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What contributes to consumer price inflation? A novel decomposition framework with an application to Austria

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What contributes to consumer price inflation?
A novel decomposition framework with an application to Austria[1]

Martin Schneider (Oesterreichische Nationalbank)

Abstract:

In this paper, we propose a new methodology for decomposing consumer price inflation into contributions of cost components using national accounts data. It builds on the well-known decomposition method for the value-added deflator and expands it by combining the cost structure of the consumption bundle underlying the harmonized index of consumer prices (HICP) derived from an input-output table with quarterly national accounts data. This allows to decompose HICP inflation into detailed cost components including imports. We apply the approach to Austria and analyze the composition of inflation for the period from the first quarter of 2019 to the first quarter of 2023. In 2022, the most significant contributors to inflation were both energy and non-energy imports. Profits contributed to inflation from the second half of 2022 onwards, whilst there have been no substantial price pressures from wages. We also find that there are considerable differences in the inflation determinants between subindices of the HICP. Whilst imports played a crucial role for inflation of food, non-energy industrial goods and energy, their influence for services inflation was minimal. The results of the analysis show that the decomposition can provide valuable insights for the conduct of monetary policy.

Keywords: Consumer price inflation, production-side decomposition, inflation accounting

JEL-Classification: C67, E25, E31.

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1 martin.schneider@oenb.at. The views expressed in this paper are strictly those of the authors and do not necessarily reflect the views of the Oesterreichische Nationalbank. The author likes to thank Friedrich Fritzer, Erwin Kolleritsch, Zuzana Molnarova, Lukas Reiss, Mirjam Salish, Richard Sellner and Patricia Walter and the participants of an internal discussion round for helpful comments and suggestions.

Non-technical summary

The current phase of high inflation has led to lively interest in this topic. One question that was often asked concerns the relative role of wages and profits for inflation. Most papers that analyze this topic use a simple decomposition of the value-added deflator. In this paper we propose a novel methodology for a production-side decomposition of HICP inflation based on national accounts data. We build on the decomposition of the value-added deflator and expand it by combining input-output data with sectoral quarterly national accounts data. This allows us to decompose HICP inflation at a granular level.

We use the approach to analyze the inflation developments in Austria for the period from the first quarter of 2019 to the first quarter of 2023. In 2022, energy as well as non-energy imports were the most important contributors to inflation. Profits contributed to inflation from the second half of 2022 onwards, whilst there have been no substantial contributions from wages. We find that there are considerable differences in the inflation determinants between subindices of the HICP. Whilst imports played the main role for inflation of food, non-energy industrial goods and energy, they hardly contributed to services inflation. The results also clearly demonstrate how particularities like the lagged wage-bargaining process in Austria impact on inflation.

We also compare the decomposition of the HICP with the decomposition of the value-added deflator, highlighting five key differences. Notable distinctions include the role of imports, the exclusion of taxes and subsidies in the value-added deflator, variations in sectoral compositions, different time series used, and the use of distinct quantities for unit cost components. These factors result in significant disparities in the relative contributions of wages and profits, with wages playing a stronger role for the value-added deflator. Additionally, we find opposite signs of profit contributions in 2021 due to divergent growth patterns between real consumption and real value added.

The paper also discusses the limitations of such a decomposition approach. It is a decomposition that is based on an accounting identity, and hence cannot explain the magnitude of inflation but only the distribution of incomes arising from the production of consumption goods. Causal relationships inferred from such identities can be misleading, as we demonstrate with the GDP demand side identity. We also discuss the potential of the decomposition in identifying the nature of inflationary shocks, distinguishing between demand-pull, cost-push, and monetary shocks. Additionally, we discuss the complexities in analyzing the role of profits in inflation, considering factors like market structure and measurement errors.

1. Introduction

Understanding inflation developments is of crucial importance for central banks. Given the importance of this topic, various approaches have been used to analyze the inflation process. One simple approach, which has been used extensively since at least two decades is a decomposition of the value-added deflator using national accounts data (ECB, 2003, ECB, 2006, Jaumotte and Morsy, 2012). The change of the value-added deflator is decomposed into contributions of the value-added components compensation of employees, net taxes on production, consumption of fixed capital and net operating surplus. This approach has become increasingly prominent during the current period of high inflation, see Abberger and Nierhaus (2023), Arce et al. (2023), Byrne et al. (2022), European Commission (2023), Fritzer et al. (2023), Hahn (2019), Hansen et al. (2023), Haskel (2023), Hebbing and Öztürk (2023) and Richardson et al. (2022) just to name a few of the numerous recent contributions in that field.[2]

Although this approach generates interesting insights into the structure of domestic value-added inflation, it is not the optimal approach for central banks, which have their focus on consumer price inflation. For the conduct of monetary policy, it is crucial that a central bank understands the composition of consumer price inflation in detail, especially with regard to the extent to which domestic cost components vs. imports contribute to inflation.

Therefore, we propose a novel approach that enhances this simple approach in a way that allows for a decomposition of the Harmonized Index of Consumer Prices (HICP). It utilizes quarterly national accounts data in combination with the cost structure of consumption goods derived from the input-output table. This allows to decompose consumer price inflation at a granular level into contributions from unit cost components[3] including domestic value-added components and imports.

Whilst there are some papers available that decompose consumer prices, this is the first paper that decompose HICP inflation in such a consistent and detailed way. Recently, there have been some papers that decompose growth of the consumption deflator into domestic contributions and imports. The European Commission (2023) analyses inflation and competitiveness developments for seven CESEE EU member countries. Besides other approaches, this paper utilizes a decomposition of the consumption deflator. The decomposition is very crude, since it decomposes the growth of the consumption deflator

[2] There numerous other approaches used to analyse the drivers of inflation. One popular approach utilises the Phillips curve. Under this approach, economic slack (e.g. the output gap) is the main driver of inflation, where an increase in slack is associated with a reduction in inflation (see e.g. Rumler, 2007, Stock and Watson, 2019, and Moretti et al., 2019). There are countless studies that analyse inflation developments with (structural) VAR models (see e.g. Aucremanne and Wouters, 1999, Wehinger, 2000, Martel, 2008, Kambar and Wong, 2018). Semi-structural models have also been heavily utilized to analyze inflation developments (see e.g. Guo et al. 2019). Another widely used approach of modelling the determinants of inflation is based on dynamic stochastic general equilibrium (DSGE) models in which inflation is mainly driven by the production costs of firms (see e.g. Smets and Wouters, 2003).

[3] Unit cost components are defined as the nominal cost component (e.g. compensation of employees) divided by the quantity of the private consumption good.

into contributions stemming from imports (food, energy and other imports), a passthrough markup and a residual. The residual captures all domestic components. Hansen et al. (2023) decompose the consumption deflator for the euro area. Therefore, they build on the decomposition of sectoral value-added deflators into contributions of labor, profits and net taxes. The contribution of imports is defined as the residual between the change of the consumption deflator and the weighted sum of changes of sectoral value-added deflators.

For the time being, there are at least two papers that decompose the CPI into contributions stemming from domestic and imported sources. Haskel (2023) decomposes the CPI for the UK, US and the euro area. His decomposition is based on a decomposition of the private consumption deflator with National Accounts data plus a residual term that captures the differences between the CPI and the private consumption deflator. Dhingra (2023) decomposes the CPI for the UK with a decomposition that does not use data from annual or quarterly national accounts. Instead, she combines data from supply-use tables with time series data for wages and various prices.

One of the papers that use input-output tables to decompose other inflation measures is that of Eder et al. (2019). They calculate producer price differentials for nine European countries vis-à-vis Germany for four broad sectors and decompose them using the Leontief prices model and a structural decomposition approach (SDA).

The remainder of the paper is organized as follows. Section 2 presents the simple value-added deflator decomposition as standard in the literature. Section 3 gives an overview of the methodology. In section 4, the calculation of cost components from the input-output table is presented. In section 5 we calculate inflation contributions by combining cost components with quarterly national accounts data. Section 6 discusses data issues and computational details. In section 7 we discuss important points to consider then analyzing the results. Section 8 presents the results of the decomposition for Austria. In section 9, we look at the differences between decomposition of the value-added deflator and the HICP. Finally, section 10 concludes.

2. A simple decomposition of the value-added deflator

We start with an illustrative example of a simple supply-side decomposition of the value-added deflator of industry j ($p_{j,t}$) from national accounts (see ECB, 2006 and Jaumotte and Morsy, 2012 for early applications). Nominal value-added of industry j ($y^r_{j,t}p_{j,t}$) is defined as the sum of k nominal cost (income) components $cc_{k,j,t}$ (compensation of employees, other indirect taxes less subsidies on production, consumption of fixed capital and net operating surplus[4] (including mixed income)).

$$y^r_{j,t}p_{j,t} = \sum_{k=1}^{K} cc_{k,j,t} \tag{1}$$

[4] Profits (net operating surplus) are not a cost component in a literal sense from a firm's perspective. For the sake of simplicity, we refer to them as a cost component.

Dividing this equation by real value-added $y^r_{j,t}$, we obtain an equation which defines the value-added deflator as the sum of its per unit cost components ($ucc_{k,j,t}$).

$$p_{j,t} = \sum_{k=1}^{K} \frac{cc_{k,j,t}}{y^r_{j,t}} = \sum_{k=1}^{K} ucc_{k,j,t} \tag{2}$$

We now take the first difference and divide both side of the equation by the previous period's value-added deflator. In addition, we expand each term of the right-hand side by its previous period's unit costs. The percentage change of the sectoral output price is hence defined as the sum of the percentage changes of its unit cost components weighted with previous period's real unit cost component.

$$\frac{dp_{j,t}}{p_{j,t-1}} = \sum_{k=1}^{K} \frac{ducc_{k,j,t}}{ucc_{k,j,t-1}} \frac{ucc_{k,j,t-1}}{p_{j,t-1}} \tag{3}$$

Figure 1: Decomposition of changes of the value-added deflator for Austria

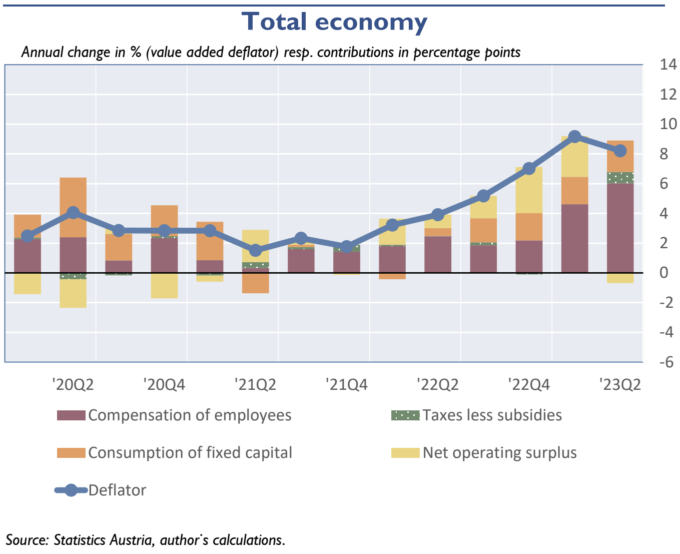


Figure 1 shows the results of the simple decomposition for Austria. In 2022, the acceleration of the value-added deflator growth was mainly explained by net operating surplus. Compensation of employees also contributed to the increase of the deflator, but not to its acceleration.

