and raw materials

Wage expenses including intermediate products at roughly 40%, ...

obtained from the cost structure data. As the intermediate inputs themselves contain both direct and indirect labour cost shares, they are incorporated into the calculation at all stages of the production of final goods, ultimately yielding wage expenses of around 40%.²⁴ However, taking into account that calculations made using input-output tables reveal that around one-fifth of goods and raw materials are imported (for more information, see the box on pp. 26 ff.) and are thus largely independent of the domestic wage setting, total wage expenses are likely to amount to closer to one-third.²⁵

If the wage expenditure included in the HICP components of rents and energy, which is likely to be very low – accounting for roughly one-fifth of HICP – is also taken into consideration, then labour costs probably make up just under 30% of headline HICP. The overall difference between goods and services is not very large, partly because many services that are relevant in the HICP are not traditional craft trade service activities.²⁶ Assuming that higher wages are fully passed through to prices, at least in the long term, price elasticity for wages can be expected to amount to around one-third, according to the cost structure analysis.

... but pass-through of wages to headline HICP just under 30% when rental and energy costs considered

SVAR analysis of the impact of wages on prices since 1970

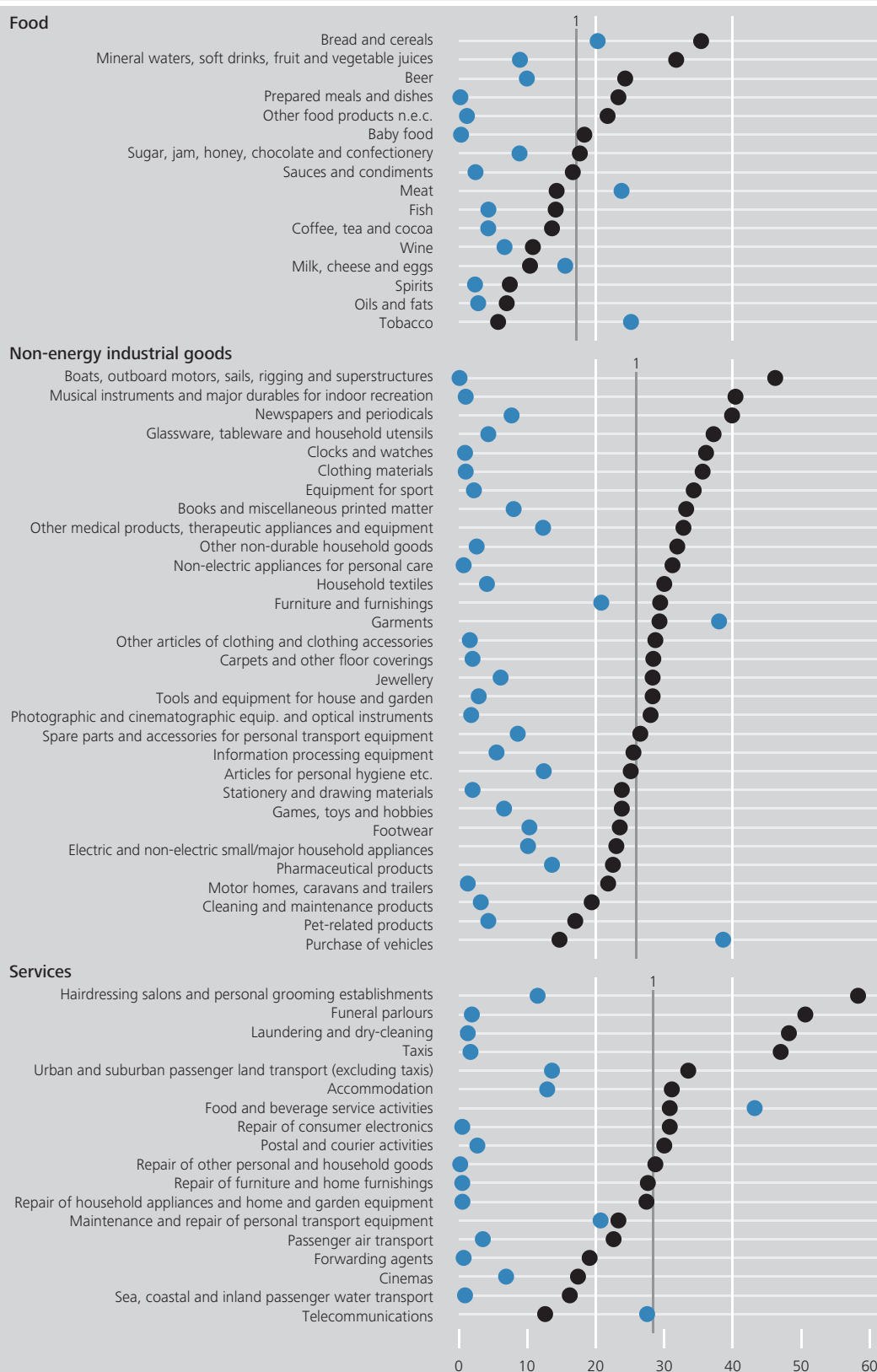
Analysing the share of HICP made up by labour costs provides a first approximation of the pass-through. Furthermore, the impact of wages on prices can be estimated using econometric methods, which use data collected over a

SVAR model with time-varying parameters estimated for 1970 onwards

²⁴ If the inputs are repeatedly replaced with the cost structure of the producing firm, an infinite geometric series is created. If wages and intermediate production account for shares of 0.25 and 0.4 respectively, this generates total wage expenses of: $\frac{0.25}{1-0.4} \approx 0.42$
²⁵ Overall wage expenses are then determined as follows: $\frac{0.25}{1-(0.4-0.08)} \approx 0.37$
²⁶ Alternatively, the small difference may derive from the fact that the wholesale and retail trade services generate high labour cost shares for goods (see the box on pp. 26 ff.).

