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Abstract

A recent discussion on the sources of inflation rise in the period 2022-2023 highlights the role of non-labor components of GDP deflator, calling them profits. The aim of our analysis is to measure profits more carefully, separating them from the cost of capital and to assess their contribution to changes of different measures of prices in the economy. We show that material costs (and especially the prices of materials) are the most important source of variation of gross output deflator, responsible for over 50% of its variance in the period 1997-2022. The role of profits in general, and after the pandemic in particular, differs between various price measures. They are contributing high to the increases of value added deflator in the period 2021-2023, whereas their contribution to gross output deflator is muted. Labor costs (of which wages are relatively more important than unit efficiency of hours) are an important contribution to both output and value added deflators. The contribution of capital is less important, with a more balanced contributions of capital price and unit efficiency. Moreover, we stress that the most attempts to assess the role of profits in the evolution of prices are based on approximate decompositions. We show that the contributions calculated without the approximation error indicate a lower, although still significant, contribution of profits to price increases in the period 2021-2022. We also present how the cost (or profit) components correlate with prices and we highlight the differences in the role of various components across industries.

Keywords: profits, capital costs, rental costs of capital, capital share, sources of inflation

JEL Codes: D24, E01, E22, E31

1 Introduction

After both post-pandemic disruptions in the Global Value Chains and the energy supply shock triggered by the Russian agression against Ukraine, many countries experienced considerable hikes in inflation rates. Central banks (see e.g. ECB, 2023; Haskell, 2023), international financial institutions (see Hansen et al., 2023) and economic comentators devoted considerable attention to a decomposition of changes in the value-added deflator into unit labor costs and a residual component called "unit profits", with the latter proved to be an important contribution to inflation in many countries (also in Poland). It raises a natural question: are profits a source of inflation? The aim of our analysis is to measure profits more carefully, separating them from the costs of capital and to assess their contribution to the variation of different measures of prices in the economy.

The OECD (2023) decomposed the GDP deflator of 15 countries and concluded that increases in unit profits, but also in unit labour costs help to account for the upturn in inflation, although to a different extent across countries. Extraordinary unit profits were also mentioned by central banks in their communication, see e.g. the interview of ECB executive board member Philip Lane with Reuters (see Lane, 2023). The conceptual framework which can be used to link profits to inflation is related to non-competitive pricing and the Phillips curve as a price setting relation of firms. A more recent and interesting theory of inflation is Lorenzoni and Werning (2023a), who showed that inflation can be derived as a manifestation of conflict (a disagreement about relative prices) between various economic actors. They showed the model where inflation (a general and sustained change in all prices) arises whenever economic agents, constrained by wage rigidities, adjust the prices which they control to influence relative prices in their own desired direction. It naturally introduces causality between profits and inflation.

Profits are defined in our study as the difference between revenues and costs that can be attributed to production factors, including capital. In the abovementioned discussions capital costs are not directly measured and the term "profits" includes additionally the remuneration of capital.[1] Sometimes, profit rate (defined as profits over sales) is interpreted as a proxy for (monopolistic) markups. However, these are related but distinct concepts - markups arise due to firms' monopoly power on markets for their outputs, resulting in profits, but profits may arise also due to other factors, like e.g. fixed costs. Moreover, Colonna et al. (2023) presented in a simple model with labor and material input that profit share can increase even if markups remain constant or diminish if only input costs grow faster than labour costs. Regarding USA, Glover et al. (2023) showed that indeed a rise of inflation was partially related to incresing markups, defined in a more proper way, consistent with De Loecker et al. (2020).