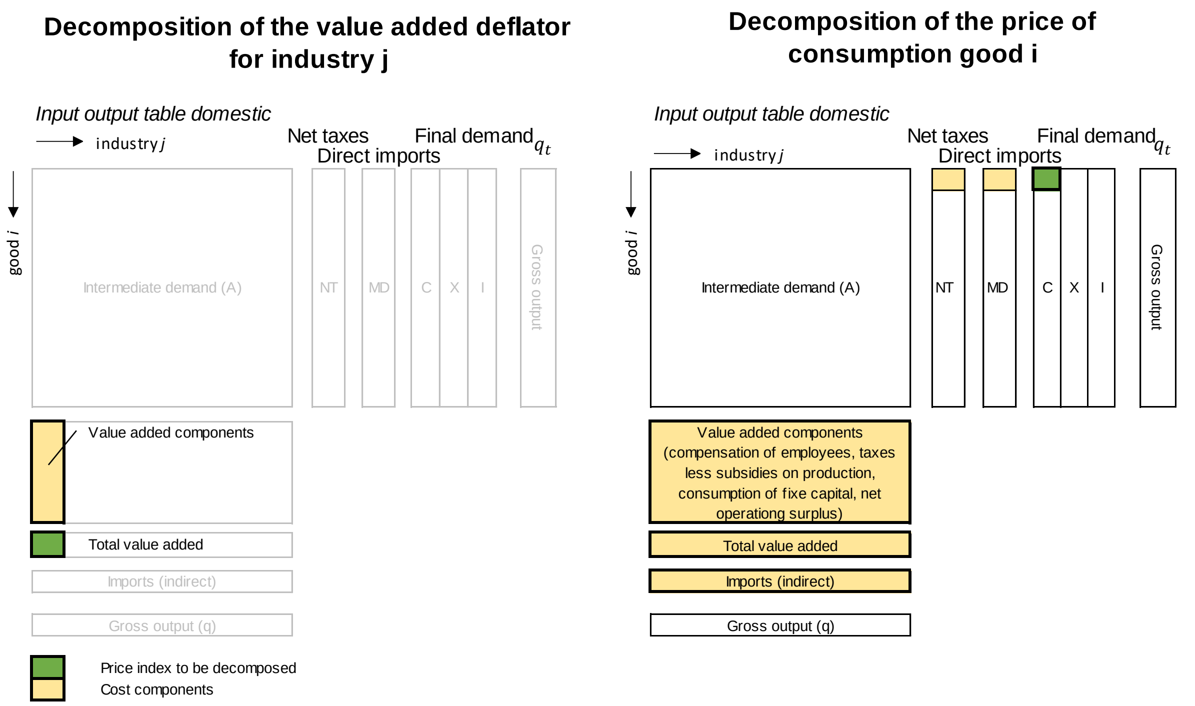
3. Overview of the methodology

In this section, we outline our novel methodology that expands the simple decomposition approach introduced in section 2 in a way that allows to decompose HICP inflation. Before presenting an overview of the method, it is important to understand the conceptual differences between the value-added deflator and the HICP.

3.1 Conceptual differences between the value-added deflator and the HICP

The *value-added deflator* $p_{j,t}$ describes the price of domestic value-added generated by production of industry j (see the left part of figure 2). Value-added neither includes imports nor intermediate goods purchased from domestic firms. The output of industry j is sold to other firms as intermediate or investment goods, to private households, the government, and foreign customers. It is nominated at basic prices, i.e. excluding trade and transport margins and net taxes on products. Since domestic value-added of industry j does not include intermediate inputs purchased from other domestic firms or from abroad, changes in cost components of other industries do not spread over to industry j.[5]

Figure 2: Overview of the cost components of the value-added deflator vs. the HICP within the input-output table framework



Footnote: This figure illustrates the decompositions of the value-added deflator and of the consumer price index within the framework of a symmetric input-output table. Such a (simplified) input-output table consists of the matrix of intermediate demand (A), a matrix that contain final demand components as well as net taxes and direct imports and a matrix that contains value-added components and indirect imports. Columns refer to industries resp. net taxes, direct imports and final demand components. Rows refer to goods, value added components and imports. Green cells refer to the price index to be decomposed, orange-colored cells to the cost components which are the result the decomposition.

Source: Author's own draft.

The *Harmonized Index of Consumer Prices (HICP)* measures the price of a basket of goods and services acquired by households within a country for final consumption. This basket includes both domestically produced as well as directly imported goods and services. The right part of figure 2 shows the cost components of the production of consumption good i. In this case, we have to distinguish between *direct cost components* (direct imports and net taxes on production) and *indirect cost components*, which are generated by domestic production of consumption good i. Due to the inter-industry linkages generated by the use of intermediate goods, consumption good i also includes the value added by other

[5] In contrast to the value-added deflator, the GDP deflator also includes taxes less subsidies on products.

(upstream) industries as well as imports. Hence, the indirect cost components include domestic value-added of all industries and indirect imports. The consumption goods that are purchased by private households are nominated at purchasing prices, i.e. they include trade and transport margins and net taxes on products.

The differences between the two price indices imply that the HICP decomposition requires substantial modifications to the decomposition method used for the value-added deflator. There are four main issues that must be addressed:

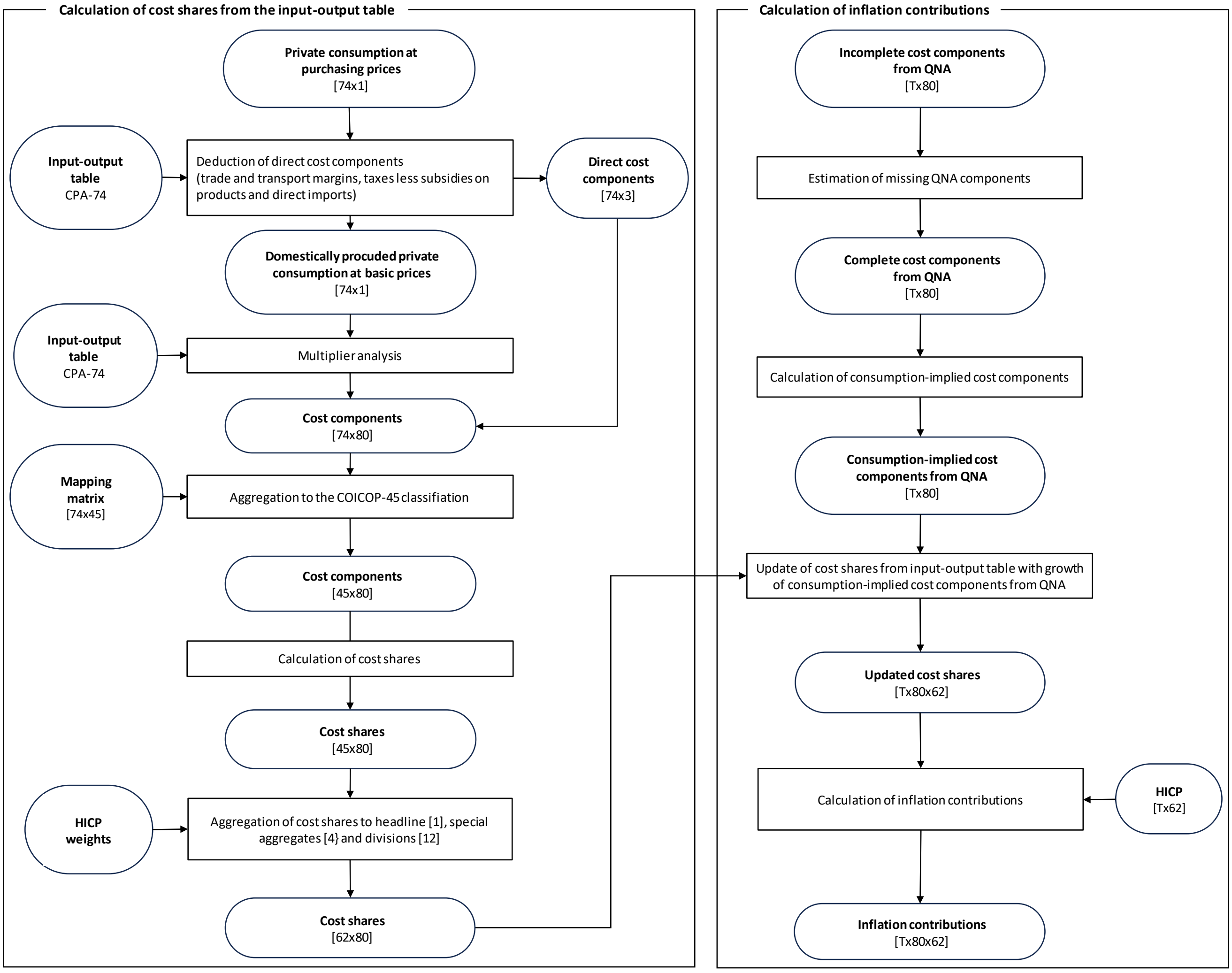
- There is no direct link between the aggregate consumption basket that is the basis of the HICP and national accounts aggregates. Hence, disaggregated HICP data must be used. We use data for 45 COICOP[6] sub-groups.
- The COICOP-45 classification must be matched with national accounts data that are available at the CPA[7]-74 level for Austria.
- The breakdown of the income side of national accounts is available for *industries*, whereas consumer prices relate to *goods and services*. Hence, input-output tables must be used to capture the relationship between industries and goods.
- The use of different price concepts (basic vs. purchasing prices) implies that we must find a way to cope with trade and transport margins, which reflect the services provided by trade and transport sectors (see section 4.2).