Distribution of wage expenditure* and share in HICP in 2016

● Wage expenditure as a percentage of sales ● Share in HICP as a %



Sources: Federal Statistical Office and Bundesbank calculations. * The wage expenses contained in the intermediate products are not taken into account in the breakdown of wage expenditure above. 1 Weighted average of wage expenditure using HICP shares from 2016.

The labour cost share of consumption: an analysis with input-output tables

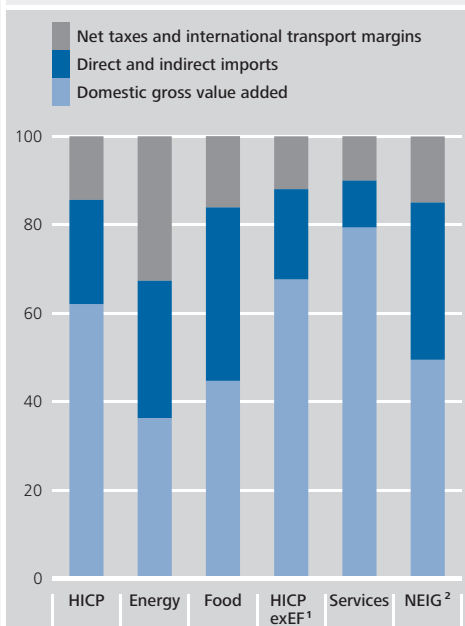
Input-output tables¹ provide comprehensive information on the interconnectedness of a country's economy both nationally and internationally. This information may be used, amongst other things, to break down the value of household consumption expenditure for the goods and services of each industrial sector into the components of net taxes, transport costs, and the nominal contribution of production factors. This latter component comprises imported intermediate goods, gross value added, taxes less subsidies, and international transport margins incurred during the production process. In this context, gross value added covers compensation of employees, mixed income, and capital income. The nominal shares of the labour and capital production factors in overall consumption expenditure may be interpreted, under certain condi-

tions, as elasticity in consumer prices with regard to the individual factors.²

In a further step, information on the composition of the Harmonised Index of Consumer Prices (HICP) and its sub-components can be derived from the composition of consumption according to the revenue account.³ Similar to the allocation of cost structure data in the main text, however, this requires the industrial sectors, according to which consumption in the input-output tables is structured, first to be aligned with the composition of the HICP consumer basket by category of goods.⁴

Breakdown of the HICP consumer basket in Germany by input factors in 2014

As a percentage of household consumption expenditures



Sources: World Input-Output Database, Eurostat and Bundesbank calculations. ¹ HICPexEF = HICP excluding energy and food. ² NEIG = non-energy industrial goods.
 Deutsche Bundesbank

¹ The "World Input-Output Table" compiled by the World Input-Output Database (WIOD) is used here. For further information, see Timmer et al. (2015) and the website www.wiod.org

² Under the assumptions presented in the Annex (see p. 32 ff.), wages in relation to turnover correspond to the elasticity of inflation with regard to wage growth. Given certain assumptions, the same relationship can be established for all other production factors.

³ With regard to the production-related linkages of individual categories of goods described in what are known as Leontief inverses, household consumption expenditure for a certain category of goods can be broken down entirely into the components of domestic gross value added, direct and indirect imports, taxes less subsidies, and international transport margins. Contributions to the HICP special aggregates, for instance, may be determined depending on how the categories of goods are aggregated.

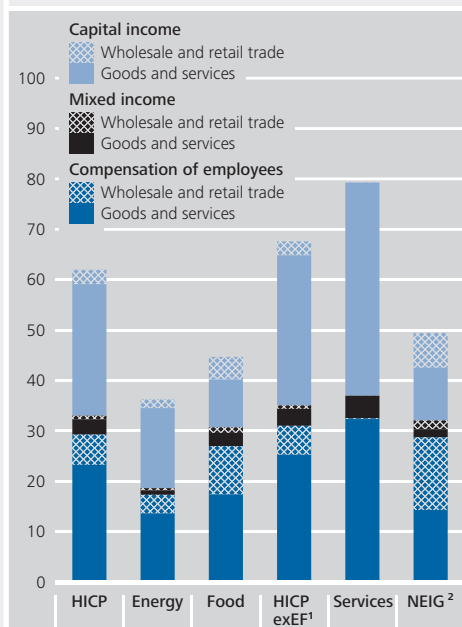
⁴ The idea of breaking down household final consumption expenditure into input factors is not new. Eurostat (2008), for example, points to the possibility of creating input-output tables for final consumption. However, there is no single approach to implementing this for the countries of the euro area. Nevertheless, in order to harness the information in the input-output tables for the analysis of price dynamics in Germany, the following methodology was applied: the linkages between the data on household final consumption expenditure in the WIOD according to the classification of products by activity (CPA) and the classification of individual consumption by purpose (COICOP) were established based on the COICOP 1999 and CPA 2008 correspondence tables lists in Eurostat's Reference And Management Of Nomenclatures (RAMON). The weights in the final consumption input-output tables were approximated using four-digit COICOP weights as well as other publicly available data. For Germany, the Federal Statistical Office published final consumption input-output tables up to 2004.