Our analysis addresses all of the the abovementioned issues in a formal way. First, we use the methodology laid out by Barkai (2020) and Comin et al. (2023) to measure profits. When one identifies the costs of capital, using rental price of capital and a capital stock (e.g. constructed with the perpetual inventory method), and accounting for mixed income and taxes, it is possible to distill profits from gross operating surplus, consistently with the discussion in Haskell (2023). It is worth mentioning that the methodology we apply does not allow to identify the economic sources of profits and how they are related to markups. Second, we use both value added and gross output deflators to stress the difference of the contribution of profits to the changes of prices, when one accounts for material costs in the price decompositions. This is in the spirit of the discussion in Colonna et al. (2023). On the other hand, the cost of materials includes profits generated by the suppliers, and the decomposition value added deflator helps to pin down the economy-wide role of profits. Third, we derive and compare the results of two distinct price decompositions. One of them is exact (without the approximation error) and allows to decompose prices into various unit cost (or unit profit) categories. As far as we know, this is the first paper showing this price decomposition method. The other method, commonly found in the

[1] Haskell (2023) stressed that the usual statistical definition of unit profits, which is based on the gross operating surplus, incorporates not only profits, but also costs of depreciation, income from housing or mixed income.

literature, is based on a total derivative and it allows to additionally distinguish between input price and unit efficiency in the case of production inputs with separately observed prices and quantities (like labor or materials). The drawback of the latter approach is the approximation error, which can be significant with large changes in the underlying cost categories. This is indeed the case in the recent periods.

We use the methodology outlined above for Poland, as an example of a country with relatively high increases of inflation in recent years. Most ot the results are presented for annual frequency of the data. The annual data cover the period 1996-2022, allowing to investigate both the recent period of high inflation, but also a specific to Poland period of economic transformation prior to its entrance to the European Union in 2004. Annual data also allow to decompose both output and value added deflators and to investigate the contribution of costs of materials to prices. We also present the decomposition of the value added deflator for quarterly frequency[2], which allows to present the results of the decomposition for the subsequent quarters of the year 2023.

Our analysis shows that the unit costs of materials contribute the most to the variance of gross output deflator in the period 1996-2022 and its contribution increased substantially in the year 2022. It is consistent with the evidence in Mućk and Postek (2023) and Szafranek et al. (2024), poiniting to disruptions in Global Value Chains and energy shocks as an important source of inflation in Poland after the COVID-19 pandemic. The prices of materials have a much more important contribution within the material costs, than the unit efficiency. Labor costs are also an important contribution to both output and value added deflator, of which hourly wages are again relatively more important than unit efficiency of hours. The contribution of capital is less important, with a more balanced contributions of capital price and unit efficiency. The contribution of profits is even smaller, with the exception of last periods, when it increased (although not to an extent suggested by the commonly used in the literature

[2] Material costs and gross output are not observed for the quarterly frequency.

contribution of a gross operating surplus). Profits are relatively more important for the evolution of value added deflator than for output deflator. It is related to the fact, that material costs in the decomposition of a gross output deflator includes also profits of the suppliers. The analysis for the subperiods showed that contrary to the previous episode of higher inflation, the role of profits in the inflationary period 2019-2022 was relatively high, but simultaneously it was twice as small as indicated by the contribution of gross operating surplus. Moreover, the discussion on the important contribution of profits in the price decomposition is based on a total derivative. We show that the contributions calculated without the approximation error indicate much muted contribution of profits to both measures of prices in recent years. We also present how the cost (or profit) components correlate with prices and we highlight the differences in the role of various components across industries.

The structure of the paper is as follows. The next section presents the details of the methodology allowing to measure costs of capital and profits using national accounts data. It also discusses the exact and approximate decompositions of prices using national accounts data. Then, we focus on measurement issues. The next section presents the results - the price decompositions fo the total economy and industries, together with a variance decomposition and a correlation analysis. The last part of the paper concludes.

