III. SECTORAL WAGE SHOCK AND INFLATION IN THE EURO AREA

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Abstract: *This chapter analyses how shocks to nominal wages affect consumer prices when taking into account the sectoral structure of the economy. Sectoral interlinkages of the economy are accounted for by using an input-output model. The chapter shows that, on top of their direct impact on production prices, wage increases may also have a sizeable second round indirect impact on prices via their effect on the cost of intermediate inputs. Moreover, a wage shock in a specific sector can have a very different impact on inflation depending on not only the sector's labour intensity but also its position in the production chain; sectors that provide more inputs to the rest of the economy have a larger impact, other things being equal. Measures of stress in the labour market, like the vacancy rate, currently seem correlated with wage growth and are relatively concentrated in sectors somewhat upstream in the production chain. This means that, if wages grow faster in sectors with higher vacancy rates, this may result in relatively stronger inflationary dynamics than if wages increased by the same rate in all sectors. However, the magnitude of the effects suggests that a gradual recovery of real wages is consistent with a continuation of gradual disinflation in the euro area as productivity increases and unit profits decline ([80]).*

III.1. INTRODUCTION

The inflation surge that has hit the euro area economy as from 2021 has been exceptionally significant. A succession of supply shocks played the main role in that surge, related first to goods shortages caused by disruptions in supply chains, and then followed by energy and food price shocks, partly due to Russia's unjustified military aggression against Ukraine. A role was also played by demand factors, due to pent-up demand for goods and especially services generated by the excess saving during pandemic lockdowns.

The effects of those shocks are now fading. As shown in Graph III.1, having peaked at 10.6% in October 2022, euro area inflation has since declined significantly to reach 2.4% in April 2024. Rapid fall in retail energy prices throughout 2023 was the main driver of the inflation decline, but underlying inflationary pressures started easing too in the second half of 2023, amidst the weak growth momentum.

In the context of economic weakness, the labour market showed signs of continued strength with unemployment at 6.5% in March 2024, almost an historic low for the euro area. Despite the decrease in inflation observed in 2023, and the gradual nominal wage increase observed as from 2021, real wages fell significantly during the surge in inflation and the early stages of the disinflation process. The cumulated fall in real wages between Q2-2022 (the peak) to Q2-2023 (the trough) was about 4.5% in the euro area (Graph III.2 shows the yearly growth rates of these variables) ([81]).

The third quarter of 2023, when growth of real compensation per employee turned positive on a quarter-on-quarter basis, likely represents a turning point in real wage developments, also in view of the decrease in inflation. Nominal wages now outpace inflation, even if they seem to have reached a plateau

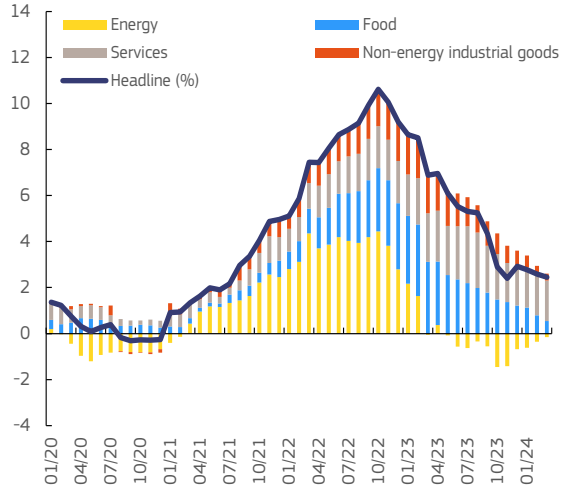
([80]) We thank E. Ruscher and L. Coutinho for valuable comments and L. Biedma for invaluable help with the data.

([81]) This is when the nominal wage is adjusted with consumer prices, the measure of real wage growth relevant for workers. Note however, that the fall in real wages has been smaller when real wage growth is adjusted with the GDP deflator, a measure that more closely approximates the calculus of employers when they define their demand for labour. Nominal wages are measured as nominal compensation per employee. Note that data for 2020 and 2021 may be distorted by the presence of the schemes supporting employment during the COVID-19 crisis.

in the middle of 2023: nominal compensation per employee expanded by 5.8% in 2023 in the EU, with a gradual deceleration in the second half of the year.

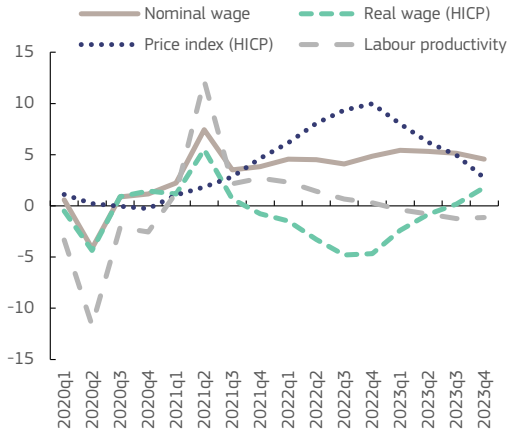
According to the Commission's Spring 2024 Forecast ([82]), nominal wage growth is projected to moderate gradually in 2024 and 2025, but to exceed inflation in both years, finally allowing workers to recoup the losses in purchasing power since 2021. This is still compatible with inflation coming back to target as unit profit growth is also expected to ease and labour productivity is set to recover over the forecast horizon. In real term, wages are set to fully recover their 2021 levels by 2025 as slowing, but still high nominal wage growth is accompanied by falling inflation.

Graph III.1: **Euro area HICP and contributions after 2020**



(1) The graph shows year-on-year HICP growth rates and the contributions of the main subcomponents.
Source: Eurostat and own calculations.

Graph III.2: **Euro area growth in nominal and real wages after 2020**



(1) Nominal wages are measured as nominal compensation per employee. Real wages as the difference between nominal wages and HICP.
Source: Eurostat and our calculations.