On balance, 62% of the input factors introduced for the production of household consumer goods in 2014 can be traced back to gross value added within the German economy. Taxes less subsidies and international transport margins make up 14%. Just under a quarter were caused by direct and indirect imports, the proceeds of which thus benefiting non-residents. Services had the largest share of gross value added, food products the largest share of imports, and energy the largest proportion of net taxes and transport margins.

As described in the introduction, individual input factors can be further differentiated using the information contained in the input-output tables. Within domestic gross value added, it is possible, for instance, to differentiate between employee compensation and mixed income on the one hand and capital income on the other. Retail and wholesale trade can also be differentiated. Looking at HICP services, for example, which have the highest share of gross value added among the HICP special aggregates, it can be seen that not even half of this gross value added is attributable to labour income. Consequently, the labour share in HICP services is only slightly higher than for food or non-energy industrial goods. This is because both of these special aggregates require an especially large amount of retail and wholesale trade, which is very labour-intensive. Only the labour cost share for the production of energy goods decreases significantly, at 18%.

Breakdown of domestic gross value added by income type in 2014

As a percentage of household consumption expenditures



Sources: World Input-Output Database, Eurostat and Bundesbank calculations. ¹ HICPexEF = HICP excluding energy and food. ² NEIG = non-energy industrial goods.
 Deutsche Bundesbank

longer period of time.²⁷ In such a context, it is possible to estimate not only the level of pass-through, but also whether this relationship has changed over time. To this end, various structural vector autoregressive models (SVARs) with time-varying parameters, which take the interdependencies of wages and prices into account, are estimated for Germany from 1970 onwards.²⁸ Both the deflator of private consumption expenditure, which exhibits very similar time series characteristics to the HICP (the actual monetary policy target variable), and the GVA deflator, as the indicator of domestic price developments, are selected as price values. Both the impact of hourly wages and that of unit labour costs are examined.²⁹ It should be borne in mind that the analysis addresses the interaction between the cyclical components of the variables under consideration; changes in longer-term relationships are not assessed.³⁰

Marked but declining pass-through of unit labour costs to GVA deflator; ...

Beginning with an examination of the unit labour costs and the GVA deflator (see the chart on p. 29), a fairly close correlation can be identified between their rates of change up to the mid-1990s. After this point, the correlation weakens, since the behaviour of profit mark-ups has changed over time. The SVAR estimates confirm this visual impression.³¹ It appears that the pass-through of unit labour costs to the GVA deflator in the 1970s amounted to just over one-third after one year, increasing to a little over one-half after four years. Since the mid-1990s, however, the pass-through has declined markedly. It currently accounts for less than one-third after one year, and after four years, it amounts to only two-fifths. Overall, the values of the empirically estimated pass-through are significantly lower than neoclassical production theory would suggest. This is most likely due to the fact that, in this theory, profit mark-ups are not determined endogenously.

... by contrast, pass-through of changes to hourly wages stable

However, a different picture emerges for the pass-through of hourly wages to the GVA deflator.³² Having remained relatively stable since the 1970s, it most recently amounted to around

two-fifths after one year and roughly three-fifths after four years. The various degrees of pass-through of unit labour costs and hourly wages to the GVA deflator can be explained by breaking down the growth rate of the GVA deflator into hourly wages, hourly productivity and profit mark-ups. In principle, it may be assumed that wage increases are reflected in higher prices, lower profit mark-ups or increased productivity. Increases in productivity themselves result either in lower prices or higher wages, or are reflected in higher profit mark-ups. Against this backdrop, the SVAR analysis indicates that the cyclical relationship between the GVA deflator and unit labour costs in Germany has become somewhat looser over the past few decades. However, this is not primarily driven by wages, but rather by productivity. Overall, the estimated pass-through of hourly wages is – in contrast to the implications

²⁷ Seasonally adjusted quarterly national accounts data for the period from the first quarter of 1970 to the first quarter of 2019 (data vintage: May 2019) are used for the analysis. Up to and including 1991, the data relate to western Germany; from 1991 onwards, they relate to Germany as a whole. They were chain-linked and scaled in such a way that the annual average of the data for western Germany in 1991 corresponds with the annual average of the data for Germany as a whole.

²⁸ The SVAR estimates with time-varying parameters are made with the help of the Bayesian Estimation, Analysis and Regression (BEAR) toolbox (see Dieppe et al. (2018)). All specifications take into account four lagged values of the endogenous variables.

²⁹ Here, hourly wages are defined as the compensation received by employees per hour worked, and unit labour costs are defined as hourly wages relative to the real GVA per hour worked.