2 Methodology

The aim of the paper is to disentangle the effects of materials, labor and capital costs, and unit profits for the evolution of prices. Before proceeding to the description of price decompositions, we start with the simple theory that allows to measure the cost of capital and profits from observables in the national accounts. We start with the measurement equation: $P_{i,t}Y_{i,t} = MAT_{i,t} + VA_{i,t}$, where $Y_{i,t}$ and $P_{i,t}$ is output in sector i in period t, and its price, $MAT_{i,t}$ denotes the cost of materials (intermediate consumption), and value added $VA_{i,t}$ is given by:

$$VA_{it} = LAB_{i,t} + GOS_{i,t} + TAX_{i,t}. \tag{1}$$

$LAB_{i,t}$ in equation (1) denotes the compensation of employees, $GOS_{i,t}$ is gross operating surplus (costs of capital, including depreciation, mixed income and profits), and $TAX_{i,t}$ are taxes (net of subsidies) on production.

The first part of this section presents a theoretical setup that follows Comin et al. (2023) and Barkai (2020). Then, we present various ways to decompose prices into cost components.

2.1 Theory - costs of capital and profits

We describe the economy as composed of I industries, indexed by i, each populated by identical firms with a Cobb-Douglas production function:

$$Y_{i,t} = Z_{i,t}K_{i,t}^{\alpha_{i,K}} H_{i,t}^{\alpha_{i,H}} M_{i,t}^{\alpha_{i,M}}, \tag{2}$$

where $K_{i,t}$ is capital (net of depreciation), $H_{i,t}$ denotes hours, and $M_{i,t}$ measures materials and components used in production, $Z_{i,t}$ measures productivity, and $\alpha_{i,j}$, where $J \in \{K, H, M\}$ is an output elasticity of a factor j. A representative firm within an industry i is a price-taker in input markets and it owns its capital.

Thus, its cost minimization problem is:

$$\min_{H_{i,t},M_{i,t},I_{i,t}} E_0 \left[\sum_{t=0}^{+\infty} \left(\prod_{s=1}^{t} \frac{1}{1+r_{i,s}} \right) \left(w_{i,t}H_{i,t} + P^M_{i,t}M_{i,t} + P^I_{i,t}I_{i,t} \right) \right] \tag{3}$$

subject to a production technology given by Equation (2) and the capital accumulation equation: $K_{i,t+1} = (1-\delta_{i,t})K_{i,t} + I_{i,t}$. $w_{i,t}$ represents hourly wage, $P^M_{i,t}$ and $P^I_{i,t}$ are prices of materials and investment good, respectively. $I_{i,t}$ is (gross) investment and $r_{i,s}$ is an industry-specific interest rate.

The optimality conditions are: $w_{i,t} = \lambda_{i,t}\alpha_{i,H}\frac{Y_{i,t}}{H_{it}}$ and $P^M_{i,t} = \lambda_{i,t}\alpha_{i,M}\frac{Y_{i,t}}{M_{it}}$ for hours and materials respectively, where $\lambda_{i,t}$ is a Lagrange multiplier associated with the production technology constraint (2). The Euler equation for the capital can be expressed as: $E_{t-1}(\frac{R_{i,t}}{1+r_{i,t}}) = E_{t-1}\left(\frac{1}{1+r_{i,t}}\left[\lambda_{i,t}\frac{\alpha_{i,K}Yi,t}{P^I_{i,t-1}K_{i,t}}\right]\right)$, where $R_{i,t}$ is the (gross) rental rate of capital,[3] given by the Hall and Jorgenson (1967) formula:

$$R_{i,t} = 1 + r_{i,t} - (1-\delta_{i,t})\frac{P^I_{i,t}}{P^I_{i,t-1}} \tag{4}$$

We are not interested in a short-term dynamics of the firm choices, but rather on the implications of this simple theory for the measurement of cost of capital and profits. So, we concentrate on a BGP solution[4] to problem (3). Additionally, we do not impose a zero-profit condition on the solution[5], so $\pi^*_{i,t} \neq 0$, and the asterisk denote the level of variables on a BPG path. Hence, $P^*_{i,t}Y^*_{i,t} = TC^*_{i,t} + \pi^*_{i,t}$, where $TC^*_{i,t}$ denotes total costs.