Despite those positive developments, some observers have stressed the importance of monitoring wage developments in the context of the disinflation process, also in relation to high nominal wage growth and the stickiness of services inflation, which has been stable at 4% in recent months ([83]). The relation between wage growth and inflation is indeed at the core of policy-making and, consequently, of analysis.

The literature on the relation between wage increases and inflation in the euro area is vast. The "cost-push" view whereby increases in labour costs are a source of consumers price inflation plays a significant role in policy making. A strong link between labour cost and price inflation has been found empirically in the case of the euro area ([84]). For instance, Bobeica et al. use data for Germany, France,

([82]) European Commission (2024), European Economic Forecast available at Spring 2024 Economic Forecast: A gradual expansion amid high geopolitical risks - European Commission (europa.eu).

([83]) Recently, despite the observed deceleration in inflation, the ECB has stressed that "wage growth is expected to become an increasingly important driver of inflation dynamics in the coming quarters, even if the declining contribution of profits to inflation suggests that labour cost increases are not being fully passed on to consumers".

([84]) This explanation has been put in doubt in the US. A number of studies favour the neoclassical view that price inflation causes wage inflation rather than the opposite New-Keynesian view, and that the causality can differ across sectors. For example, Knotek et al. (2014) do not find that labour cost increases precede or follow price increases and Peneva et al. (2017), find little evidence that independent movements in labour costs have had a material effect on price inflation in recent years. Knotek, E. S. and Zaman, S. (2014), "On the Relationships between Wages, Prices, and Economic Activity," Economic Commentary, (Aug); Peneva E. V. and Rudd, J. B. (2017), "The Passthrough of Labor Costs to Price Inflation," Journal of Money, Credit and Banking, 49(8):1777–1802.

Italy, and Spain both for the economy as a whole and for services, manufacturing, and construction to show that over 1985-Q1-2018-Q1 there was a strong link between labour cost and price inflation ([85]). Such a link depends on the state of the economy and on the shocks hitting the economy; the pass-through of labour costs on to price inflation is more likely under demand shocks than under supply shocks ([86]). However, the existing literature also tends to conclude that, notwithstanding the existence of labour cost pass-through, risks of a wage-price spiral in the euro area are limited ([87]).

More recently Arce et al. replicate the semi-structural model developed for the US by Bernanke and Blanchard ([88]) to break down the effect of the main drivers of inflation in the euro area. Their findings point to the relevance of supply-side shocks, 'with a more limited role for demand shocks as captured by labour market tightness, notwithstanding the supply-demand imbalances due to pent-up demand and supply chain disruptions.' They find that real wage catch-up and bargaining resulted in higher nominal wage growth, but that labour market overheating, as measured by the job vacancies to unemployment ratio, only started to impact wage growth and price inflation in the euro area towards the end of 2023 ([89]). The pre-COVID elasticity that they find in their wage equation with respect to their measure of labour market stress is 0.3, while the elasticity of inflation to nominal wage growth is almost 0.5, both lower than inflation expectations and past inflation respectively.

Notwithstanding the substantial empirical literature on the link between inflation and wages, little is known of the impact of the sectoral structure on the propagation of wage shocks to consumption prices. In particular do wage shocks in different sectors have sizeably different implications for consumer prices? This is a relevant gap in the literature because to understanding how a wage shock propagates to final prices, it is necessary to take into account the sectoral dimension of the wage shock and the interaction across different sectors. It also makes it possible to analyse the effect of the sectoral dimension of a wage shock itself. This analysis can only be conducted using an input-output model, and this is what the present chapter does. While this can be considered a relatively standard exercise ([90]), we are not aware of any recent application of input-output models to analyse this question for the euro area.

The present chapter analyses the impact on inflation of a 5% increase in nominal wages under the assumption of a simple input-output model. This is a purely hypothetical shock and results would not change qualitatively for a shock of a different magnitude. To better understand the link between shock propagation and the sectoral structure of the economy, three illustrative simulations are analysed. The simulations are based on different assumptions as to the sectoral allocation of the overall 5% wage shock.

([85]) Bobeica E., M. Ciccarelli, I. Vansteenkiste (2019) "The link between labour cost and price inflation in the euro area", ECB WP 2235. For a model-based analysis, see also Gumiel, J. E. and Hahn, E. (2018), "The Role of Wages for the Pick-Up in Inflation", Economic Bulletin Issue 5, ECB.

([86]) See also the speech by Christine Lagarde, President of the ECB, at the plenary session of the European Parliament, Strasbourg, 26 February 2024, European Parliament plenary debate on the ECB Annual Report (europa.eu) and Blanchard, O. (2022), "Why I worry about inflation, interest rates, and unemployment," Realtime Economic Issues Watch, 14 March

([87]) For example, Alvarez et al. (2022) show that only a small minority of episodes of large acceleration of nominal wages were followed by further sustained acceleration in (wages and) prices. See Alvarez J., J. Bluedorn, N. Hansen, Y. Huang, E. Pugacheva, and A. Sollaci (2022), "Wage-price spirals: What is the historical evidence?", IMF WP 22/221, and Baba, C. and J. Lee (2022), "Second-round effects of oil price shocks—Implications for Europe's inflation outlook," IMF WP 22/173.

([88]) See previous footnote.

([89]) "However, caution is needed when interpreting the consequences of high labour market tightness on wages [in recent quarters], as the model may fail to recognise that real wages might not have been able to catch up with past inflation if the labour market had not tightened." Arce O., M. Ciccarelli, A. Kornprobst, and C. Montes-Galdón (2024), "What caused the euro area post-pandemic inflation? An application of Bernanke and Blanchard (2023)", ECB Occasional Paper Series 343. The paper to which they refer is Bernanke, B. S. and Blanchard, O. J. (2023), "What Caused the US Pandemic-Era Inflation?", NBER WP 31417.