3.2 Main parts of the analysis

The proposed approach utilizes quarterly national accounts data supplemented with additional data on imports and indirect taxes less subsidies in combination with the cost structure derived from input-output tables to decompose the HICP and its subindices. The method consists of two main parts. In the first part we calculate the cost shares for each consumption good from the input-output table at the CPA-74 level and aggregate them to the COICOP classification. In the second part, we update these cost components with data from quarterly national accounts (incl. own estimates for missing components) and trade data. Figure 3 gives a detailed overview of the calculations.

[6] Classification of individual consumption by purpose.
[7] Classification by activity.

Figure 3: Overview of the decomposition of HICP inflation



Source: Author's own draft.

4. Calculation of cost components from the input-output table

In this section we explain the calculation of cost components from the latest input-output table.

4.1 Calculation of cost components at the CPA-74 level

We use the input-output table for Austria for the year 2019 with 74 goods/industries.[8] For each good i, we distinguish between *direct* and *indirect cost components*. *Direct cost components* are direct imports and taxes less subsidies on goods. These can be obtained from the input-output table for private consumption without further calculations. The inflation contribution from taxes on goods is a special case, as it can be calculated easily as the difference between HICP inflation and HICP inflation at constant tax rates as

8 Statistics Austria publishes an input-output table with 64 industries/goods on its webpage. A more detailed table with 74 industries/goods and several additional tables can be purchased (Statistik Austria, 2023). See section 6 for an overview and table A-3 for details on the tables we have used for the analysis.

published by Statistics Austria. Although we do not have to include direct taxes on goods in our cost components for the decomposition, we include it for reporting purposes.

Indirect cost components are generated by the domestic production of consumption good i. We use a multiplier analysis to derive the indirect cost component k in industry j attributable to the production of consumption good i ($cc_{k,j,i}^{CPA}$) at the CPA-74 level. For each good i, we set the final demand vector D_i to zero except for good i, which we set to the value of private consumption at basic prices from the input-output table. Multiplying D_i with the Leontief-inverse ($(I-A)^{-1}$)[9] gives the vector of output Q_i generated in all industries by the production of D_i.

$$Q_i = (I-A)^{-1} D_i \tag{4}$$

The cost component k of industry j necessary to produce consumption good i ($cc_{k,j,i}^{CPA}$) can be derived by multiplying output of industry j generated by the production of consumer good i ($q_{j,i}$) with the share of cost component k ($cc_{k,j}^{IO}$) in output of industry j ($q_{j,i}$) from the input-output table.

$$cc_{k,j,i}^{CPA} = \frac{cc_{k,j}^{IO}}{q_j} q_{j,i} \tag{5}$$

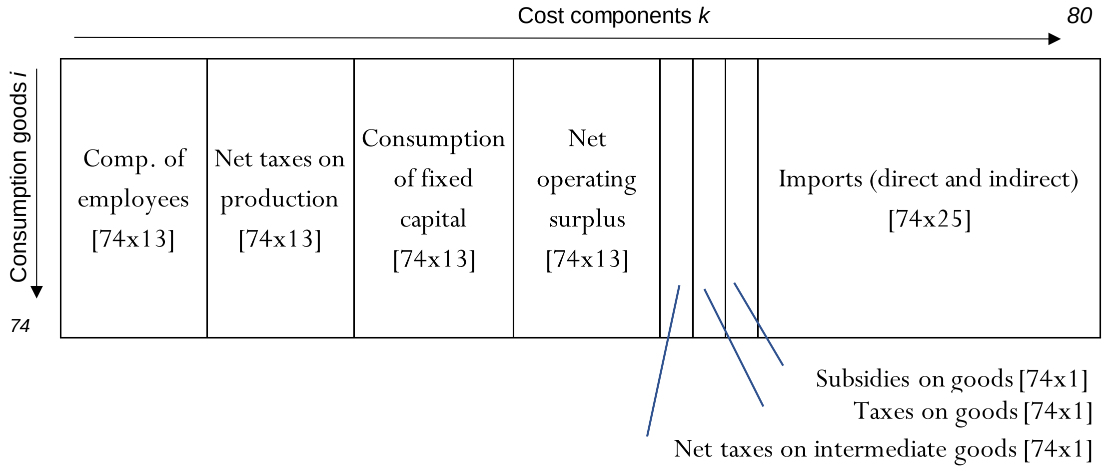
For each of the 74 CPA goods i at basic prices, we obtain detailed indirect cost components for all 74 industries. These include compensation of employees, other indirect taxes less subsidies on production, consumption of fixed capital and net operating surplus (including mixed income), net taxes on intermediate demand as well as imports for 74 goods and services categories. This gives us a total of 5846 (=74*79) cost components for each CPA good. To keep the decomposition manageable, we aggregate these cost components in a meaningful way. With regards to the number of industries, we aggregate them to the 13 industries that are available in quarterly national accounts.[10] The 74 import goods per industry j that are available in the input-output table are first aggregated to 25 goods and services categories. In addition, we sum up imports over all industries j, giving us 25 import cost components. We further sum up the components of net taxes on intermediate goods, and the two direct cost components taxes on goods and subsidies on goods, each to one overall component per good i. Direct imports are aggregated to the 25 goods and services categories as indirect imports and are added to indirect imports. This gives us a total of 80 cost components for each consumption good i at purchasing prices (=4*13 cost components per industry + 25 imports + 3 direct cost

[9] A is the matrix of technology coefficients which can be obtained by dividing the matrix of intermediate demand by output by industry.

[10] Agriculture, forestry and fishing (NACE A), Mining and quarrying, energy, water and sewerage (NACE BDE), Manufacturing (NACE C), Construction (NACE F), Trade and repair of motor vehicles (NACE G), Transportation and storage (NACE H), Accommodation and food services (NACE I), Information and communication (NACE J), Finance and insurance activities (NACE K), Real estate activities (NACE L), Business-related services (NACE MN), Public sector activities (NACE OPQ), Arts, entertainment, recreation and other private services (NACE RTU).

components). We collect these cost components for all CPA-74 goods in one matrix with the dimension 74x80 (see figure 4).[11]

Figure 4: Cost components for each CPA-74 good derived from the input-output table



Source: Author's own draft.

4.2 Aggregation of cost components from CPA-74 to the COICOP-45 level

The next step is to aggregate the cost components from the CPA-74 level to the COICOP-45 level. Therefore, we need a correspondence table that contains private consumption for both classifications. Statistics Austria provides such a table (table 25) in its detailed input-output data set (Statistik Austria, 2023).[12] The correspondence table X^{PP} is nominated at purchasing prices, i.e. including trade and transport margins and net taxes on products. Table A-1 in Appendix 1 illustrates the structure of this table. Each row describes how consumption good i at the CPA-74 level can be mapped to one or more COICOP-45 categories j. To obtain an aggregation matrix $\hat{X}^{PP}$, we divide each element of the correspondence table X^{PP} by its row sum. See appendix 1 for some details on aggregation matrices.

$$\hat{x}_{i,j}^{PP} = \frac{x_{i,j}^{PP}}{\sum_{j=1}^{J} x_{i,j}^{PP}} \tag{6}$$

The aggregation of the direct cost components subsidies on products (sp^{CC45}) and direct imports of consumption goods (md^{CC45}) at the COICOP-45 level can be obtained by

$$sp^{CC45} = \left(\hat{X}^{\mathrm{PP}\prime} * sp^{CPA74}\right)' \tag{7}$$

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[11] In the remainder of the paper, we use subscript k for all cost components instead of cost components per industry j as we did in equation 5.

[12] For countries where the statistical office does not provide this table, it can be estimated with the RAS method utilizing consumption vectors for the COICOP and the CPA classifications and a seed matrix (see Cai and Vandyck, 2020).

$$md^{CC45} = \left(\hat{X}^{\mathrm{PP}\prime} * md^{CPA74}\right)' \tag{8}$$

For the *aggregation of indirect cost components,* we need to address the issue caused by the use of different price concepts in the input output table. Goods purchased by consumers are at purchasing prices, i.e. they include trade and transport margins. This means the output of the trade and transport sectors is included in the price of the goods they purchase and that consumers do not consume wholesale or retail goods directly. In contrast, the indirect cost components that we have calculated are at basic prices, i.e. trade and transport sectors are reported as entities. If we look at correspondence table A-1, we see that the output of transport and trade sectors is zero, as it is included in the final value of other goods.[13] This implies that the indirect cost components of these industries would be lost during aggregation when we use aggregation matrix X^{PP}. Hence, we must convert matrix X^{PP} from purchasing to basic prices (X^{BP}). Therefore, we take a look at the composition of domestically produced private consumption good i at purchasing prices (c_i^{DPP}), which is defined as domestically produced private consumption good i at basic prices (c_i^{DBP}) plus wholesale trade margins (wtm_i), retail trade margins (rtm_i), transport margins (trm_i), and taxes on products (tp_i) less subsidies on products (sp_i).[14]

$$c_i^{DPP} = c_i^{DBP} + \ wtm_i + rtm_i + trm_i + tp_i - sp_i \tag{9}$$

We convert $X^{\mathrm{PP}}$to basic prices in the following way. For each of the CPA-74 goods and for each margin (wholesale, retail, and transport), we deduct the share of the respective margin from the row in X[15] and add the margin to the corresponding margin goods.[16] Table A-2 shows the resulting correspondence table at basic prices (X^{BP}). We can see that now there are non-zero elements in the rows of the margin goods, i.e. the cost components of the trade and transport sectors are assigned to COICOP-45 good which include these margins in their final value. Multiplying the transpose aggregation matrix with the matrix of cost components at the CPA-74 level gives us the transpose matrix of cost components at the COICIP-45 level.[17]

$$cc_i^{IO45} = \left(X^{\mathrm{BP}\prime} * cc_i^{IO74}\right)' \tag{10}$$

We proceed by adding the direct cost components to the corresponding columns of CC_i^{IO45}.

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13 For transport margins there are some non-zero elements in the rows since households consume some transport services directly. For wholesale and retail trade, all elements in the respective row of X^{PP} are zero.

14 Margins and net taxes are available for each final demand component in the Austrian input-output table.

15 Therefore, we implicitly assume that the share of each margin in the value of each COICOP good is constant.

16 Wholesale trade margins are provided by wholesale- a. retail trade, repair of motor vehicles (45) and wholesale trade, excl. motor vehicles and -cycles (46), retail trade margins by retail trade, exc. motor vehicles and -cycles (47) and trade margins by Land transport services a. transport services via pipelines (49), water transport services (50), air transport services (51), warehousing and support services for transportation (52) and insurance, reinsurance and pension funding services (65). The shares of each margin goods in total margins per type of margin (wholesale, retail, and trade) can be obtained from the detailed set of input-output tables provided by Statistics Austria.