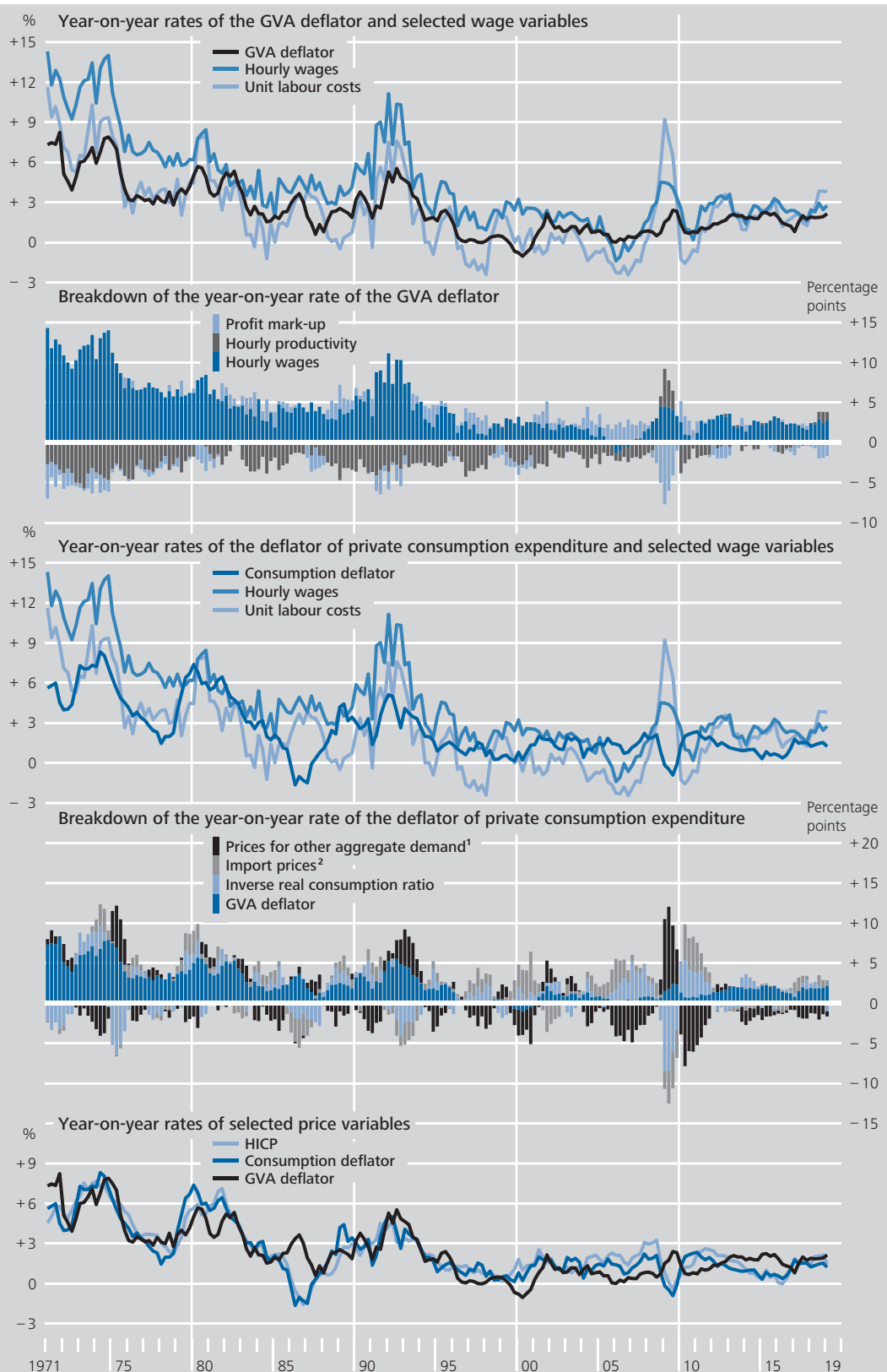
³⁰ This means that the model-implied relationship between wage and price fluctuations from their respective stochastic trends is being examined. See also the box on p. 31.

³¹ The VAR model includes the annualised quarterly rates of change of unit labour costs and of the GVA deflator. The pass-through of unit labour costs to the GVA deflator is defined as a cumulated impulse-response function of the rate of change of the GVA deflator relative to that of unit labour costs following an identified shock to the latter.

³² The VAR model includes the annualised quarterly rates of change of hourly productivity, unit labour costs and the GVA deflator. The pass-through of hourly wages to the GVA deflator is defined as a cumulated impulse-response function of the rate of change of the GVA deflator relative to that of unit labour costs following an identified shock to hourly wages. A Cholesky decomposition of unit labour costs is used to determine the shock to hourly wages and describes a change in unit labour costs that cannot contemporaneously be attributed to a change in hourly productivity.

Selected wage and price variables

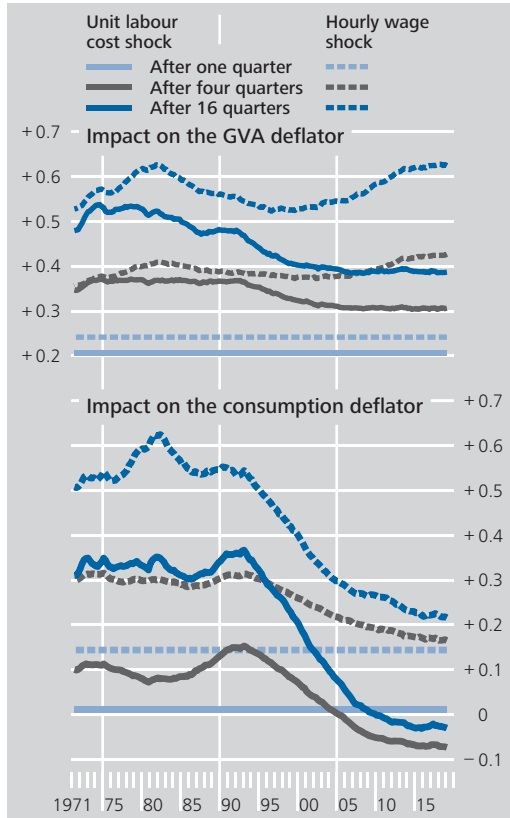
Quarterly data, seasonally adjusted



Source: Bundesbank calculations based on data from the Federal Statistical Office. **1** Impact of the deflators of other aggregate expenditure components on the difference between the consumption deflator and the GVA deflator. **2** Impact of the import deflator on the difference between the consumption deflator and the GVA deflator.