([90]) See Miller R. E. and P. D. Blair (2009), "Input-Output Analysis. Foundations and Extensions", Cambridge University Press, second edition, Chapter 12 for a very clear exposition of the problems and of the model used here.

The chapter shows that the characteristics of the sectors where the shock takes place play a role in the transmission of wage shocks to inflation. First, wage shocks in larger sectors have a bigger impact than those in smaller sectors. Second, wage shocks taking place in sectors that are more labour-intensive have a bigger impact on inflation. Finally shocks in more upstream sectors influence the costs of more sectors, and therefore have a bigger impact on inflation.

The rest of the chapter is organised as follows. Section III.2 discusses the hypothetical wages shock used in the three simulations, also in relation to the evidence on labour market developments in the different sectors, stressing the existing tensions and their potential role in the increase in nominal wages. Section III.3 compares the different effects on inflation of the three possible shocks considered. Section III.4 discusses the result of the simulation and Section III.5 provides conclusions.

III.2. THE METHODOLOGY USED FOR THE SIMULATIONS

As explained in more details in Box III.1, the simulations are based on a standard set of assumptions used in the application of input-output models ([91]). An input-output model for the euro area separates its economic activity into producing sectors. Each producing sector demands intermediate inputs from other sectors, and primary inputs from the rest of the world and from workers and capital owners, in order to serve the other sectors and the final demand. Traditionally, the input-output model is interpreted as demand model. Firms have a Leontief production function with fixed input and labour coefficients. The Leontief coefficients are computed as the ratio of the value of each input used to produce the output of a given sector to the total output of that sector. The model then makes it possible to compute the inputs across the economy's different sectors that are necessary to satisfy a given final demand.

However, this model can also be used to compute the impact of cost shocks on downstream sectors and final demand ([92]). In this case, the shock to the input cost is passed forward onto the rest of the economy, with downstream firms reflecting the shock.

In the present analysis, the cost shock is represented by an exogenous percentage increase in wages ([93]). The increase is passed on by firms to their prices. The increase in those prices becomes the increase in intermediate costs for downstream sectors. The downstream sectors then pass on the increase in intermediate costs generated by wage increases in their upstream domestic sectors (and in their own wages) on their output prices. This generates a new vector of output sectoral prices ([94]).

It should be noted that this method assumes, implicitly, that i) firms were optimally choosing their prices at the moment they were hit by the shock, given the increase in costs of the previous years; and ii) firms, having a Leontief production function pass on all increases in costs (prices and wages) to their output prices. The increases in prices that are found in the simulations can therefore be interpreted as an upper bound to the price increases that should result from the shock. This is because should the production

([91]) Among very many presentations of the input-output models, for a complete and simple treatment see Miller R. E. and P. D. Blair op. cit.

([92]) For a recent policy application to the effects of the increase of oil see European Commission (2023), "Inflation Differentials in Europe and Implications for Competitiveness. Thematic Note to support In-Depth Reviews", Institutional Paper 198/2023.

([93]) In practice, labour costs are increased by the chosen amount, assuming implicitly that social contributions remain proportional to wages.

([94]) Strictly speaking, this is done using the Ghosh model. This is the input-output model where one keeps fixed the ratios of matrix representing the transactions of intermediate goods divided by the output per row, as opposed to the Leontief model in which one keeps fixed the ratios by column. The Ghosh model per se does not have a meaningful economic interpretation, while the Leontief model can be interpreted in terms of fixed production coefficients. However, the two give the same results under the assumption that the percentage changes following the shock are interpreted as price changes, which is our case. See Miller R. E. and P. D. Blair op. cit.

function be different, firms would react by (in part) substituting more costly inputs with less costly ones leading to a smaller increase in final prices ([95]).

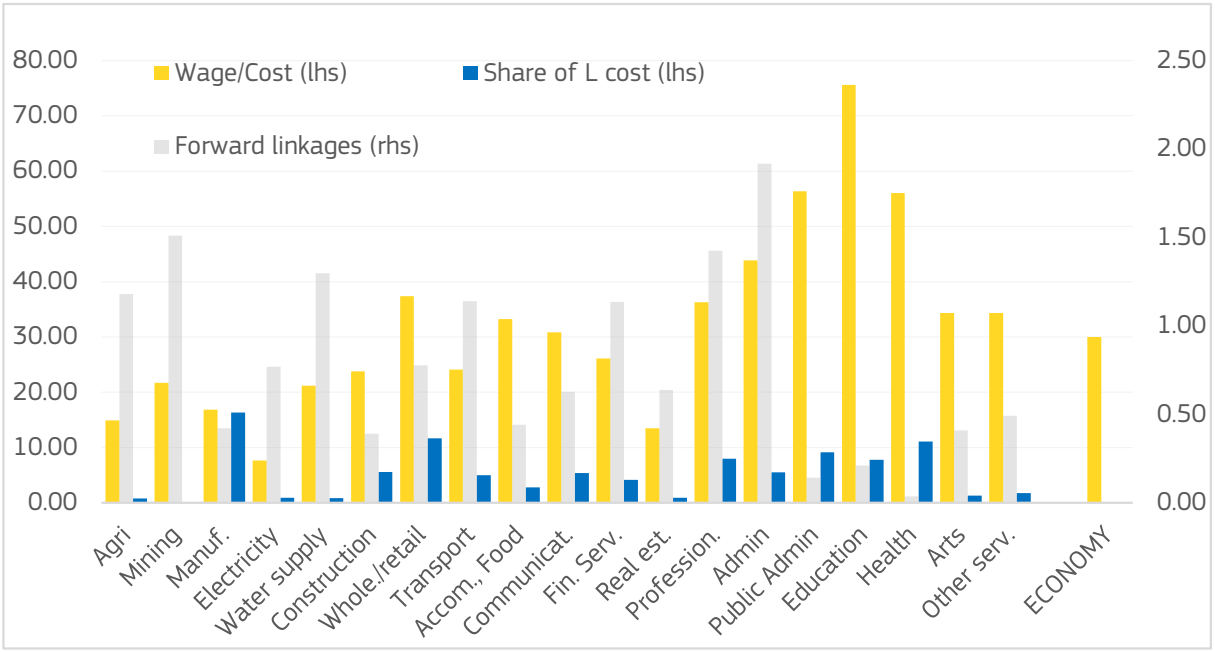
Finally, a corresponding new vector of final consumption prices is computed, which is consistent with the new output prices ([96]). Sectoral price increases are then aggregated using the sectoral shares of the consumption vector, with the aggregate increase representing the effect of the wage shock on consumer prices.