[3] In our problem, the firm owns the capital and decides how much to invest. Equivalently, firm can rent the capital $K_{i,t}$ prior to period t priced with $P^I_{i,t-1}$ at the rental rate $R_{i,t}$. A firm should not prefer any of these situations, so: $P^I_{i,t}I_{i,t} = R_{i,t}P^I_{i,t-1}K_{i,t}$.

[4] A Balanced Growth Path, BGP, is defined as a situation in which output, TFP and factor prices grow at a constant rate and the interest rate is constant.

[5] We are indifferent to the sources of profits in the economy. They can be due to firms' monopoly power, fixed costs or the inflexibility of the demand. We just allow for profits in equilibrium.

When we plugin the FOCs into the total cost equation we get:

$$TC^*_{i,t} = P^{M*}_{i,t} M^*_{i,t} + w^*_{i,t} H^*_{i,t} + \left((1 + r^*_i) P^{I*}_{i,t-1} - (1 - \delta_i) P^{I*}{}_{,i,t}\right) K^*_{i,t} = \tag{5}$$

$$P^{M*}_{i,t} M^*_{i,t} + w^*_{i,t} H^*_{i,t} + R^*_{i,t} P^{I*}_{i,t-1} K^*_{i,t}. \tag{6}$$

Moreover, on a BPG total costs coincide with marginal costs and $TC^*_{i,t} = \lambda^*_{i,t} Y_{i,t}$, so $\lambda^* = \left(1 + \frac{\pi^*_{i,t}}{TC^*_{i,t}}\right)^{-1}$. Comparing equations (1) and (5) it follows, that the gross operating surplus can be decomposed into:

$$GOS_{i,t} = R_{i,t} P^I_{i,t-1} K_{i,t} + \pi_{i,t}. \tag{7}$$

When we independently measure the the flow of services generated by the stock of capital, $CAP_{i,t} = R_{i,t} P^I_{i,t-1} K_{i,t}$, profits $\pi_{i,t}$ can be calculated residually from Equation (7). Thus, profits here are defined as the difference between revenues and costs that can be attributed to production factors, including capital. A similar approach to calculate profits was introduced by Barkai (2020). As the national accounts do not separate labor income from incomes of self-employed, our definition of profits includes mixed income. In principle, it is possible to extract labor income from mixed income, see e.g.Gollin (2002) or **?** for Polish case. However, the separation of capital costs from the incomes of self-employed is more challenging and we leave this for further research. Thus, when possible to extract mixed income from the gross operating surplus we treat it separately in our decompositions. In Poland mixed income is calculated only for the total economy, so the measure of aggregate profits in the empirical part does not include mixed income and the measures of sectoral profits do include them.

A similar logic of the model can be applied for output measured as value added and absent costs of materials among the cost categories. While the inclusion of materials and relaying on gross output is a natural modeling choice from the price-setting perspective, as described above, it has some drawbacks. The costs of materials consist of profits made by the suppliers of these materials. When one is interested in assesing the "final" contribution of profits to price changes in the total economy (analogous to the distoncion between the final and gross output), the calculation based on value added is better suited. Thus, in the empirical application we present both approaches.

2.2 Exact decomposition of the output deflator

After showing how to disentangle the capital cost and profits from gross operating surplus, we present two ways to calculate the contributions of various cost categories (and profits) to prices. Here, we describe the exact decomposition of output price dynamics, and the next section shows the approximate decomposition, allowing additionally to disentangle the price and quantity (efficiency) effects. The exact decomposition is, to our knowledge, a novel one in the literature.