Model calculation of the impact of unit labour costs on the gross value added (GVA) deflator and the deflator of private consumption expenditure*

Quarterly data



* Cumulated impulse-response function of the rate of change of the respective deflator relative to that of the unit labour costs following a unit labour cost shock or an hourly wage shock. Estimation results of an SVAR model with time-varying parameters for one, four and 16 quarters. The impact of unit labour costs on the deflators after four and 16 quarters changes over time. The impact after one quarter is time-invariant due to the model design.

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of neoclassical production theory – greater than that of unit labour costs. This is presumably due to the fact that the estimation approach based on hourly wages is less restricted in econometric terms than the unit labour costs-based approach, and therefore captures the changed behaviour of profit mark-ups more flexibly. This means that the pass-through can be quantified more reliably.

In the case of the consumption deflator, the pass-through of unit labour costs has declined even more strongly than for the GVA deflator.³³ Since the 1970s, it has decreased from 10% to around zero after one year, and from 35% to

Pass-through of hourly wages to consumption deflator also intact, ...

approximately zero after four years. The pass-through of hourly wages to the consumption deflator has also declined. In recent years, however, it has been considerably greater than zero, and currently amounts to 10% after one year and 22% after four years.

Generally speaking, it appears that the pass-through to the consumption deflator is significantly lower than the pass-through to the GVA deflator. There are three reasons for this: first, private consumption expenditure includes a significant proportion of imported goods, the prices of which are likely to be largely independent of domestic wage developments. Second, estimates show that the pass-through of wages to the other deflators is higher than to the consumption deflator. Finally, it is the gross value added excluding taxes on goods which is being examined, whilst indirect taxes account for a substantial share of consumer prices.

... but generally lower than for GVA deflator

The pass-through of wages to prices changes very little if the estimations also use the unemployment rate as a proxy for aggregate capacity utilisation.³⁴ In the context of the SVAR estimation, this merely affects the established stochastic trend of inflation (see the box on p. 31).

Taking capacity utilisation variables into account barely alters pass-through results

Conclusion and outlook

Overall, the results of the various analyses indicate that the pass-through of wages to consumer prices amounts to approximately one-third. A 1% change in wages thus results in a change of consumer prices by around 0.3%.

³³ The VAR model takes into account the annualised quarterly rates of change of the import deflator, the hourly productivity rate, unit labour costs, the consumption deflator and the deflator of other aggregate demand. The pass-through of unit labour costs and of hourly wages to the consumption deflator is defined in the same way as the pass-through to the GVA deflator.

³⁴ Aggregate capacity utilisation, which is usually approximated by the output gap, the unemployment gap or the unemployment rate, is used as a further determinant of inflation, particularly in Phillips curve estimates.

The stochastic trend of inflation

The main text's analysis using the structural vector autoregression (SVAR) model is based on data from 1970 through to the current year. Over this long period of almost 50 years, it is likely that changes to the underlying structural conditions will have been extremely significant as to how inflation has developed in Germany. These include, for instance, the reunification of Germany, the increasing global ties of the German economy, the rising competitive pressure due to globalisation, and the different monetary policy environment following the launch of the single monetary policy for the euro area. On top of this, there was the "Great Moderation", a prolonged period starting in the mid-1980s during which inflation rates fell significantly around the world.¹

These kinds of changes in the underlying economic conditions are typically reflected in changing trends in macroeconomic variables, such as the inflation rate. The SVAR approach used in the main text depicts such influences as changes in the stochastic trends of the analysed variables produced by the estimated model. By contrast, the pass-through from wages to prices in this model refers solely to the interaction between the cyclical components of wages and prices.²

The model shows that the stochastic trend of inflation in Germany – as measured by both the gross value added deflator and the private consumption deflator – saw a distinct decline in the period from 1970 to 1999. Since then, both stochastic trends have been relatively stable.

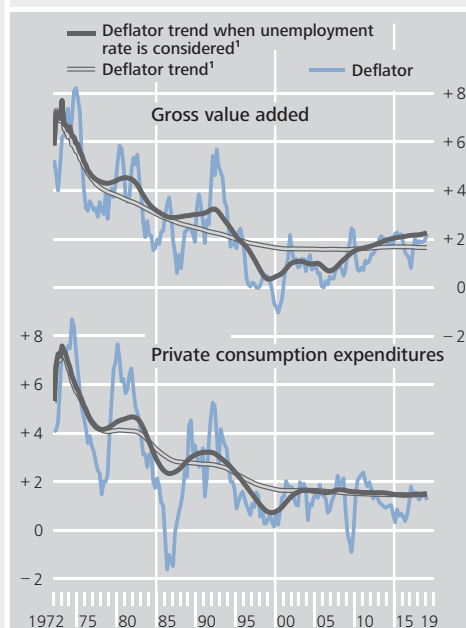
If the unemployment rate is included in the SVAR estimation as an approximation value

for aggregate capacity utilisation, there is markedly higher variation in the stochastic trend of inflation over the medium term. This could mean that capacity utilisation had a major impact on the stochastic trend of inflation. Conversely, the model could, at least in some cases, incorrectly attribute the strong cyclical fluctuations in the registered unemployment rate to the trend.

The stochastic trend of the private consumption deflator in both variants has remained relatively stable since 2002, with a growth rate of around 1½%. The trend of the gross value added deflator has stood slightly above this level in recent years. This likely reflects structural differences between the individual components of gross value added that are associated with different sectoral price trends.

Stochastic trends in the annual rate of change of selected deflators

Quarterly, seasonally adjusted



Sources: Federal Statistical Office and Bundesbank calculations.
 1 Estimated using an SVAR model with time-varying parameters.
 Deutsche Bundesbank

¹ See Bernanke (2004).