Thus, the reaction to a wage shock can loosely be conceptualised in the following phases. First, there is a shock to wages. Second, firms fully reflect the increase in costs in their prices. Third, all firms, given the assumed production function, increase their prices to reflect the increases in the cost of the intermediates that they use ([97]). These are then reflected in final demand.

III.3. THE ILLUSTRATIVE WAGE SHOCKS

As indicated above, the illustrative wage shock corresponds to an increase by 5% of nominal wages for the total economy ([98]).

Graph III.3: **Labour cost per sector (%), labour share over total economy(%) and forward linkages indicator**



(1) Wage costs are measured as the ratio between compensation of employees and total costs measured as total output minus gross operating surplus. Share of Labour costs are the share of labour costs of the sector over the total of the economy. The forward linkages indicator is the row sum of matrix G of equation (4) of the Box (see footnote 102).

Source: Eurostat and own calculations.

([95]) This assumes that the gross operating surplus is unchanged. If one considers that the gross operating surplus is equivalent to profits, this implies unchanged profits.

([96]) See Box III.1.

([97]) It should be noted that, in principle, the calculation of the indirect effect via the Leontief and Ghosh matrices represents the limit of an infinite number of interactions of decreasing size.

([98]) Under the assumption that social contributions are proportional to wages, this corresponds to a 5% increase in total compensation of employees (D1 in national account parlance).

As already stressed, the shock is purely hypothetical even if its magnitude broadly matches the cumulated fall in real wages observed between the latest peak in euro area real wages in Q2-2021 and their trough in Q2-2023.

As a first approximation to understand the sectoral dimension of a wage shock, the distribution of the ratio of labour cost over total cost and over gross output is represented in Graph III.3 (yellow bars). If one looks at aggregate data, labour cost of employees ([99]) constitutes on average around one quarter of total output in the economy (24%), and one third of total costs (30%). The variation of wage costs across sectors is relatively high: non-market sectors public administration and defence, compulsory social security (O), education (P), and human health and social work activities (Q) post labour costs higher than 55% of total costs and 50% of gross output; the sectors agriculture (A), electricity, gas, steam and air conditioning supply (D) and real estate activities (L) post labour costs at or below 15% of total costs and 10% of gross output.

The share of wages in costs is, however, likely not to be the total effect of the wage increase: as sectors raise their output prices, this will increase the cost input from other sectors, since sectors use each-other's outputs in their production as intermediate goods. The next sections go into more detail describing these sectoral interlinkages and discuss the methodology used to calculate the effect of wage increases of various sectoral profiles on inflation, taking into account both the direct and the indirect effects.

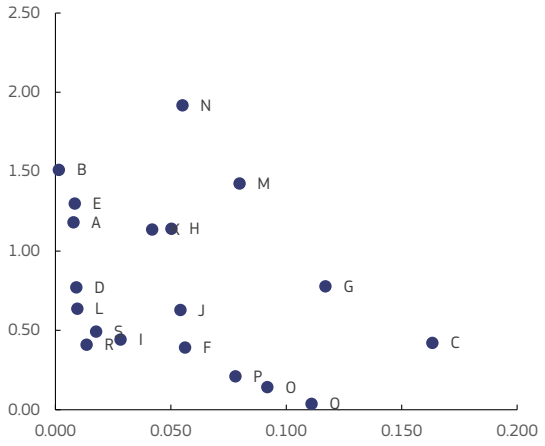
III.3.1. Three structural factors that determine the inflationary impact of wage shocks

The direct impact on the consumer price index from the increase in the cost of labour described above depends on the size of the increase in wages and the aggregate labour cost share. However, to understand the full impact of a wage shock on total inflation other aspects than the direct increase in costs are important. The section focusses on the aspects concerning the structure of the economy.

Consider a shock that has a certain sectoral composition. On top of the share of cost that labour represents in each sector, the size of the sector with respect to the total economy, measured as the share of the sector's labour cost over the total labour cost of the economy is significant for the impact of the shock on the aggregate consumer price ([100]). A 1% increase in wages will have a greater impact on overall consumer prices if it affects a large sector than a small one, and the impact on prices will be greater the larger the share of costs represented by wages in that sector. The two indicators are correlated, but the correlation coefficient is only 0.4. The size of the different sectors is shown in Graph III.3. The graph plots the 19 main NACE sectors and shows that the manufacturing sector (C) is the largest sector in terms of labour costs with 16% of labour income of the total economy, followed by human health and social work activities (Q) and by wholesale and retail trade plus repair of motor vehicles and motorcycles (G) both with shares of 11-12%, followed by the sectors public administration, defence and compulsory social security (O) and education (P) just below 10%.

([99]) Total cost is measured as total output minus gross operating surplus. Therefore, for the purpose of the present exercise gross operating surplus are considered equivalent to profits.
([100]) Clearly the impact on the price of each sector depends also on the share that the given sector represents in consumption.

Graph III.4: **Forward linkages indicator and labour cost shares**



(1) Forward linkages index (see footnote 102) is on the Y-axis and labour cost shares are on the X-axis.