17 We apply this aggregation for indirect cost components only. Direct cost components are aggregated with the aggregation matrix at purchasing prices.

The next step is to convert the cost components into cost shares that sum up to one by dividing the cost components by private consumption at purchasing prices.

$$cs_i^{IO45} = \frac{cc_i^{IO45}}{c_i^{PP}} \tag{11}$$

Finally, we aggregate the cost shares at the COICOP-45 level to headline inflation, four special aggregates (food, non-energy industrial goods, energy and inflation) and to twelve divisions by multiplying them with a matrix with the respective HICP weights (see appendix A-1).

$$cs_i^{IO17} = cs_i^{IO45} * \mathrm{W}^{HICP} \tag{12}$$

We add these 17 additional rows to the matrix of cost shares, resulting in a 62x80 matrix of cost shares.

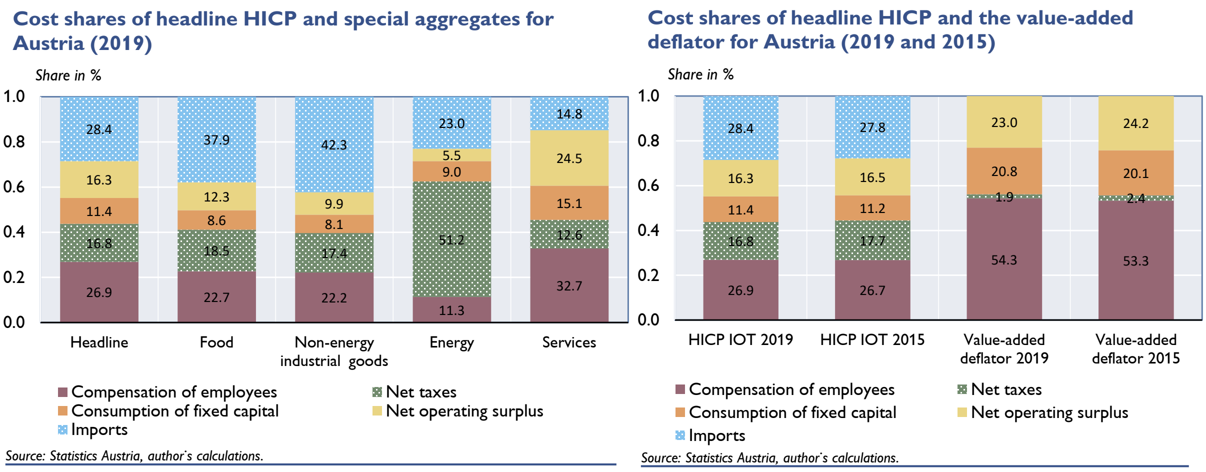
$$cs_i^{IO62} = cs_i^{IO17} \mid cs_i^{IO45} \tag{13}$$

The left panel of figure 5 shows the resulting cost shares of headline inflation and the special aggregates for the input-output table 2019. There are substantial differences between these aggregates. The import content is highest for non-energy industrial goods and lowest for services. For energy it is also rather low due to the high role of net taxes, which amount to more than half of the total value of energy goods. The share of wages is lowest for energy and highest for services. The role of profits is highest for services, partly due to the role of mixed income of self-employees, which is part of net operating surplus in national accounts. Net taxes also play an important role for consumer prices.

The right panel of figure 5 compares the cost structure of headline inflation for 2019 with the cost structure derived from the input-output table 2015. It shows that the differences are very small.[18] In addition, it shows the cost structure of the value-added deflator directly calculated from national accounts data for these two years. The difference between the cost structure of the HICP and the value-added deflator will be discussed in section 9.

[18] The similarity of the cost structures for those two years translates into very similar decompositions. For the year 2022, the inflation contribution of compensation of employees – which amounts to 1.2 percentage points based on the IO table 2019 – changes to 1.1 percentage points for the IO table 2015. Similarly, the changes for the other cost components are also very small (Net operations surplus: 2.0 pp → 2.1 pp., Imports: 4.8 pp → 4.6 pp).

Figure 5: Cost shares of HICP and the value-added deflator



5. Calculation of inflation contributions

In the second part of the exercise, we use quarterly national accounts data and trade data together with the cost structure of the 45 COICOP goods derived from the input-output table to decompose consumer price inflation. This part consists of four steps: the first step is to estimate the cost components that are missing in quarterly national accounts. In the second step, we isolate the share of the cost components implied by private consumption from other final uses and refer to them as consumption-implied cost components. The third step is to combine the cost components derived from the input-output table with growth rates of our consumption-implied cost components at the quarterly level. Finally, the last step is to decompose HICP inflation.

5.1 Estimation of missing quarterly national accounts components

We calculate inflation contributions based on quarterly national accounts (QNA) data per industry (plus detailed data on imports of goods and services). The published QNA data only contain value-added and compensation of employees per industry. Therefore, we must estimate the three missing components (net taxes on production, consumption of fixed capital and net operating surplus). The following sections briefly summarize the procedure. Details of the procedure can be found in Fritzer, Reiss and Schneider (2023).

Taxes less subsidies on production

In normal times, subsidies to firms do not play a significant role (apart from agriculture), as their share is low (2000-2019: 1.7% of gross value-added) and stable over time. In 2020 and 2021, however, their share increased to 7.1% due to the COVID pandemic. In 2022, the Austrian government paid subsidies to firms due to high energy prices. Fritzer, Reiss and Schneider (2023) use several data sources to break down quarterly subsidies by industry. The breakdown of short-time work subsidies is derived from detailed data from the Ministry of Labour. For the other crisis subsidies, the estimates are based on data from the COVID-19 Federal Financing Agency (COFAG), the Ministry of Finance and Statistics Austria.

Consumption of fixed capital

Consumption of fixed capital or depreciation is currently available in annual national accounts up to 2021. To obtain quarterly estimates until 2023Q1, we first have to estimate annual values for 2022 and 2023 based on the perpetual inventory method. The capital real stock of industry j in year t ($k_{j,t}$) results from the capital stock of the previous year ($k_{j,t-1}$) plus real investments in year t ($i_{j,t}$) minus real depreciation ($d_{j,t}$). The capital stock of *t-1* is depreciated with the depreciation rate r_j ; the investments of year t at half the rate (Huber, 2015).

$$k_{j,t} = k_{j,t-1} + i_t - d_t = k_{j,t-1} * (1 - \mathrm{r}_j) + i_{j,t} * (1 - 0.5 * \mathrm{r}_j) \tag{14}$$

Real depreciation can be calculated from

$$d_{j,t} = r_j(k_{j,t-1} + 0.5 * i_{j,t}). \tag{15}$$

Since the capital stock in national accounts is valued at replacement prices and not at historical acquisition costs as in firm's accounting, real depreciation must finally be inflated with the capital stock deflator $p^K_{j,t}$. Since this is only available until 2021, we update it with for 2022 and 2023 with the change of our own estimate of the investment deflator $p^I_{j,t}$.

$$d^{nom}_{j,2022} = d_{j,t} * \frac{p^I_{j,t}}{p^I_{j,2021}} * p^K_{j,2021} \tag{16}$$

Finally, we interpolate annual depreciation to the quarterly frequency using a temporal disaggregation method (Chow and Lin, 1976), with the quarterly depreciation for the total economy from sectoral accounts as regressor. This ensures that the aggregation of deprecation over industries fits with data from sectoral accounts for the total economy.

Net operating surplus

Finally, net operating surplus of firms is calculated as residual.

Adjusting compensation of employees and net operating surpluses for crisis subsidies

The subsidies granted during the COVID-19 crisis (mainly short-term work, sales compensation, loss bonus, fixed cost subsidies and loss compensation) are included in the income components compensation of employees and net operating surplus, distorting the inflation contributions of these components. Without further adjustments this leads to large positive contributions of net operating surplus and compensation of employees in some quarters during the pandemic, as output fell and net operating surplus and compensation of employees remained high due to the subsidies, and a negative contribution of (negative) net taxes on production, which offset each other partly. It can be assumed that the COVID subsidies did not have a substantial impact on the price-setting behaviour of firms since their goal was primarily to reduce losses and not to reduce prices. Therefore, net operating surpluses and compensation of employees (due to short-term work subsidies) were adjusted by the respective crisis subsidies.

Imports of goods and services

Data on imports of goods are available at the monthly frequency. We forecast missing observations (usually one month) with ARIMA time series models (usually one month is estimated to complete the current quarter). We use the same treatment for service imports, which are available at the quarterly frequency and where usually one quarter is missing when quarterly national accounts are released.

5.2 Calculation of consumption-implied cost components

The next step is to address the problem that industry-specific cost components in national accounts (value-added, imports, net taxes on intermediate goods) correspond to the sum of all final demand components and not consumption only.[19] For example, a strong growth of equipment investment (which has a very high import content) causes imports to grow strongly. Without differentiating between various final demand components, this strong import growth results in an overestimation of the import contribution to consumer price inflation.

To avoid such distortions, we must calculate cost components that are specific to private consumption. We begin by calculating cost shares $cs_{k,f}^{IO}$ for all 11 demand components f in national accounts except changes in inventories.[20] We perform a multiplier analysis using the input-output table as described for private consumption in section 4 (see equations (4) and (5)). We then aggregate over the 74 CPA goods to obtain aggregated results for each final demand component. [21] This gives us an 11x80 matrix of cost shares similar to figure 4. We then calculate *hypothetical cost components* $\widetilde{cc}_{k,f,t}^{QNA}$ for each final demand component by multiplying the respective cost share ($CS_{k,f}^{IO}$) from the input-output table with the final demand component from QNA ($d_{f,t}^{QNA}$).

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[19] For taxes and subsidies on products, consumption-specific data can be obtained directly from input-output tables.

[20] Final consumption by households, final consumption by government, final consumption by NPISH, gross fixed capital formation - dwellings, gross fixed capital formation - other buildings and structures, gross fixed capital formation - machinery, gross fixed capital formation - transport equipment, gross fixed capital formation - cultivated assets, gross fixed capital formation - intangible fixed assets, exports of goods, exports of services.