² Peneva et al. (2017) likewise estimate a stochastic trend in their analysis of the wage-price pass-through, but do not elaborate on it further. Bobeica et al. (2019) correct the wage and price variables ahead of their econometric analysis of how they trend by adjusting both the wage and the price variables for inflation expectations.

Pass-through of wages to prices in Germany, according to different models

Method	Price variable	Pass-through	
		Level	Time variation
Cost structure ¹	HICP	0.3	Not analysed
SVAR ²	Consumption deflator	0.2	Slight downward trend
	Memo item: GVA deflator	0.6	No time variation
Macro model ³	HICP	0.3	Not analysed

¹ Pass-through derived from sectoral labour cost shares. ² Permanent hourly wage shock, pass-through scaled to the reaction of unit labour costs. ³ Permanent shock to compensation per employee. Pass-through in SVAR and macro models cumulated over four years.

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However, it takes considerably longer than one year for the cyclical adjustment of prices to a

wage shock to be largely complete. Examining the consumption deflator since 1970, there is some evidence to support the argument that the pass-through of wage shocks to prices has weakened in Germany. In any case, the decline has been only slight since the financial crisis of 2007-08, and has come to a halt in recent times. In this context, it is also important to note that, since the start of the 2000s, the stochastic trend of the inflation rate in Germany, which was determined using the SVAR model, has no longer been declining; rather, it has been trending sideways. The cyclical impact of wages on prices should therefore not be greatly affected by the estimated trend seen in recent times. With this in mind, there is much to suggest that the above-average wage growth experienced in Germany over the past few years will result in a gradual rise in inflation.

Annex

The wage-price relationship in economic theory

In the long-term neoclassical equilibrium, unit labour costs as measured by domestically produced goods and the prices of domestically produced goods rise at the same rate

The starting point for these considerations on the long-term wage-price relationship period is neoclassical production theory.³⁵ Assume that, in a model of an open economy, the aggregate of goods produced domestically by a representative firm Y_t may be characterised by a Cobb-Douglas production function with constant returns to scale:³⁶

$$Y_t = A_t N_t^{\alpha_1} K_t^{\alpha_2} M_t^{1-\alpha_1-\alpha_2},$$

$$\alpha_1, 1 - \alpha_1 - \alpha_2 \in (0, 1)$$

where N_t denotes labour input, K_t capital input, M_t imported intermediate goods, and A_t total factor productivity.³⁷ The nominal costs per unit of labour amount to W_t , the nominal costs per unit of capital R_t and the nominal costs per unit of imported intermediate goods P_t^m . It is additionally assumed that the representative firm behaves rationally, that all goods and factor markets are characterised by perfect competition and that there are no price rigidities.

According to the first-order conditions for optimal labour input, nominal costs per unit of labour corres-

pond in the long-term growth equilibrium to the marginal revenue product of labour.

$$\alpha_1 \frac{P_t Y_t}{N_t} = W_t \Leftrightarrow \alpha_1 = \frac{W_t N_t}{P_t Y_t} \quad (1)$$

where P_t describes the deflator of domestically produced goods. Alternatively, the ratio of the aggregate nominal wage bill to sales of the goods produced domestically corresponds to the output elasticity of labour.³⁸

After solving expression (1) for the deflator P_t , taking the logarithm and forming first differences, the inflation rate of domestically produced goods π_t is ob-

³⁵ See, for example, Mas-Colell et al. (1995).

³⁶ In-house analyses show that, in the short to medium term, a CES specification with a substitution elasticity that may diverge from 1 matches the aggregate production function of the German economy more closely than the Cobb-Douglas specification used here, which assumes a substitution elasticity of 1.

³⁷ In this form of presentation, domestically produced intermediate goods are already reduced to the three basic input factors: labour, capital and imported intermediate goods.

³⁸ This relationship serves as a justification for the calculations based on enterprises' cost structure. In the analysis, the pass-through is defined as the wages to sales ratio.

tained as a function of the growth rates of wages per unit of labour less labour productivity. Put differently, in a growth equilibrium, inflation corresponds to the growth rate of unit labour costs measured by the goods produced domestically.³⁹

$$\pi_t = \underbrace{\frac{\Delta \ln W_t - (\Delta \ln Y_t - \Delta \ln N_t)}{\Delta \ln ULC_t}}_{\Delta \ln ULC_t} \quad (2)$$

Pass-through of wages to prices possibly less than 1, however

Consequently, in the long-term neoclassical equilibrium, unit labour costs and prices grow at the same rate. With regard to the impact of wages per unit of labour on prices, it should be noted, however, that labour productivity is likewise a function of factor prices that can be determined using conditional factor demand. Expressed in growth rates, this is written as

$$\begin{aligned} \Delta \ln Y_t - \Delta \ln N_t = & \Delta \ln A_t + (1 - \alpha_1) \Delta \ln W_t \\ & - \alpha_2 \Delta \ln R_t \\ & - (1 - \alpha_1 - \alpha_2) \Delta \ln P_t^m. \end{aligned} \quad (3)$$

Under perfect competition on the factor markets, the representative firm responds to a change in wages by substituting labour with capital or imports until labour productivity has returned to the higher wage level. This effect counteracts wage pressure on prices, which means that the elasticity or pass-through between labour costs and prices, as shown in Equation (4), merely corresponds to $\alpha_1 < 1$.

$$\begin{aligned} \pi_t = & - \Delta \ln A_t + \alpha_1 \Delta \ln W_t \\ & + \alpha_2 \Delta \ln R_t \\ & + (1 - \alpha_1 - \alpha_2) \Delta \ln P_t^m. \end{aligned} \quad (4)$$

In summary, it may be noted that neoclassical production theory, under the assumption of perfect competition on the factor markets and the goods market, suggests that the pass-through between wages and prices should be determined in the long term by the ratio of the nominal wage bill to the value of the domestic supply of goods. The impact of changes in unit labour costs measured by domestically produced goods on prices should, moreover, be greater than is the case for changes in wages.