Source: Eurostat and own calculations.

However, in total market-oriented activities cover broadly two thirds of total labour costs of the economy. The smallest sectors are mining (B), where labour cost represents a very small share of total economy labour costs (0.2%), agriculture (A), and real estate activities (L), both below 1%.

Thus a 1% increase in wages in manufacturing is a shock that is around 20 times larger for the economy than a 1% increase in, say, agriculture.

The third relevant factor to assess the impact of a wage shock relates to the interlinkages between sectors of the economy ([101]). Increased labour costs in one sector, say A, when reflected in its prices, means that the costs of intermediates goods bought by sectors downstream from sector A increase and are then reflected in price and cost increases along the value chain to final demand. This implies that the same wage shock concentrated in sectors that provide greater inputs to the rest of the economy, has a larger impact on overall inflation. Sectors can be ranked according to a forward linkages index, which is higher for sectors having a greater impact on the economy, (i.e. for being more upstream in the value chain) ([102]). The index says by how much a 1EUR increase in wages in one sector increases production prices (under the stated assumptions) in the other sectors.

Graph III.4 compares this indicator for the different sectors along with labour costs. It shows that the sum of the responses of all other sectors to a EUR 1 increase in total labour costs in the administrative and support service activities (N) will be an increase of the value of total output by around EUR 2, while it will have an impact of only EUR 0.02 if this takes place in human health and social work activities (Q). In general, market sectors post larger values for the forward link index, pointing to positions more upstream in the chain, with the most upstream position (after sector N) being occupied by mining (B) and professional, scientific and technical activities (M).

Graph III.4 shows that the forward linkages index and the size of the sector in 2022 were negatively correlated, indicating that larger sectors seem to be in general nearer to the final demand in the supply chain. This implies that those two factors tend, to some degree, to balance each-other out in terms of the overall impact of any given shock ([103]).

([101]) To compute the linkages between sectors, the latest available Input-Output matrix (2019) has been projected forward to 2023 using national accounts data and maintaining the same shares of intermediate inputs (domestic and imported) as in 2019 as detailed in Box III.1.

([102]) The concept of (backward and) forward linkages has been introduced by Hirschman, A. (1958), "The Strategy of Economic Development", Yale University Press. It is computed as the sum of the row coefficients of the matrix of equation (4) in the Box for the corresponding sector, deducting the self-consumption coefficient. Leaving the self-consumption coefficient in the calculation would not change the ranking significantly. A similar indicator can be created by adding up the of the direct output coefficient matrix (namely the input-out matrix named B in the Box). It should be noted that this section only considers direct links between sectors, but it abstracts from indirect links, like for example the dynamic relationship between public and private wages or the role of unions in driving inflation.

([103]) A word of caution on this analysis is that the size and the position of any given sector depend on the rules adopted by statistical offices to decide which companies belong to a sector and on the level of aggregation chosen. For example, manufacturing is a very large sector which contains upstream and downstream sub-sectors, while mining is smaller and its position in the value chain is likely to be less affected by the aggregation level.

III.3.2. Three different scenarios in the context of recent labour market developments

To show the relevance of the structure of the economy for the inflationary content of a wage shock, one needs to analyse various shocks to overall wages that have the same aggregate size but have a different sectoral composition. To this end, in this sub-section, three scenarios are presented. Each of them is consistent with the shock presented in the previous step, in that, the aggregate wage bill is increasing by 5%. However, these scenarios differ in terms of their sectoral composition. Keeping a constant increase in total labour costs is necessary to enable comparability among the three scenarios, even if one has to pay the price of taking into account very high wage increases in certain sectors (typically small ones) under one of the scenarios.

The three scenarios are presented in Table 1 of Box III.1 and their logic can be described as follows.

The first scenario is a scenario in which the increase in nominal wages is equal across the economy, namely to 5% in all sectors, as indicated above. While this size is purely hypothetical, it broadly corresponds to the increase in wages that would bring real compensation per employee back to its 2021 level in the euro area.

In the second scenario, while the total wage bill increase remains at 5%, nominal wage increase are differentiated across sectors so as to broadly reflect the relative sectoral differences in real wage losses since the recent surge in inflation. Indeed, since 2021 a larger reduction in real wages has taken place in market sectors B to E and in finance (K). Real wages in some non-market activities, e.g. in arts (R) and in other services (S), have decreased more moderately although they have decreased more strongly in the public sector. Against this background, the second scenario assumes faster wage growth in the sectors that have experienced larger losses in purchasing power since 2021 ([104]).

The third scenario reflects a situation in which all the recovery in real wages happens in the market sectors B to N, and it happens in proportion to labour market tightness in each of those sectors as indicated by the growth of the vacancy rate in recent years ([105]). This scenario reflects the strength of the labour market in the euro area (Graph III.5) and the existence of a positive relation between nominal wage increase and the vacancy rate (see Graph III.6).

The euro area recently posted a broad-based growth in labour shortages, resulting in vacancy rates, that are close to their record levels in almost all sectors. However, while vacancy rates have been increasing in most sectors, Graph III.5 shows that there is a significant variation across sectors. Between 2019 and 2023, the strongest growth in the vacancy rates can be found in manufacturing (C); electricity, gas, steam and air conditioning supply (D), wholesale and retail trade, repair of motor vehicles and motorcycles (G), financial and insurance activities (K) and professional, scientific and technical activities (M). In the post-pandemic period (2021-2023) mining and quarrying (B), water supply, sewerage, waste management and remediation activities (E) and transportation and storage (H) also experienced a relatively strong growth in vacancy rates.