[21] Note that the results of the multiplier analysis for the different demand components are the same for each CPA-74 good. Differences in aggregated cost components between demand components are caused by differences in the goods structure.

$$\widetilde{cc}_{k,f,t}^{QNA} = cs_{k,f}^{IO} * d_{f,t}^{QNA} \tag{17}$$

Finally, we calculate *consumption-implied cost components* ($cc_{k,\mathrm{C},t}^{QNA}$) by multiplying the share of the hypothetical cost component of private consumption in the sum of the hypothetical cost components of all demand components with the cost component from QNA ($cc_{k,t}^{QNA}$).

$$cc_{k,\mathrm{C},t}^{QNA} = \frac{\widetilde{cc}_{k,C,t}^{QNA}}{\sum_{f=1}^{F} \widetilde{cc}_{k,f,t}^{QNA}} * cc_{k,t}^{QNA} \tag{18}$$

5.3 Update of cost shares from the input-output table with growth of consumption-implied cost components

As a next step, we update the cost shares from the input-output table with the growth of consumption-implied cost components ($cc_{k,i,t}$) in quarter t.

$$cs_{k,i,t} = cs_{k,i}^{IO45} * \frac{cc_{k,\mathrm{C},t}^{QNA}}{cc_{k,\mathrm{C},2019}^{QNA}} \tag{19}$$

These cost shares[22] take structural shifts since the year of the input-output table such as the sharp increases of energy prices into account. The increasing importance of energy is reflected in a higher share of the energy cost component, resulting in a higher contribution than derived from the input-output table 2019.

5.4 Calculation of inflation contributions

In the final step, we use these cost components to calculate inflation contributions. We first have to calculate nominal private consumption of good i (which is not available in quarterly national accounts) as the sum of its cost shares.

$$c_{i,t} = \sum_{k=1}^{K} cs_{k,\mathrm{i},t} \tag{20}$$

Then we divide by the consumer price index to obtain real consumption of good i.

$$c_{i,t}^{r} = \frac{c_{i,t}}{p_{i,t}} \tag{21}$$

After this, we calculate unit cost shares (per real unit of consumption good i)

$$ucs_{k,\mathrm{i},t} = cs_{k,\mathrm{i},t} / c_{i,t}^{r} \tag{22}$$

Finally, we obtain contributions to year-on-year inflation using the same decomposition formulae as used for value-added deflator (equation (3)).

[22] The results of (19) are no cost shares in a literal sense they do not add up to one. However, this does not matter for the decomposition since private consumption is calculated as the sum of all cost shares.

$$\frac{dp_{i,t}}{p_{i,t-4}} = \sum_{k=1}^{K} \frac{ducs_{k,\mathrm{i},t}}{ucs_{k,\mathrm{i},t-4}} \frac{ucs_{k,\mathrm{i},t-4}}{p_{i,t-4}} \tag{23}$$

6. Data and computational details

The decomposition requires various tables from the input-output statistics, aggregation matrices, HICP data and data from quarterly and annual national accounts. Table A-3 gives an overview of the data used for the decomposition. For Austria, we use the latest input-output table from published by the statistical office for year 2019 (Statistik Austria, 2023). The input-output table is available for 74 industries/goods. We use the symmetric input-output tables for domestic production and for imports at basic prices, the tables on wholesale, retail and transport margins at current prices, the tables on taxes and subsidies on production at current prices and the table on final use at purchasers' prices.

We conduct the decomposition of the HICP at the COICOP 3-digit level (45 goods). We also decompose headline inflation, inflation for special groupings (4) and divisions (12). Since the decomposition method is non-linear[23], we calculate the decomposition based on aggregated cost components instead of aggregating the results. We do the same for annual vs. quarterly results. Due to the publication lag of the first full release of quarterly national accounts of two months we can calculate our decomposition with a delay of one and a half months after the publication of HICP inflation of the last month of a quarter.

7. Interpretation of the results

Before presenting the results in the next section, we should look at the meaningfulness and the limitations of our approach. There are several points to consider.

7.1.1 The magnitude of inflation cannot be explained by the decomposition

By construction, the decomposition of the HICP – as well as the decomposition of the value-added deflator – cannot explain the magnitude of inflation, but just the distribution of incomes generated by the production of the consumption bundle underlying the HICP to the production factors.

7.1.2 Reasoning from an accounting identity

An important point to consider is that the decomposition is based on an accounting identity. It is well-known in economics that inferring a causal relationship from an identity can lead to misleading results (Albrecht, 2023).

[23] It is non-linear since we divide each cost component *k* for the production of consumption good *i* by private consumption good *i*, which is calculated as the sum of all cost components. Table A-4 shows the aggregation error when aggregating the results vs. the cost components for the quarterly and the annual decomposition.

Let us demonstrate this with the GDP demand side identity which states that GDP is the sum of private consumption, investment, government consumption and exports minus imports (Y=C+I+G+X-M). We can make *two types of errors* when drawing conclusions from this identity. The *first* is that causality can run in the opposite direction as the identity might suggest. Whilst the GDP demand side identity suggests that GDP is caused by the sum of the demand components less imports, the causality might run in the opposite direction in the case of a positive technology shock that increases the level of production, which in turn leads to higher demand. The *second* error is that we – often implicitly – make the ceteris-paribus assumption that the other variables on the right-hand side of the identity do not change. This assumption might not hold in many cases. In our example drawing the conclusion that an increase of a demand side component (e.g. exports) by one euro leads to an increase of GDP by one euro is false for at least two reasons. Firstly, a demand shock causes GDP to increase only in the case of idle production capacities. Otherwise, export demand might crowd out other demand components. Secondly, exports have a direct import content which causes GDP to increase less than exports even in the case of idle production capacities.

Whilst the identity does not establish a causal relationship between the variables on the right-hand side and the variable on the left-hand side, it does also not rule out that such a relationship exists. Therefore, we need an economic theory in the background that establishes the causal relations between the variables to reason from an accounting identity.

7.1.3 Can the decomposition be informative about the nature of shocks that drive inflation?

Next, we want to look at the question whether the decomposition can tell us anything about the nature of shocks that drive inflation. In his survey on macroeconomic theories of inflation, Totonchi (2011) groups the drivers of inflation into five categories, namely monetary shocks, demand shocks, supply-side shocks, structural and institutional factors.[24] While it seems obvious that our decomposition cannot help identifying structural and institutional factors as the drivers of inflation, we want to look whether it can be informative about the remaining three inflation shocks. According to the *monetary theory of inflation*, money supply drives inflation. *Demand-pull inflation* occurs when the level of aggregate demand grows faster than the level of aggregate supply, which causes prices to increase. *Cost-push inflation* occurs when firms increase their prices when their costs rise. The typical method to disentangle the different types of shocks is to estimate an empirical model that includes theory-based restrictions such as a structural VAR model (Shapiro, 2022, Firat and Hao, 2023).

The mechanics of demand-pull and cost-push inflation are different. For *cost-push inflation*, the trigger is an initial increase of the costs of a production input, e.g. imported raw materials. As a response, firms try to increase their prices to maintain their profit

[24] The literature on macroeconomic theories of inflation is broad. Other contributions are Burton, 1972, Parkin, 1994, Schwarzer, 2018, Totonchi,2011, Fahlevi et al., 2020, just to name a few.

margins. In the next stage, employees demand higher wages to compensate for their loss of purchasing power. This results in further price increases.[25] Weber and Wasner (2023) have referred to this process as "sellers's inflation". If the initial trigger comes from abroad, then this should show up as a high contribution of imports[26]. The domestic cost components should follow in the same order as outlined above, namely profits followed by wages. If we can observe such a pattern in our decomposition, then cost-push inflation is a likely explanation. For *demand-pull inflation*, we have to distinguish between a domestic and an international demand shock: For a domestic demand shock, imports should not have the most important contributions. With regard to domestic cost components, we would expect the same order as for a cost-push shock, namely that in the beginning firms' profits will benefit from inflation, followed by wages. For an international demand shock that drives up commodity prices, imports may also contribute significantly to domestic inflation. Through the lens of our decomposition, a *monetary shock* is indistinguishable from a *demand shock* without the use of additional indicators with regards to the monetary conditions.

7.1.4 The role of profits

Special care must be taken when analyzing the role of profits. Profits are not a cost-component in a literal sense but could be understood as the residual between the revenues and costs of a firm.[27] With regards to the direction of causality, there are two possibilities. Firstly, firms set prices based on their costs plus a profit markup. Secondly, profits are caused by the difference between prices and the costs of the firm. The behavior of prices and profits depends on a variety of factors, such as the market structure, the degree of price rigidities, the price elasticity of demand and the type of shock. In addition to this more fundamental problem, the profit measure in National Accounts (net operating surplus) has to be treated with special care for a variety of reasons. Firstly, it is calculated as a residual by subtracting compensation of employees, taxes less subsidies and consumption of fixed capital from value added by industry. Hence, all measurement errors of the other variables impact on net operating surplus. This holds especially for consumption of fixed capital, which is a crude estimate calculated with the perpetual-inventory approach, utilizing assumptions on depreciation rates. Secondly, it contains not only firm's profits in a narrow sense, but also net mixed income (which incorporates the entrepreneurial income of unincorporated enterprises in the household sector as well as the labor compensation of self-employees). It also includes the corporate income tax and interest payments, which may have implications for economic analysis (ECB, 2004). Another important point to consider is that an increase of nominal (unit) profits does not necessarily imply that profitability (the mark-up or

[25] Ruch (2016) and Baba and Lee (2022) have estimated second-round effects of energy price shocks.

[26] Increasing import prices can be the consequence of a global demand shock, but we don't want to further explore this argument.

[27] Profits include interest on capital which are costs to the firm.

profit margin) has increased. Colonna et. al (2023) show that only an increase of the markup can signal price pressures arising from profits.[28]

7.1.5 Further caveats

Besides the points discussed above, there are further caveats. Firstly, the analysis depends on the cost structure of the last year where an input-output table is available. If this is a year which is subject to a large shock, this could impede the results. Secondly, the analysis is static and assumes that all transactions within the production chain occur within one period. While this should be relatively innocuous at the annual frequency, quarterly results should be interpreted with caution. Thirdly, the inter-industry linkages reported in the input-output table do not have to apply in the short term, i.e., production can be maintained for some time without some of the intermediate inputs. Fourthly, the analysis hinges on the quality of quarterly national accounts data, which are often subject to revisions.

8. Results of the HICP decomposition for Austria

In this section, we present the results of the decomposition for Austria from the first quarter of 2019 until the first quarter of 2023 (figure 6). Inflation in Austria was very low until the end of 2020. From the last quarter of 2020 onwards, imports of non-energy goods began to push up consumer prices due to the supply-chain disruptions in the wake of the pandemic and the related price increases. The contribution of non-energy imports in the first quarter of 2021 of 4.1 percentage points was broad-based and mainly determined by imports of manufactured goods (1.6 pp), imports of machinery (0.5 pp), imports of crude materials (0.4 pp), imports of miscellaneous manufactured articles (0.4 pp), imports of crude materials (0.4 pp) and food (0.2 pp). Energy imports slightly dampened the inflation contribution of imports.