The value of output in current prices is a sum of cost components, profits and texes: $P_{i,t}Y_{i,t} = MAT_{i,t} + LAB_{i,t} + CAP_{i,t} + \pi_{i,t} + MI_{i,t} + TAX_{i,t}$. Dividing by output in previous prices $P_{i,t-1}Y_{i,t}$ we get:

$$\frac{P_{i,t}Y_{i,t}}{P_{i,t-1}Y_{i,t}} = \frac{MAT_{i,t}}{P_{i,t-1}Y_{i,t}} + \frac{LAB_{i,t}}{P_{i,t-1}Y_{i,t}} + \frac{CAP_{i,t}}{P_{i,t-1}Y_{i,t}} + \frac{\pi_{i,t}}{P_{i,t-1}Y_{i,t}} + \frac{MI_{i,t}}{P_{i,t-1}Y_{i,t}} + \frac{TAX_{i,t}}{P_{i,t-1}Y_{i,t}}. \tag{8}$$

After some algebra we get the exact decomposition of the deflator of gross output into cost components:

$$\frac{\Delta P_{i,t}}{P_{i,t-1}} = \left(1 - \frac{P_{i,t-1}}{P_{i,t}}\right) \Big(\frac{MAT_{i,t}}{P_{i,t-1}Y_{i,t}} + \frac{LAB_{i,t}}{P_{i,t-1}Y_{i,t}} + \frac{CAP_{i,t}}{P_{i,t-1}Y_{i,t}} + \\ + \frac{\pi_{i,t}}{P_{i,t-1}Y_{i,t}} + \frac{MI_{i,t}}{P_{i,t-1}Y_{i,t}} + \frac{TAX_{i,t}}{P_{i,t-1}Y_{i,t}}\Big). \tag{9}$$

Equation (9) shows how to decompose the percentage changes in output deflator into a sum of various cost components. Annual data allows to disentangle all components in equation (9), except for mixed income in sectoral decompositions (it is then a part of residual profits). In quarterly data both taxes and mixed income are not separated from GOS in the Eurostat data, so they are attached to residual profits, except for total economy decompositions, where quarterly mixed income is observed and separated from profits (and profits are measured including taxes). Moreover, without the costs of materials the decomposition in (9) can be applied to value added (in this case $Y_{i,t}$ is value added and $P_{i,t}$ its deflator. In quarterly data only value added and its components are observed.

2.3 Approximate decomposition of the output deflator

The exact decomposition, introduced in section 2.2 allows to disentangle the cost categories and their contribution to price changes. In order to additionally account for price and quantity (efficiency) effects, one need to use a total derivative. The drawback of this approach is the approximation error.

Again, let's start with the measurement equation for output, now explicitly accounting for price and quantity effects in material, capital and labor costs: $P_{i,t}Y_{i,t} = P^M_{i,t}M_{i,t} + w_{i,t}H_{i,t} + R_{i,t}P^I_{i,t-1}K_{i,t} + \pi_{i,t} + MI_{i,t} + TAX_{i,t}$, where $P^I_{i,t-1}K_{i,t}$ is capital measured in the replacement costs of the previous period. Computation of the total derivative in the neighborhood of the current level of prices gives:

$$\frac{dP_{i,t}}{P_{i,t}} + \frac{dY_{i,t}}{Y_{i,t}} \approx \left(\frac{dP^M_{i,t}}{P^M_{i,t}} + \frac{dM_{i,t}}{M_{i,t}}\right)\frac{P^M_{i,t}M_{i,t}}{P_{i,t}Y_{i,t}} + \left(\frac{dw_{i,t}}{w_{i,t}} + \frac{dH_{i,t}}{H_{i,t}}\right)\frac{w_{i,t}H_{i,t}}{P_{i,t}Y_{i,t}} + \left(\frac{dR_{i,t}}{R_{i,t}} + \frac{d(P^I_{i,t-1}K_{i,t})}{P^I_{i,t-1}K_{i,t}}\right)\frac{R_{i,t}P^I_{i,t-1}K_{i,t}}{P_{i,t}Y_{i,t}} + \frac{d\pi_{i,t}}{\pi_{i,t}}\frac{\pi_{i,t}}{P_{i,t}Y_{i,t}} + \frac{dMI_{i,t}}{MI_{i,t}}\frac{MI_{i,t}}{P_{i,t}Y_{i,t}} + \frac{dTAX_{i,t}}{TAX_{i,t}}\frac{TAX_{i,t}}{P_{i,t}Y_{i,t}}. \quad (10)$$