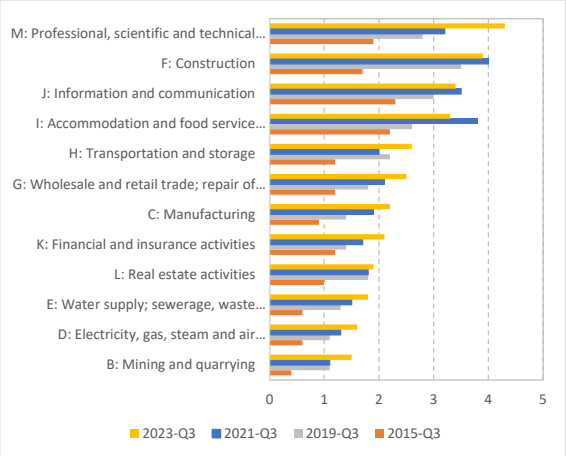
Across sectors, wage growth has shown a strong association with pre-pandemic vacancy rates ([106]). Cumulative wage growth since the beginning of 2019 was higher in sectors that experienced higher vacancy rates in the pre-pandemic period (Graph III.6) ([107]).

([104]) For the purpose of the simulation, we look at the peak decrease in real wages, namely the decrease that took place between Q3-2021 and Q3-2023.

([105]) Details on the computation of this shock are given in Box III.1.

([106]) In particular, the cross-sectional association suggests that a sector in which the vacancy rate was 1 ppt higher pre-pandemic experienced higher wage growth by about 0.5 ppt annually over the four subsequent yearsIt is prudent to look at this longer period since wage growth over the pandemic period was hard to interpret, being affected by fluctuating hours worked (related to pandemic containment measures) as well as government measures to cushion the impact of the pandemic. See, e.g., Bodnar, K., Gonçalves, E.,

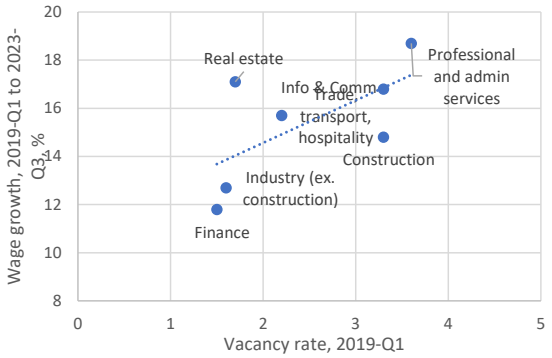
Graph III.5: **Job vacancies by sector**



(1) Job vacancies are shown for Q3 at different years. Q3-2023 was the peak quarter for vacancies.

Source: Eurostat (Job Vacancy Survey) and own calculations.

Graph III.6: **Nominal wage growth (Q1-2019 - Q3-2023) and the vacancy rates (Q1-2019) across sectors**



(1) Wage growth is compensation of employees with per capita adjustment by sectorial employment. Compensation is seasonally and calendar adjusted where possible. Vacancy rates are unadjusted.

Source: Eurostat and own calculations.

This pattern is likely to be related to labour demand dynamics since cumulative wage growth tended to be higher in sectors that added more employment (not shown). The third shock is therefore built by allocating the 5% increase in total compensation of employees across those sectors in proportion to the observed increase in vacancy rates (see Box III.1). Wages in non-market sectors are assumed to remain constant. This assumption is not realistic. It is therefore important to stress the illustrative nature of the shock, but its features help to stress the various direct inflationary impact between wage increases in market and non-market sectors.

III.4. THE RESULTS

The direct effect of an increase in labour costs of 5% represents an increase in total costs of around 1.5% and of 1.2% in total output. If firms fully reflect such an increase in their prices, leaving everything else unchanged, this will generate a direct increase in output prices of the order of 1.2% ([108]). This is smaller than the impact of a wage shock on the gross value-added deflator. Compensation of employees is around 53% of gross value added. Therefore an increase in wages by 5% would imply, all

Gornicka, L. and G. Koester (2022) "Wage developments and their determinants since the start of the pandemic",ECB Economic Bulletin, Issue 8/2022, European Central Bank, Frankfurt.

([107]) The existing literature finds that indices of labour market tightness correlate positively with wage growth notably in low-pay sectors, despite the fact that tightness has so far play a limited role in contributing to wage acceleration. See Duval, R. Ji, Y. Li, L. Oikonomou, M. Pizzinelli, C., Shibata, I., Sozzi, A. and M. M. Tavares. (2022). Labor market tightness in advanced economies. IMF Staff Discussion Notes 2022/1, Washington D.C.

([108]) The wage ratio increases by almost 10 ppt of value added if one includes in compensation of employees the wages earned by self-employed (imputed wages), which are recorded as mixed income and are part of the gross operating surplus. Given the illustrative mature of the exercise, the imputation is not done here.

other things being equal, an increase in the GDP deflator by around 2.7%. The larger size generated by using the GDP share results from the fact that, in this case, the presence of the intermediate costs, which are around 60% of the total costs paid by the sector are ignored, thus magnifying the impact of a wage increase on costs and thus on prices.

The three scenarios presented in the previous section show how the differing sectoral composition of a wage shock of the same size changes its impact on consumer prices. Table III.1 shows the impact on consumer prices under the three scenarios.

Under the first scenario, where wages grow by the same amount in each sector, the impact on consumer prices is simulated to be at 1.9%. As expected, the total price effect in this scenario is larger than the direct effect of the initial increase in wages on consumer prices, as the wage shock is propagated through the economy via the sectoral inter-linkages. The indirect effects increase the direct effect by around a half. However, it is interesting to notice that, even taking into account the indirect effects, the impact of a wage shock on final consumer prices is just less than one third of the size of the initial wage shock. The impact is also smaller than the direct impact on the GDP deflator. The use of input-output models is the only way to correctly assess the effect of a wage increase on consumer prices, even more so if the wage increases are concentrated by sector as shown below. Indeed, the three shocks, despite having the same aggregate size, have a different impact on inflation.

Table III.1: **Increase in consumer prices (%) under the three scenarios**

Scenario 1	Scenario 2	Scenario 3
1.9%	1.8%	2.8%

Source: Own calculations.