Other influences on the pass-through given imperfect markets

This outcome does not change even if the assumption of perfect condition is discarded and monopolistic competition with constant or exogenously variable mark-ups is assumed. It is conceivable, however, that – especially over the short and medium term – the identified relationships change if the mark-up in the model is endogenously determined

in a time-varying manner.⁴⁰ The pass-through can also change as a result of imperfections on the factor markets.⁴¹ In this respect, search and matching frictions capture a large number of market imperfections in the labour market, such as heterogeneities, information deficits or indivisibilities.⁴² In particular, it is assumed that labour input is not infinitely divisible, as employees and employers first have to find each other in a time-consuming and resource-intensive manner.⁴³ Although the model-based pass-through of costs per labour unit W_t to prices still corresponds to the above-described constant α_1 , the costs per labour unit W_t are composed of the wage per employee ω_t , plus the expected search costs of hiring one employee $\kappa q(\theta_t)$, less expected savings from not having to hire another employee in the next model period:⁴⁴

$$W_t = \omega_t + \frac{\kappa}{q(\theta_t)} - (1 - \sigma)\beta \frac{\kappa}{q(\theta_{t+1})}. \quad (5)$$

The function $q(\theta_t)$ here represents the aggregate ratio of advertised vacancies V_t to newly filled positions M_t while κ describes the costs of advertising a vacant position for one model period. Under the assumption of a Cobb-Douglas matching function, the rate q is a function of labour market tightness θ_t , defined as the aggregate ratio of advertised vacancies to the number of unemployed persons U_t . The expected savings on search costs – the last term in the above equation – additionally depends on the exogenous job separation rate σ as well as the time preference rate β .

³⁹ Abstracting from imports in the model, Y_t reflects real gross value added and P_t reflects the gross value added (GVA) deflator.

⁴⁰ For instance, modelling consumption patterns at the level of individual product varieties (deep habits) leads in equilibrium to countercyclical movements in firms' mark-ups; see Ravn et al. (2006).

⁴¹ For the sake of simplicity, solely the impact of imperfections in the labour market is discussed below. For the impact of imperfections in the financial markets, see, for example, Brzoza-Brzezina et al. (2013).

⁴² See Pissarides (2000).

⁴³ The following theoretical considerations are based on the model assumption that the representative production firm acquires labour input N_t on a frictionless market from a temporary employment agency at a price of W_t per unit. Following successful recruitment, the temporary employment agencies compensate the formerly unemployed workers with the wage ω_t . See Christoffel and Kuester (2008).

⁴⁴ See Krause et al. (2008).

$$\Delta \ln W_t = \frac{\bar{\omega}}{\bar{W}} \Delta \ln \omega_t - \frac{\kappa}{\bar{W}q(\theta)} (\Delta \ln q(\theta_t) - (1 - \sigma)\beta \Delta \ln q(\theta_{t+1})). \quad (6)$$

According to Equation (6), the trend-adjusted, log-linearised and then differenced version of Equation (5), search costs may lead to the cost per unit of labour not rising at the same rate as an increase in wages per employee.⁴⁵ The pass-through of employees' wages to prices is therefore reduced by the fact that, because of the search costs, wages per labour unit represent only a part of total labour costs.

In summary, it may therefore be stated that the model-based pass-through between wages per employee and the deflator of domestically produced goods depends on labour market search costs,⁴⁶ the production elasticity of labour input, and, possibly, variations in the mark-ups.⁴⁷ Furthermore, search and matching theory makes it clear that – especially over the short to medium term – it is important to include labour market tightness in the empirical estimations in order to control for the resulting variation in labour costs and to obtain an unbiased estimator of the wage-price pass-through.

New Keynesian Phillips curve: consideration of aggregate utilisation

Neoclassical production theory as well as search and matching theory explain the relationship between wages and prices solely in terms of the cost side. In this vein, there is no variable that explicitly represents fluctuations in aggregate capacity utilisation or aggregate demand, which – especially over the short to medium term – have empirical relevance. If it is instead assumed in a New Keynesian modelling approach that rational firms are unable to adjust their prices frictionlessly and that the aggregate price level can therefore adjust only gradually, firms take into account not only current marginal costs but also future marginal costs in their price setting.⁴⁸ The optimal price P_t^* is given by the weighted sum of future expected marginal costs λ_t :⁴⁹

$$\hat{p}_t^* = E_t \left[\sum_{\tau=0}^{\infty} (\beta\theta)^\tau \hat{\lambda}_{t+\tau} \right], \quad (7)$$

where E_t denotes the expectation operator. If this relationship is rewritten and a price index is formed from the percentage $(1 - \theta)$ of enterprises that can adjust their prices in each period and the percentage θ of enterprises that are unable to adjust their prices,⁵⁰ a simple New Keynesian Phillips curve is obtained:

$$\pi_t = \kappa(\hat{\lambda}_t - \hat{p}_t) + \beta E_t[\pi_{t+1}] \quad (8)$$

κ is what is known as the “slack” parameter. This indicates how strongly inflation – conditional on inflation expectations – responds to aggregate capacity utilisation, which is usually measured as real marginal costs, the output gap, the unemployment gap or the unemployment rate. New-Keynesian theory thus attributes the direct transmission channel between aggregate capacity utilisation and prices to price rigidities. A direct relationship between nominal wages and the inflation rate does not exist in the simple New Keynesian model, however.⁵¹

The wage-price relationship in the national accounts

A relationship between wage or labour compensation and prices may likewise be derived from the national accounts. The starting point for this is gross value added (GVA), which is, by definition, the sum of compensation of employees and gross operating surplus, with the latter variable being composed of

Relationship between wages and GVA deflator

⁴⁵ The equation is derived on the assumption that the variables follow a deterministic growth path. See King and Rebelo (1999).