After some basic algebra we can collect the terms and arrive at a relation:

$$\begin{aligned}\frac{dP_{i,t}}{P_{i,t}} \approx \frac{dP^M_{i,t}}{P^M_{i,t}}\frac{P^M_{i,t}M_{i,t}}{P_{i,t}Y_{i,t}} - \left(\frac{dY_{i,t}}{Y_{i,t}} - \frac{dM_{i,t}}{M_{i,t}}\right)\frac{P^M_{i,t}M_{i,t}}{P_{i,t}Y_{i,t}} + \\ + \frac{dw_{i,t}}{w_{i,t}}\frac{w_{i,t}H_{i,t}}{P_{i,t}Y_{i,t}} - \left(\frac{dY_{i,t}}{Y_{i,t}} - \frac{dH_{i,t}}{H_{i,t}}\right)\frac{w_{i,t}H_{i,t}}{P_{i,t}Y_{i,t}} + \\ + \frac{dR_{i,t}}{R_{i,t}}\frac{R_{i,t}P^I_{i,t-1}K_{i,t}}{P_{i,t}Y_{i,t}} - \left(\frac{dY_{i,t}}{Y_{i,t}} - \frac{d(P^I_{i,t-1}K_{i,t})}{P^I_{i,t-1}K_{i,t}}\right)\frac{R_{i,t}P^I_{i,t-1}K_{i,t}}{P_{i,t}Y_{i,t}} + \\ + \left(\frac{dMI_{i,t}}{MI_{i,t}} - \frac{dY_{i,t}}{Y_{i,t}}\right)\frac{MI_{i,t}}{P_{i,t}Y_{i,t}} + \left(\frac{d\pi_{i,t}}{\pi_{i,t}} - \frac{dY_{i,t}}{Y_{i,t}}\right)\frac{\pi_{i,t}}{P_{i,t}Y_{i,t}} + \\ + \left(\frac{dTAX_{i,t}}{TAX_{i,t}} - \frac{dY_{i,t}}{Y_{i,t}}\right)\frac{TAX_{i,t}}{P_{i,t}Y_{i,t}} \end{aligned} \tag{11}$$

Equation (11) shows how various cost components affect output prices.[6] First, the prices of materials, labor and capital (rental price $R_{i,t}$) affect output prices positively, with the magnitude determined by respective shares of cost category in nominal output. Second, quantities affect output prices as changes in real unit efficiencies (e.g. changes in Y/L in the case of labor). Moreover, higher efficiency translates into lower output price, with a magnitude given by its output share. Third, the other cost components that cannot be decomposed into price and quantity, affect prices positively, in per unit of output term (e.g. π/Y in the case of profits), again scaled by their output shares.

The remarks from section 2.2 concerning the treatment of mixed income and taxes in quarterly and annual data also apply here. The same holds true for the decomposition of the value added deflator instead of output deflator.

[6] In practice, prices here are measured as deflators of respective quantities.

3 Measurement

The main source of data are the industrial (with a 1-digit NACE disaggregation) national accounts datasets, taken from Eurostat. Regarding quarterly data, all variables are de-seasonalized and adjusted for calendar days (either by Eurostat, or using an automatic X-13ARIMA-SEATS procedure). The analysis covers the period 1996-2022 in case of annual data, and the period expands to 2Q2023 in case of quarterly data.

Labor income $LAB_{i,t}$ is measured in terms of annual hours worked $H_{i,t}$ (using Eurostat national accounts employment datasets) of employees. We do not include persons self-employed in the definitions of labor, as their income is a part of mixed income. The other variables used in price decomposition are directly observable in national accounts, except for variables measuring the costs of capital.