In the second scenario, there happens to be a slightly negative correlation of the shock, measured as the percentage increase in wages, with the forward linkage index (-0.1). This implies that the second scenario simulates slightly larger increases in more downstream sectors, and the overall impact is 1.8%, marginally smaller than in the first scenario. The very small correlation between the forward linkages index and the shock points to a certain similarity between the two first scenarios, but this is enough to decrease the impact in proportion to the total inflation effect.

A clearer indication of the importance of the presence of forward linkages is given by the third scenario. In this scenario wages in the market sectors (except agriculture) increase proportionally more in the sectors with higher labour market stress, while wages in the non-market sectors remain constant. The correlation between the shock and the forward linkages index is positive (0.5) reflecting the fact that more stressed sectors tended to be upstream sectors. This scenario is relatively different from the uniform scenario, in that a considerably larger shock is given to wages of upstream sectors. In this case the simulated increase in inflation is just below 3%, a considerably larger amount than the previous cases ([109]).

([109]) It should be noted that the second shock posts a small positive correlation between the share of labour cost represented by the sector in the total economy and the assumed sectoral increase in wages (0.2) while in the third shock the correlation between the shock and the size of the sectors is negative (-0.3), reflecting the fact that most stressed sectors were smaller sectors. This does not affect the result, most likely because the size effect is accounted for by assuming the same economy-wide shock.

Box III.1: Methodological framework for sectoral wage shock analysis in the euro area

This box explains the simulations' methodology used in the text. Simulations are based on input-output (I-O) models. In the I-O model, the production output of each sector (o) is determined as a function of intermediate consumption, domestic (Z) and imported (M) and its value-added components (v). Value added is composed by Compensation of Employees (w), Taxes (t) and Gross Operating Surplus (gos). To establish the notation, one can write

$$o = Z'i + M'i + v; \quad v = w + t + gos \tag{1}$$

In this text, lower-case letters denote vectors, upper-case letters represent matrices. In Equation (1) Z' is Z transposed, and i denotes a unit vector.

Data

Data for these variables at the chosen sectoral decomposition for the euro area [1] are available at different dates. Precisely, these data for the euro area can be sourced starting from 2022 national accounts [2] and the 2019 I-O table [3]:

- Intermediate consumption. Recent data by sector on intermediate consumption are not available. However, one can compute the 2022 aggregate intermediate consumption data by subtracting value added from total output (P1) from national accounts and then allocate them between imported and domestic intermediate consumption and between the different sectors. Precisely, the entries of the domestic intermediate consumption matrix were found by applying the shares of the sectoral consumption on the total intermediate consumption as in the 2019 I-O table. The same approach was employed for the matrix of imported intermediate goods.

- Value-added components. Value added data by NACE sector for 2022 are available from national account. w (D1), as Compensation of Employees, are available. t were estimated as the same proportion of total value added (B1G) as in the 2019 I-O table [4]. gos (B2A3G) were subsequently determined by subtracting the sum of the wages and taxes from the total value added for 2022.

The computation of the shocks

The starting point for calculating the shocks is a 5% nominal wage growth per employee for the total economy. This is used directly to compute the shock in the first scenario. The second scenario allocates a shock of the same aggregate size broadly in proportion to the decrease in real wages in the different sectors between 2021-Q2 and 2023-Q2. Nominal wages by sector are computed as the difference between the percentage change of compensation of employees divided by the number of employees at the quarterly frequency. Real wage growth was computed by subtracting HICP from nominal wages growth.

(1) The sectoral breakdown corresponds to the 21 sectors of "NACE 2.1" classification, available at: ShowVoc (europa.eu).
(2) The most recent data for the euro area at sectoral level for output (P1), intermediate consumption (P2), value added (B1G) and compensation of employees (D1) are, at the time of the analysis, 2022 data available in national accounts: Statistics | Eurostat (europa.eu). Starting from these data and using the shares retrieved from the 2019 I-O table, it is possible to imply domestic/imported intermediate consumption and specific value-added components for 2022.
(3) The 2019 I-O table was selected, despite 2020 being the latest available year at the time of analysis, to prevent the distortion effects of COVID-19 in subsequent years' estimates. The 2019 I-O table is available at: Statistics | Eurostat (europa.eu). This I-O table presents a sectoral breakdown of 64 sectors, which have been grouped to match the 21-sector aggregation proposed in this analysis.
(4) Taxes are not directly available in national accounts of 2022, thus requiring the explained computation under the assumption that tax shares over VA are constant over time.

(Continued on the next page)

Table 1:

NACE sector	Scenario 1	Scenario 2	Scenario 3
Agriculture, Forestry and Fishing (A)	5%	3%	0%
Mining and Quarrying (B)	5%	7%	6%
Manufacturing (C)	5%	7%	8%
Electricity, Gas, Steam and Air Conditioning Supply (D)	5%	7%	8%
Water Supply; Sewerage, Waste Management and Remediation Activities (E)	5%	7%	8%
Construction (F)	5%	5%	6%
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles (G)	5%	4%	8%
Transportation and Storage (H)	5%	4%	7%
Accommodation and Food Service Activities (I)	5%	4%	8%
Information and Communication (J)	5%	7%	7%
Financial and Insurance Activities (K)	5%	8%	8%
Real Estate Activities (L)	5%	6%	5%
Professional, Scientific and Technical Activities (M)	5%	3%	9%
Administrative and Support Service Activities (N)	5%	3%	6%
Public Administration and Defence; Compulsory Social Security (O)	5%	6%	0%
Education (P)	5%	6%	0%
Human Health and Social Work Activities (Q)	5%	6%	0%
Arts, Entertainment and Recreation (R)	5%	2%	0%
Other Service Activities (S)	5%	2%	0%