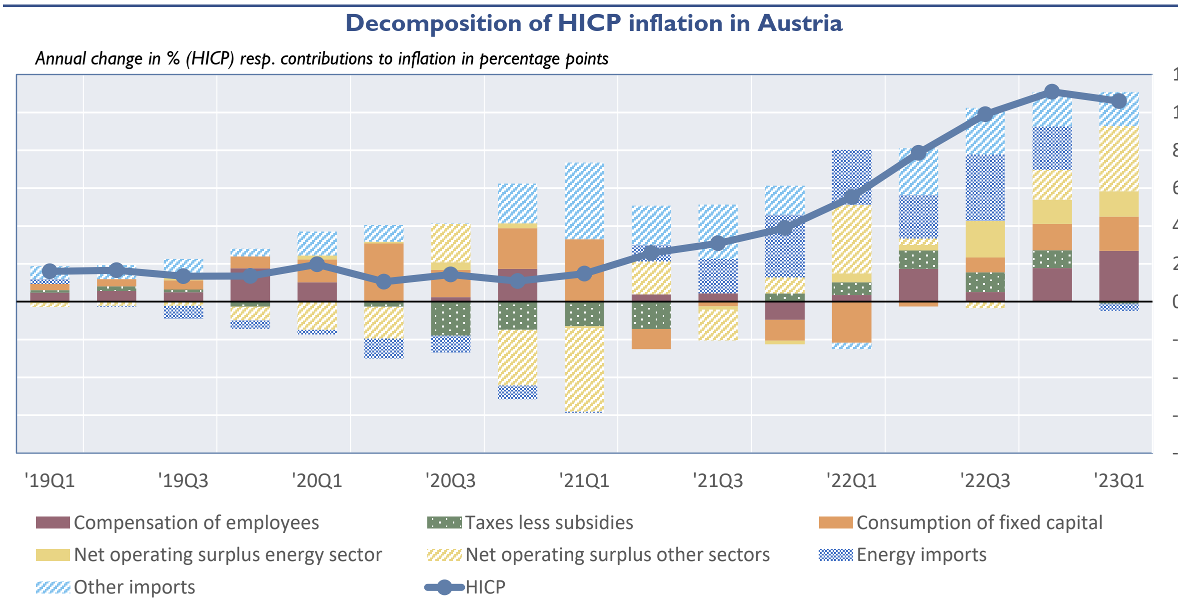
Prices for energy imports (mainly gas) started to rise even before the start of Russian war against the Ukraine in February 2022. The contributions of energy imports led to an increase in inflation from mid-2021 onwards. From the third quarter of 2021 until the fourth quarter of 2022, energy imports contributed 2.7 percentage points to headline inflation on average. For the year 2022, the contribution amounts to 2.5 percentage points or 29 % of inflation (+8.6 %). In the first quarter of 2023, energy imports slightly dampened inflation.

The role of profits for inflation is determined both by the pandemic and by increasing energy prices. During the pandemic, they fell stronger than real output and dampened prices. Profits of the energy sector began to contribute to inflation from the third quarter

[28] Other profit measures to consider are the profit share (profits over value-added), the mark-up (profits over unit labor costs), profit margins (profits over total output) and the rate of return on capital (profits over the capital stock) (ECB, 2004). In addition to these profit measures derived from National Accounts, profit measures based on firm's data can provide additional insights.

of 2022 onwards. This implies a lag of one year to energy imports. This is a very plausible result, since contracts for conducted energy (electricity, gas and district heating) are usually adjusted once a year in Austria. The increase in the contribution of profits in the non-energy sector is to a large extend driven by the recovery after the pandemic. The strong positive contribution of 3.6 percentage points in the first quarter of 2022 originates from accommodation and food service activities (5.8 pp). This was partly offset by lower profits in trade and repair of motor vehicles, manufacturing, and services. In the fourth quarter of 2022 and the first quarter of 2023, profits in the non-energy sector outpaced profits in the energy sector in their role for inflation. Accommodation and food service activities accounted for two thirds of the non-energy sectors contribution in both quarters. Additional contributions mainly came from finance and insurance activities and construction.

Figure 6: Inflation contributions to headline HICP inflation



Source: Statistics Austria, OeNB calculations.

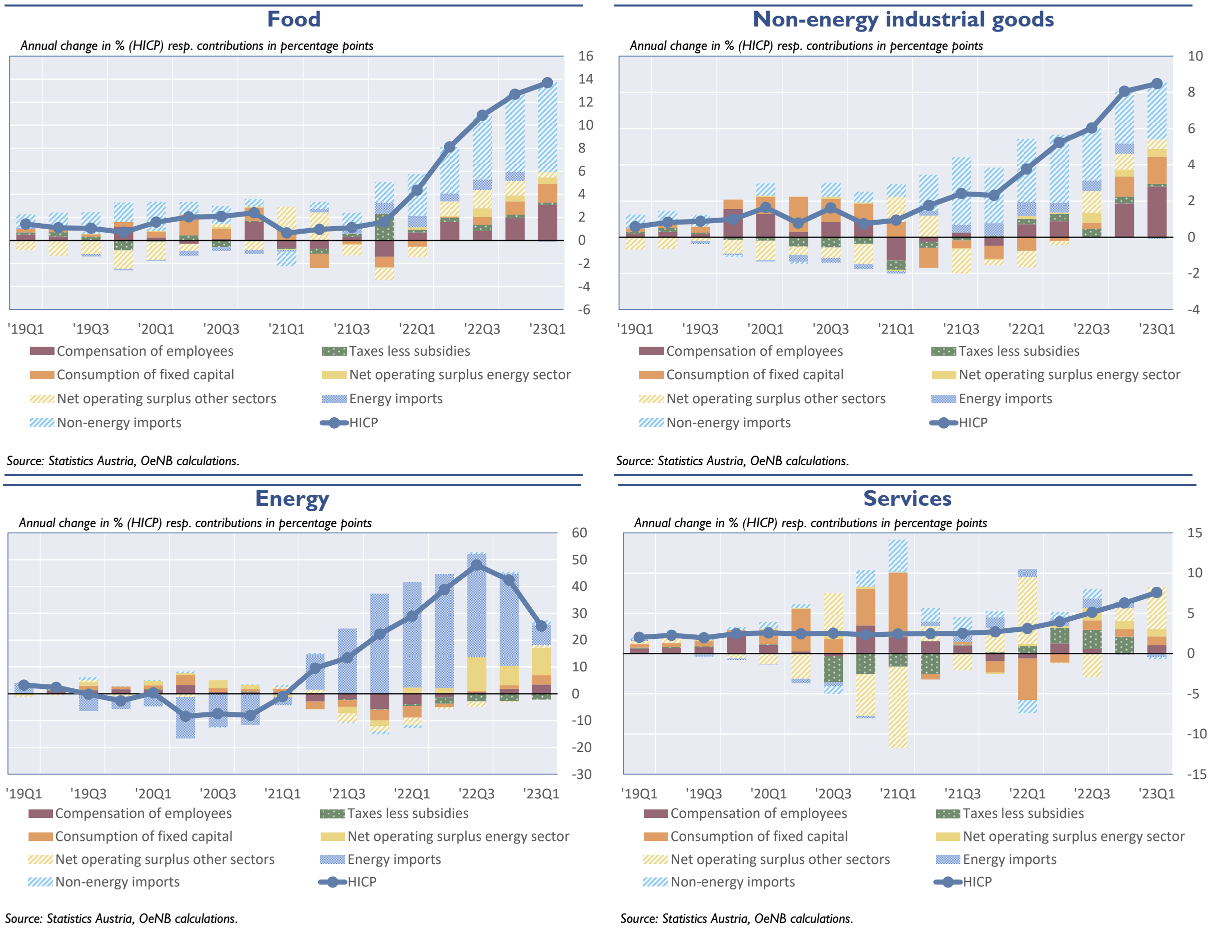
Taxes less subsidies also contributed to inflation. The VAT reduction dampened inflation for four quarters starting in the third quarter of 2020. In 2022, the suspension of the reduction contributed positively to inflation. Note that wages and profits have been adjusted for crises-related subsidies, which also eliminates the contributions of these subsidies.

Due to the delayed wage adjustment process that is common in Austria[29], there has been no substantial price pressure from wages in 2022. Wages contributed 1.3 percentage points or 15 % to inflation, which is clearly below the average cost share of wages of 27% (2019). In the fourth quarter of 2022 and the first quarter of 2023, the collectively agreed wage increases began to accelerate and lead to slightly higher wage contributions.

[29] The Austrian wage bargaining is characterized by wage leadership reached by the metal workers, setting a precedent for other sectors to follow. The outcome are staggered wages, which usually remain valid for one year (Knell and Stiglbauer, 2009).

In addition to the decomposition of headline inflation, we present the decomposition of the four special groupings to demonstrate the granularity of the approach in figure 7. The profile and the structure of inflation differ considerably between the groups. *Food* inflation rose significantly during the course of 2022, reaching 13.7 % in the first quarter of 2023. This was to a large extend driven by food imports, which explain more than half of food inflation. Profits in trade and repair of motor vehicles, agriculture and the energy sector also contributed to food inflation. The role of wages was below their cost share in 2022.

Figure 7: Inflation contributions for special groupings



The inflation profile and the determinants for *non-energy industrial goods* are similar to food. Imports are also the most important component, with imports of manufactured goods contributing most to inflation. The domestic contribution (especially of wages) is slightly higher than for food inflation.