The cost of capital is defined as: $CAP_{i,t} = R_{i,t}P^{I}_{i,t-1}K_{i,t}$. First, the (net) fixed assets are measured in constant 2000 replacement costs ($P^{I}_{i,2000}K_{i,t}$) using the Perpetual Inventory Method (PIM). The beginning of period t productive assets of a class j in a sector i, $K_{i,j,t}$ accumulates according to:

$$K_{i,j,t+1} = (1 - \delta_{i,j})\, K_{i,j,t} + I_{i,j,t}, \tag{12}$$

where the the asset class j includes: 1) buildings and structures, 2) dwellings (assigned exclusively to section L - real estate services), 3) transport equipment, 4) machinery and other equipment, 5) land cultivation, and 6) intangible assets. Depreciation rates for individual productive assets, differing for NACE industries, $\delta_{i,j}$, were taken from the EU KLEMS, see **?**. Gross investments $I_{i,j,t}$ were downloaded from Eurostat industrial databases. Equation (12) applies to physical investment and capital, although in the data both are measured in monetary units. Equation (12) can be expressed as $K_{i,j,t} = K_{i,j,0} + \sum_{k=0}^{t-1}(1-\delta_{i,j})^k I_{i,j,t-(k+1)}$. Thus, it is possible to measure all physical quantities in monetary units when all quantities are multiplied by one price, $P^{I}_{i,j,0}$ for some base period $t = 0$.

Investments in the data are measured in chain linked 2005 volumes, thus we recalculated them to prices from the base year 2000 using the relative price $P^I_{i,j,2000}/P^I_{i,j,2005}$. The initial (net) values of capital for the base year 2000, were also taken from the Eurostat database of stocks of fixed assets by asset class and a sector of activity, and they were measured in the current replacement costs. Since the investment data also cover the pre-base period of 1996-1999, the PIM equation was applied backwards to reconstruct the measures of capital for this period. The resulting capital stocks in constant replacement costs of the year 2000 were aggregated across all assets classes. As the measurement of costs of capital used in Equation (7) requires the value of capital in the replacement cost from the previous year, we multiply the aggregated capital stock in constant replacement costs with the relative price $P^I_{i,t-1}/P^I_{i,2000}$.

The price decomposition in quarterly frequency requires quarterly capital stocks. Investment data in quarterly frequency is available only for the total economy, and we followed the above procedure using quarterly depreciation rates using a geometric interpolation. Industry-level quartely investments data for asset classes are unavailable and we interpolated annual capital series to quarterly frequency using GLS maxlog method of Chow and Lin (1971). It maintains both a consistency for the mean within a year, and a consistent aggregation to a total economy. The lower right panel of Figure 1 shows the growth rate of the capital stock (for quarterly frequency).