The shock for the third scenario aims at reflecting the tensions in the sectoral labour markets, also weighted by the size of the sector. It is computed as follows. First, changes in the vacancy rates over the quarters between 2019-Q3 to 2023-Q3 for the market sectors excluding agriculture are computed. Even if we are aware that wages and labour market data for 2020-21 can be distorted by the presence of job retention schemes, we still prefer to keep a longer series, as explained in the text. The vector of increases in vacancie rates is multiplied times the vector of share of compensation of employees, thus creating the basis for a weights vector. The latter is then normalized to generate a weights vector whose elements sum up to 1 that can be used to allocate the shock across sectors. Second, the 5% increase in the aggregate wage bill is allocated to the sectors using as an allocation key the weights' vector. Table 1 details the shocks applied to each sector under the three different scenarios:

The calculations

The Ghosh version of the input-output model provides a general framework for analyzing both the direct and indirect impacts of input shocks on sectoral output prices. The difference with the traditional Leontief input-output model is that, while in the Leontief model the production coefficients are set, i.e. the ratio of the inputs used in each sector divided by the output of the sector, the Ghosh version sets the ratio of the demands for the output of each sector. The two models have different pros and cons, with the Ghosh model being used to analyse how a shock to inputs in one sector spreads on downstream sectors, while the Leontief version is used to analyse how demand shocks are transmitted to upstream sectors. Yet, when assuming that the only shocks concern prices, the results of the two give identical results ([5]). Following Výškrabka and Zeugner (2023) ([6]), Equation (2) ([7]) introduces the matrix B, where each cell in a given row is the ratio of the rows of Z divided the corresponding row total output o. Equation (3) sets total output. Equation (4) defines the Ghosh inverse.

([5]) For more details see Chapter 12 of Miller R. E. and Blair P. D. (2009), "Inpu-Output Analysis. Foundations and Extensions", Cambridge University Press, second edition.
([6]) Výškrabka M. and Zeugner S. (2023), "Inflation spillovers in the euro area in an input-output framework", European Commission.
([7]) In the notation of matrix algebra, placing a "hat" (^) over a vector symbol indicates the creation of a diagonal matrix, wherein the elements of the vector are positioned along the main diagonal.

(Continued on the next page)

Box (continued)

$$B = \hat{o}^{-1} Z \quad (2)$$

$$o = B^{'} o + M^{'} i + v \quad (3)$$

$$G = (I - B')^{-1} \quad (4)$$

$$o = \mathrm{G}'(\mathrm{v} + M'i) \quad (5)$$

The Ghosh inverse allows to compute a detailed decomposition of variations in the output prices by tracing them back to the contributions of changes in costs of production inputs, under the assumption of perfect additive pass-through—where the total increase in the output precisely matches the aggregate increase in input costs— which allows to directly link observed shifts in output prices with changes in wages. Equation (5) can be reformulated in terms of changes to show how changes in wage costs drive adjustments in gross output prices as:

$$\Delta o = G'(v\, \widehat{Dw}) \quad (6)$$

$$o^{*} = \Delta o + o \quad (7)$$

In equation (6) Dw represents the vector of the shocks to wages, which is computed as the product of the sectoral wage growth rate, chosen as detailed above, times the starting value of the compensation of employees. Δo is the increase in prices under the simulation and o^{*}represents the the value of output at basic prices computed under the new set of wages.

In order for the model to be fully coherent, it is necessary that the final demand respects the identity which establishes that total domestic output is equal to the sum of the uses, namely the sum of the value of output which is used as intermediate good plus the output which is used to satisfy the final demand in each sector. This is obtained via Equations (9) and (10) below

$$A = \hat{o}\, B\, \hat{o}^{-1} \quad (8)$$

$$f = (\mathrm{I} - \mathrm{A})\, o \quad (9)$$

$$f^{*} = (\mathrm{I} - \mathrm{A})\, o^{*} \quad (10)$$

$f^{*} - f$ is interpretable as the increase in prices per sector. Finally, to compute the aggregate increase in consumption prices, the increases in prices per sector (in percentage) are aggregated using as weights the weights of the vector consumption.

III.5. CONCLUSIONS

Overall, simple simulations with an input-output model confirm the findings of the literature that the increase in consumer prices generated by the impact of wage shocks are considerably smaller than the original shock. As such they are unlikely to generate situations in which a wage shock triggers a wage price spiral. This is because the share of wage costs in total production costs is relatively low.

While labour costs represent around one third of total costs, taking into account the second-round effects can significantly increase the impact of a wage shock on consumer prices. The most interesting result of the chapter is that such second round effects can be relatively large depending on the (size and) position of the sector in the interlinkages map of the economy. Shocks originating in larger and more upstream sectors have a substantially larger impact than shocks originating in smaller and downstream sectors. This means that, in the present situation, a scenario in which workers in all sectors

obtain the same increase in wages would have a smaller inflationary impact than a shock of the same aggregate size but restricted to the more upstream market sectors.

The results presented in this chapter are based on very stylised illustrative scenarios. Many factors that play an important role in inflation dynamics, including other cost shocks and inflation expectations, are not modelled here. Nevertheless, the analysis presented here can be useful for forecasters as it provides a tool to estimate with more accuracy the inflationary implications of a given nominal wage growth scenario. In its Spring 2024 forecast, the Commission expects real wages to recover by 2025 their 2021 level, driven by moderately increasing wages and further slowing of inflation. Against the background of partial reversal of the positive labour demand and supply shock of the past few quarters and subdued growth prospects for the beginning of 2024, it seems likely that such an increase in real wages will happen while inflation continues to stabilise. This illustrates that inflation is driven not only by wage cost dynamics but also by other factors (notably other cost factors including energy). Finally, the push to nominal wages is projected to be very gradual, and smaller than the illustrative choice made in this chapter for clarity purposes. This would imply smaller second-round effects and a reduced inflationary impact.