Energy inflation peaked at 48 % in the third quarter of 2022, with energy imports explaining the bulk of inflation. Profits in the energy sector explain 13 % of energy inflation in 2022. The role of the different energy imports differs over time. Gas imports contributed most to inflation the fourth quarter of 2021 and the first half of 2022. The contribution of oil imports was more or less stable at 8 percentage points in the course of

2022. In the first quarter of 2023, energy inflation fell substantially due to the declining role of energy imports.

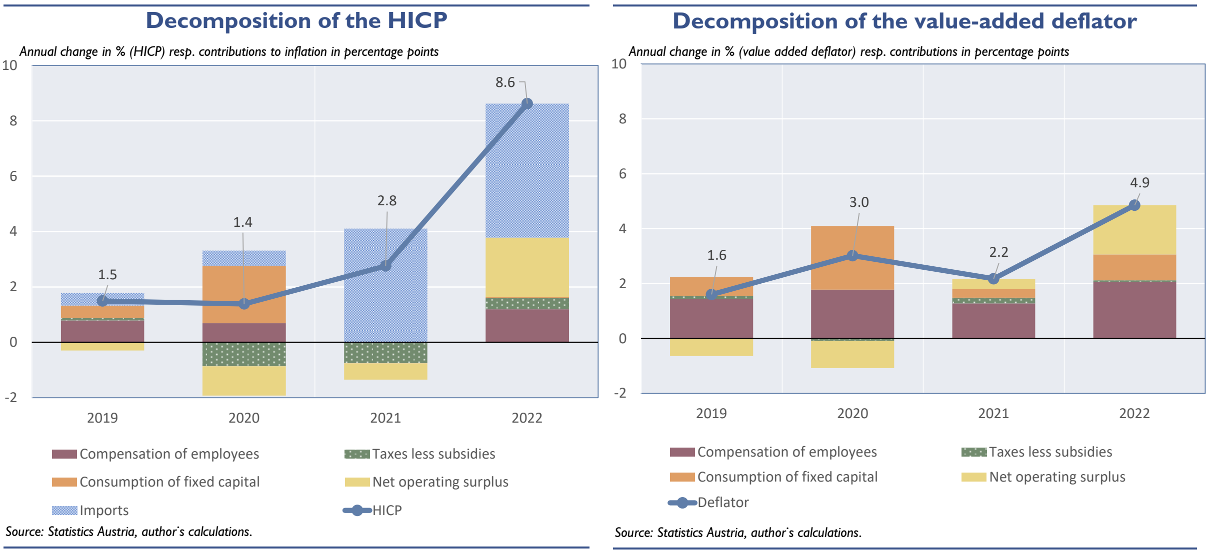
Services inflation exhibits a completely different profile and structure. Compared to headline inflation, it is lower and somewhat delayed. Its composition was more affected by the pandemic than for the other groups. This shows up in the contributions of profits from the non-energy sector. In the course of 2022, the suspension of the VAT reduction fuelled inflation. In the first quarter of 2023, profits in accommodation and food service activities contributed most to inflation, explaining 4.8 percentage points of services inflation of 7.6 %. Profits in finance and insurance services contributed 0.8 percentage points. Interestingly, the contribution of wages to services inflation was negligible.

9. Explaining the differences of the decomposition results between value-added deflator and HICP

In this section we compare the decomposition of the HICP with the decomposition of the value-added deflator. The decompositions differ due to five factors (figure 8). First, imports play an important role for the HICP, while they are not included in the value-added deflator. Second, taxes and subsidies on goods are not part of the value-added deflator.[30] The VAT reduction during the COVID-19 pandemic and its expiry as well as the reduction in energy taxes are therefore not included. Third, the sectoral compositions of the two price indices differ. The value-added deflator takes total value added of all sectors into account, while the HICP decomposition weights the sectors with their consumption shares from the IO analysis. As a result, public services, construction and manufacturing play a smaller role in the HICP. At the same time, the service sectors have a significantly higher weighting in the HICP. The differences in the cost shares of the HICP and the value-added deflator can be found in the right panel of figure 5. While compensation of employees and gross operating surplus (including consumption of fixed capital) have a similar share (26.9 % vs. 27.7 %) for the HIPC, the share of compensation of employees (54.3 %) is much higher than the share of gross operating surplus (43.8 %) for the value-added deflator. This results from the differences in the sectoral composition of the two price indices.

[30] Taxes less subsidies on production are part of the value-added deflator.

Figure 8: Comparison of the decomposition of the value-added deflator and the HICP



Fourth, the series ultimately used in the decompositions differ. Whilst we use exactly the same time series as input in the calculations, we proceed one additional step for the HICP-decomposition. This is the calculation of the consumption-implied cost components (section 5.2). The consumption-implied cost components show a different course than the original national accounts series, which are used for the deflator decomposition. Specifically, private consumption fell more sharply during the pandemic than the other demand components and grew more strongly during the upswing. The fifth factor is given by the fact that we use a different quantity to calculate the unit cost components. In the case of the value-added deflator, we divide by real value added. For the HICP, we divide by the real consumption good. Consequently, the profile of a unit cost component can differ between the two decompositions, even if the nominal cost component is identical.

Besides imports and taxes less subsidies on products, these factors result in huge differences regarding the relative role of wages and profits. Wages play a much stronger role in the decomposition of the value-added deflator. The main reason is the sectoral composition (see above). The weight of public services (which have a very high wage share) in the HICP is considerably lower than their share in total value added.

Another striking difference between the two decompositions is the opposite sign of the contribution of profits in 2021. For the value-added deflator, the contribution is positive, while it has a negative sign for the HICP. The reason is that real consumption grew stronger than real value added in that year, leading to the opposite sign of changes (and hence contributions) in unit profits.

10. Summary and conclusions

In this paper we have proposed a novel methodology for a production-side decomposition of HICP inflation based on national accounts data. By combining input-output data with quarterly national accounts data, HICP inflation can be decomposed at a granular level. We used the approach to analyze the inflation developments in Austria for the period from the first quarter of 2019 to the first quarter of 2023. In 2022, energy as well as non-energy imports were the most important contributors to inflation. Profits contributed to inflation from the second half of 2022 onwards, whilst there have been no substantial contributions from wages. We find that there are considerable differences in the inflation determinants between subindices of the HICP. Whilst imports played the main role for inflation of food, non-energy industrial goods and energy, they hardly contributed to services inflation. The results also clearly demonstrate how particularities like the lagged wage-bargaining process in Austria impact on inflation.

Compared to the results of the simple decomposition of the value-added deflator (which is often used as a proxy for the decomposition of consumer prices due to its simplicity), our approach has advantage that it provides an accurate picture of consumer price inflation. This includes the contributions of imports, taxes less subsidies on products (including the value-added tax) and detailed contributions of cost components by industries.

The results have a high policy relevance. For central banks, they allow to disentangle domestic and foreign determinants of inflation, which is of high relevance for monetary policy. They also can shed light on the role of distributional aspects between wages and profits and can provide valuable input into the annual wage bargaining rounds. Due to the breakdown of cost components by industry, they allow to discuss policy questions such as the role of sectoral profits for inflation in detail.

There are several avenues for *future research* in this area. Given the crucial importance of inflation for central banks, other central banks should aim to implement such a decomposition for their countries. If one wants to dig deeper and split up the contributions of unit cost components (e.g. unit labor costs) into a price and a productivity component, this can be done easily for cost components where price data are available (e.g. wages). Another way forward would be to decompose the contribution of a cost component into a “normal” component and an “excessive” component, which results from above-average growth of a cost component. This allows to better assess distributional aspects. Summing up, our decomposition approach provides new valuable insights and should not be missing in the toolboxes of central banks and other policy institutions.

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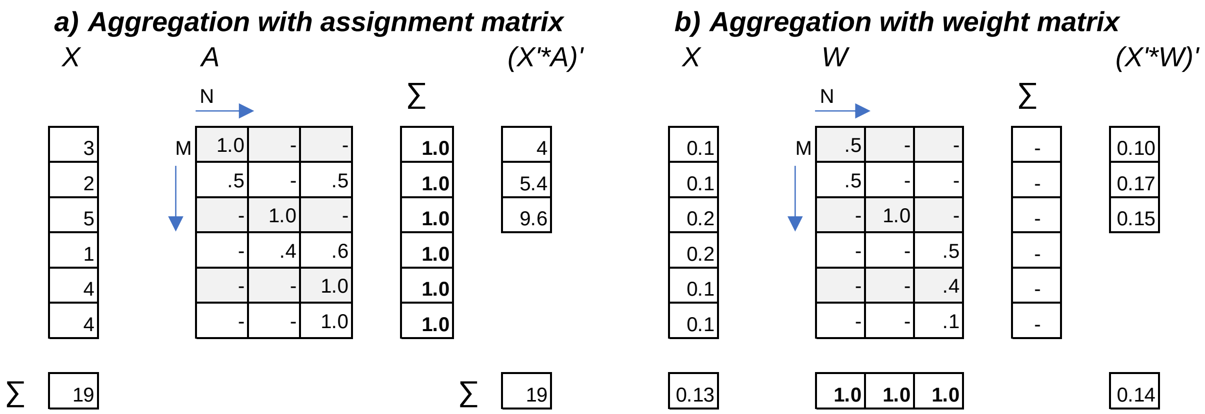
12. Appendix

A-1 Aggregation

Aggregation between different statistical classifications is a crucial part of this exercise. The best way to aggregate matrices or vectors is to set up an appropriate aggregation matrix for each aggregation. Therefore, it is important to understand the difference between two different aggregation matrices, which we name *assignment matrices* and *weight matrices*.

Assignment matrices are used for aggregations where variables in levels (e.g. imports in MEUR) are aggregated from a more granular to a less granular level (e.g. CPA-74 to SITC/BPM6-25). In this case, a CPA-74-import good is usually assigned to one SITC/BPM6-25 category by setting the value of the corresponding element of the assignment matrix to one. However, there can be occasions where one CPA-74 good is assigned to two or more SITC/BPM6-25 goods. In this case, the respective entries in the aggregation matrix must sum up to one. *In any case, the row sum of an assignment matrix must be one*. The left part of figure A-1 shows an aggregation with an assignment matrix. Note that the sum of the aggregated vector equals the sum of the original vector.

Figure A-1: Types of aggregation matrices



Weight matrices are a generalisation of weight vectors (e.g. HICP weights). The multiplication of a vector with a weight delivers a scalar number. *Their column sum of a weight matrix must be equal to one*, implying that the aggregate is a weighted sum of its components. We use these weight matrices to aggregate between different levels of the COICOP-classification. The right part of figure A-1 shows an aggregation with a weight matrix. Note that the mean sum of the aggregated vector does not have to equal the mean of the original vector.