⁴⁶ According to a study based on US data, the average costs of the job application process per newly hired employee amount to roughly 19% of an average employee's wage per month. This does not yet take account of any training costs that are incurred at the beginning of the employment relationship; see Silva and Toledo (2009). As the German labour market is more highly regulated, the cost per newly hired employee is likely to be higher in Germany. As a consequence of the more regulated labour market, however, the average length of time an employee in Germany stays in a single job is longer than it is in the United States (see Hertweck und Sigrist (2015)). For this reason, such costs tend not to be paid as frequently in Germany as in the United States.

⁴⁷ These factors also apply to gross value added, but not to the aggregate demand deflator. In this case, the pass-through is also reduced by the share of imports. This also applies to its individual components, such as the consumption deflator.

⁴⁸ See Calvo (1983) or Rotemberg (1982) for an alternative modelling of price rigidities.

⁴⁹ For any given variable x_t , its percentage deviation from the long-term stationary equilibrium is defined as $\hat{x}_t = \ln x_t - \ln \bar{x}$. This assumes that \bar{x} is stationary either inherently or in efficiency units.

⁵⁰ The price index is formed as follows:
 $P_t = [(1 - \theta)(P_t^*)^{1-\varepsilon} + \theta(P_{t-1})^{1-\varepsilon}]^{\frac{1}{1-\varepsilon}}$,
 where $-\varepsilon$ describes the price elasticity of demand.

⁵¹ In an extended New Keynesian model with unemployment and wage indexation, it is possible to show that the wage growth rate depends directly on the inflation rate as well as the unemployment rate and, therefore, a direct relationship between wages and prices does exist; see Galí (2011).

operating surplus/mixed income, net taxes on production, and depreciation less net taxes on goods and services:

$$GVA = W + \underbrace{S + NPA - TXS + \delta}_{\text{gross operating surplus (GOS)}} .$$

If the ratio of gross operating surplus (*GOS*) and employee compensation (*W*) is denoted by μ , there results for the GVA deflator (GVA^d), i.e. the ratio of nominal and price-adjusted value added:

$$GVA^d = \frac{GVA^n}{GVA^r} = \frac{W}{GVA^r} (1 + \mu).$$

inflation measured in terms of the GVA deflator inflation thus corresponds to the sum of the growth rates of unit labour costs (*ULC*) and the mark-up:

$$\pi_t^{GVA} = \frac{\Delta \ln W_t - \Delta \ln Y_t + \Delta \ln \mu_t}{\Delta \ln ULC_t}$$

Relationship between wages and consumption deflator

In the hypothetical case of constant mark-ups, the growth rate of the GVA deflator – just like the rate of price increase of the supply of goods in neoclassical production theory – corresponds to the growth rate of the associated unit labour costs. In order to create a relationship between employee compensation and the private consumption deflator, the expenditure identity of GDP (*GDP*) is used. Following this, GDP corresponds to the sum of private final consumption expenditure (*C*), general government spending (*G*), investment (*I*), and the external balance (*X-IMP*). Furthermore, in line with the income account, GDP is produced by gross value added plus net taxes on goods (*TXS*):

$$\begin{aligned} GDP - TXS &= C + I + G + X - IMP - TXS \\ &= GVA. \end{aligned}$$

Dividing the equation by real gross value added, the GVA deflator is found as the weighted sum of

the deflators of the individual expenditure components:

$$\begin{aligned} GVA^d &= \frac{C^r}{GVA^r} C^d \\ &+ \frac{(G + I + X - TXS)^r}{GVA^r} \times \\ &(G + I + X - TXS)^d - \frac{IMP^r}{GVA^r} IMP^d. \end{aligned}$$

Transposing the equation after the consumption deflator (C^d) and substituting the GVA deflator gives

$$\begin{aligned} \frac{C^r}{GVA^r} C^d &= ULC(1 + \mu) + \frac{IMP^r}{GVA^r} IMP^d \\ &- \frac{(G + I + X - TXS)^r}{GVA^r} \\ &\times (G + I + X - TXS)^d. \end{aligned} \quad (9)$$

It should be noted that this relationship is true in terms of the level and not in logarithms. Following a number of transformations, this results in

$$\begin{aligned} \ln C^d &= \ln ULC + \ln(1 + \mu) - \ln \frac{C^r}{GVA^r} \\ &+ \ln \left(\frac{GVA + IMP}{GVA} \right) \\ &- \ln \left(\frac{GVA + IMP}{GVA + IMP - XCIMP} \right), \end{aligned} \quad (10)$$

where $XCIMP = G + I + X - TXS$ denotes all other aggregate demand. The sum of the first two terms on the right-hand side of this equation corresponds to the GVA deflator. The other three summands reflect the difference between the deflator of private consumption expenditure and the GVA deflator. The first of these summands is the inverse real consumption ratio. The second summand contains the impact of import prices. The last term reflects the fact that the prices of other expenditure components may differ from those of consumer goods and it also captures the impact of taxes on goods and services on the deflators of the expenditure components.

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