A-2 Tables

Table A-1: Correspondence table from CPA-74 to COICOP-45 at purchasing prices

Table 25 **Final consumption expenditure by households ÖCPA x COICOP**

current prices, in 1000 € (at purchasing prices)

ÖCPA x COICOP		01.1 Food	01.2 Non-alcoholic beverages	02.1 Alcoholic beverages	02.2 Tobacco	03.1 Clothing	03.2 Footwear	…	12.5 Insurance	12.6 Financial services n.e.c.	12.7 Other services n.e.c.
01	Products of agriculture, hunting and related services	2772043	-	-	70946	-	-	…	-	-	-
02	Products of forestry, logging and related services	-	-	-	-	-	-	…	-	-	-
03	Fish and fishing products	166926	-	-	-	-	-	…	-	-	-
05-07	Coal a.lignite; crude petroleum a.natural gas; metal ores	-	-	-	-	-	-	…	-	-	-
08-09	Other mining a. quarrying prod.; mining support services	-	-	-	-	-	-	…	-	-	-
...								…			
45	*Wholesale- a. retail trade, repair of motor vehicles*	-	-	-	-	-	-	…	-	-	-
46	*Wholesale trade, exc. o.motor vehicles a. -cycles*	-	-	-	-	-	-	…	-	-	-
47	*Retail trade, exc. o.motor vehicles a. -cycles*	-	-	-	-	-	-	…	-	-	-
49	*Land transport services a. transport services via pipelines*	-	-	-	-	-	-	…	-	-	-
50	*Water transport services*	-	-	-	-	-	-	…	-	-	-
51	*Air transport services*	-	-	-	-	-	-		-	-	-
52	*Warehousing and support services for transportation*	-	-	-	-	-	-		-	-	-
53	*Postal and courier services*	-	-	-	-	-	-	…	-	-	-
	...							…			
65	Insurance, reinsurance and pension funding services	-	-	-	-	-	-	…	5756736	-	-
	...	-	-	-	-	-	-	…	-	333177	-
93	Sporting services, amusement and recreation services	-	-	-	-	-	-	…	-	-	-
94	Services furnished by membership organisations	-	-	-	-	-	-	…	-	-	113487
95	Repair services of computers, pers. a. household goods	-	-	-	-	88029	62459		-	-	-
96	Other personal services	-	-	-	-	94614	-		-	-	1100299
97	Services of households as employers of dom. personnel	-	-	-	-	-	-		-	-	-
	Total	**17680532**	**2150774**	**2722891**	**3789421**	**9181600**	**2218204**		**6073872**	**2500793**	**2108461**

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Table A-2: Correspondence table from CPA-74 to COICOP-45 at basic prices

Table 25 **Final consumption expenditure by households ÖCPA x COICOP**

current prices, in 1000 € (at basic prices)

ÖCPA x COICOP		01.1 Food	01.2 Non-alcoholic beverages	02.1 Alcoholic beverages	02.2 Tobacco	03.1 Clothing	03.2 Footwear	…	12.5 Insurance	12.6 Financial services n.e.c.	12.7 Other services n.e.c.
01	Products of agriculture, hunting and related services	1766450	-	-	45209	-	-	…	-	-	-
02	Products of forestry, logging and related services	-	-	-	-	-	-	…	-	-	-
03	Fish and fishing products	104431	-	-	-	-	-	…	-	-	-
05-07	Coal a.lignite; crude petroleum a.natural gas; metal ores	-	-	-	-	-	-	…	-	-	-
08-09	Other mining a. quarrying prod.; mining support services	-	-	-	-	-	-	…	-	-	-
	...										
45	*Wholesale- a. retail trade, repair of motor vehicles*	*170839*	*20199*	*24781*	*35637*	*93800*	*22449*		-	-	-
46	*Wholesale trade, exc. o.motor vehicles a. -cycles*	*1302219*	*185791*	*277745*	*392277*	*261937*	*49991*		-	-	-
47	*Retail trade, exc. o.motor vehicles a. -cycles*	*4329941*	*458250*	*478157*	*699666*	*3141853*	*773362*		-	-	-
49	*Land transport services a. transport services via pipelines*	*79624*	*6142*	*3079*	*5240*	*13302*	*2551*		-	-	-
50	*Water transport services*	*2748*	*212*	*106*	*181*	*459*	*88*		-	-	-
51	*Air transport services*	*1412*	*109*	*55*	*93*	*236*	*45*		-	-	-
52	*Warehousing and support services for transportation*	*34727*	*2679*	*1343*	*2285*	*5802*	*1113*		-	-	-
53	*Postal and courier services*	-	-	-	-	-	-		-	-	-
	...										
65	Insurance, reinsurance and pension funding services	2200	170	85	145	368	70		5756736	-	-
	...										
93	Sporting services, amusement and recreation services	-	-	-	-	-	-		-	-	-
94	Services furnished by membership organisations	-	-	-	-	-	-		-	-	113487
95	Repair services of computers, pers. a. household goods	-	-	-	-	88029	62459		-	-	-
96	Other personal services	-	-	-	-	94614	-		-	-	1100299
97	Services of households as employers of dom. personnel	-	-	-	-	-	-		-	-	-
	Total	**2150774**	**2150774**	**2722891**	**3789421**	**9181600**	**2218204**		**6073872**	**2500793**	**2108461**

Table A-3: Data needed for the decomposition

#	Sheet	Data	Unit of measure	Frequency	Dimension	Comment
	Input output data (data_IO.xlsx)					
1	Consumption data	Private consumption incl. Net taxes and margins	Nominal	**A**	74x8	
2	tab05	Final demand component at purchasing prices	Nominal	**A**	74x10	
3	tab16	Wholesale trade margins final demand	Nominal	**A**	74x10	
4	tab17	Retail trade margins final demand	Nominal	**A**	74x10	
5	tab18	Transport margins final demand	Nominal	**A**	74x10	
6	tab19	Product taxes, final demand	Nominal	**A**	74x10	
7	tab20	Subsidies of products, final demand	Nominal	**A**	74x10	
8	tab25	Mapping matrix ÖCPA 74 x COICOP 45	Nominal	**A**	74x45	
9	tab29	Input-output table, domestic production	Nominal	**A**	74x74	
10	tab30	Input-output table, imports	Nominal	**A**	74x74	
	Aggregtion matrices (data_aggmat.xlsx)					
1	74x13	Aggregation matrix from 74 NACE industries of input-output table to 13 industries of quarte	IO cost components (levels)		**74x13**	Assignment matrix
2	74x25	Aggregation matrix from NACE 74 goods to 25 SITC/BPM6 goods (for imports of intermedia	Imports of intermediate gooc		**74x25**	Assignment matrix
3	45x12	Aggregation matrix from 45 COICOP 3-digit goods to 12 COICOP divisions			**45x12**	Weight matrix
4	45x4	Aggregation matrix from 45 COICOP 3-digit goods to 4 COICOP special aggregates			**45x4**	Weight matrix
	Quarterly data data_QNA.xlsx)					
	HICP data					
1	HICP-M	HICP per COiCOP good	Index	M	Tx46	Headline and 45 COICOP 3-digit groups
2	HICP.CTR-M	HICP at constant tax rates per COiCOP good	Index	M	Tx46	Needed to calculate the inflation contributions of taxes on products
3	HICP.W-A	HICP weights	1	A	Tx45	
	Quarterly cost components					
4	B1G.R-Q	Gross value added per industry	Real	Q	Tx13	For decomposition of the value-added deflators; not needed for decomposition of HICP
5	B1G-Q	Gross value added per industry	Nominal	Q	Tx13	
6	D1-Q	Compensation of employees	Nominal	Q	Tx13	
7	Dx9X39.T-Q	Taxes less subsidies on production per industry - total	Nominal	Q	Tx13	Author's own compilation based on auxiliary data (tax data, data on subsidies)
8	Dx9X39.W-Q	Taxes less subsidies on production per industry - crisis-related wage subsidies (short-term	Nominal	Q	Tx13	---- "" -----
9	Dx9X39.P-Q	Taxes less subsidies on production per industry - crisis-related profit subsidies	Nominal	Q	Tx13	---- "" -----
10	Dx9X39.R-Q	Taxes less subsidies on production per industry - other taxes less subsidies	Nominal	Q	Tx13	---- "" -----
11	D31-Q	Subsidies on products per COICOP per good	Nominal	Q	Tx45	Author's own compilation based on auxiliary data
12	D21x31.ID-Q	Taxes less subsidies on intermediate goods	Nominal	Q	Tx1	Proxied by overall taxes less subsidies
13	P71-M	Imports of commodieties	Nominal	M	Tx13	Level of disaggregation can be choosen (1-….)
14	P72-Q	Imports of services	Nominal	Q	Tx12	Level of disaggregation can be choosen (1-….)
	Quarterly data used to calculate consumption-caused cost components					
15	Demand-Q	Final demand components	Real	Q	Tx11	
	Annual cata used for cross-checking					
16	B1G-A	Gross value added per industry	Nominal	A	Tx13	Not necessary, but we have used different sources for quarterly (Statistics Austria) and annual (Eurostat) data
17	B1G.R-A	Gross value added per industry	Nominal	A	Tx13	---- "" -----
18	B1G-A	Gross value added per industry	Nominal	A	Tx13	---- "" -----
19	D1-A	Compensation of employees	Nominal	A	Tx13	---- "" -----
20	Dx9X39-A	Taxes less subsidies on production per industry - total	Nominal	A	Tx13	
21	P51C-A	Consumption of fixed capital	Nominal	A	Tx13	Important for cross-check, since quarterly data has been estimated
22	B2A3N	Net operationg surplus	Nominal	A	Tx13	Important for cross-check, since quarterly data has been calculated as residual
	Data used for calculation of consumption of fixed capital (perpetual inventory)					
23	DEP-A	Consumption of fixed capital per industriy	Nominal	A	Tx13	
24	KSR-A	Capital stock per industry	Nominal	A	Tx13	
25	KSN-A	Capital stock per industry	Real	A	Tx13	
26	ITR-A	Gross fixed capital formation per industry	Real	A	Tx13	Historical data until 2021 has been projected until 2024
27	ITD-A	Gross fixed capital formation per industry	Deflator	A	Tx13	Historical data until 2021 has been projected until 2024
28	DEP.TOT-Q	Quarterly consumption of fixed capital for total economy	Nominal	Q	Tx1	Quarterly profile used to interpolate annual data to quarters with Chow-Lin method
29	Forec	Forecast of GFC and GFC deflator per industry	Real/Deflator	A	Tx13	Author's own forecast based on aggregate BMPE figures & judgement on sectoral distribution

Table A-4: Difference of the aggregation of quarterly contributions vs. aggregation of the cost components to the annual frequency (aggregation error)

	HICP	Compensation of employees	Taxes less subsidies	Consumption of fixed capital	Net operating surplus energy sector	Net operating surplus other sectors	Energy imports	Other imports
2022	0.0	-0.2	-0.1	-0.3	0.2	0.3	0.3	-0.3
2021	0.0	0.0	0.1	0.2	0.0	-0.9	0.2	0.3
2020	0.0	0.0	0.0	-0.1	0.0	0.4	0.0	-0.2

Source: Author's own calculations.

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