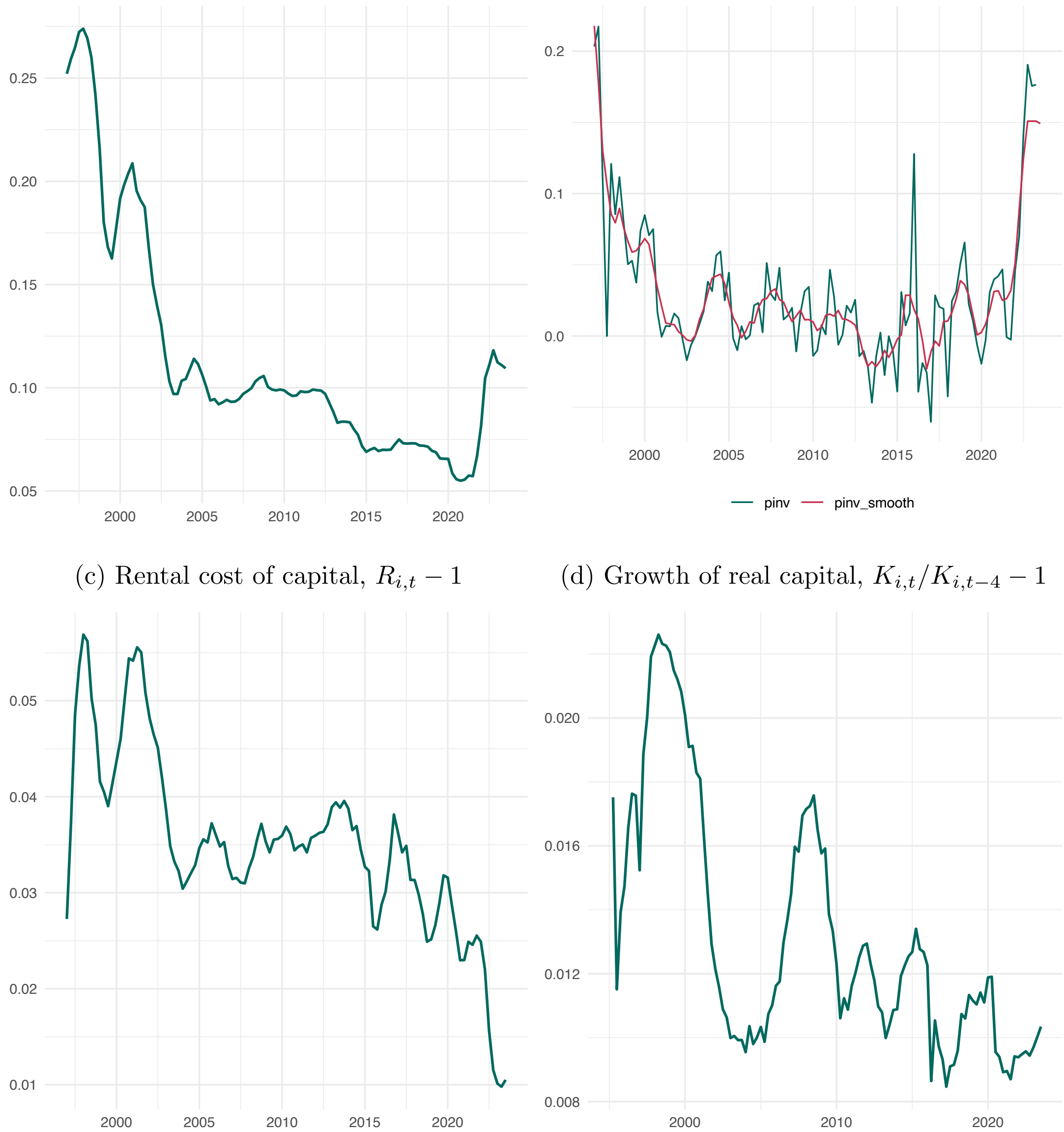
The rental cost of capital, $R_{i,t}$ (also referred to as a user cost of capital) was calculated using equation (4). Regarding quarterly data we use analogous rental rate, expressed in quarterly terms: $R_{i,t} = \left(1 + r_{i,t} - (1 - \delta_{i,t}) \frac{P^I_{i,t}}{P^I_{i,t-4}}\right)^{\frac{1}{4}}$. Due to the relatively high short-term volatility in quarterly data, the annual growth of investment prices was smoothed using a moving average with a window length of +/- 2 quarters (upper right panel of figure 1 plots both the raw adn smoothed annual investment price inflation).

The $r_{i,t}$ in equation (4) and its quarterly equivalent is measured as a weighted

Figure 1: Components of the cost of capital for the total economy

(a) Weighted Average Cost of Capital, $r_{i,t}$ (b) Growth of investment price, $P^I_{i,t}/P^I_{i,t-4}-1$

(c) Rental cost of capital, $R_{i,t}-1$ (d) Growth of real capital, $K_{i,t}/K_{i,t-4}-1$



Source: own calculations using Eurostat databases

average cost of capital (also referred to as WACC), given by:

$$r_{i,t} = r^{LT}_t + \frac{D_{i,t}}{D_{i,t}+E_{i,t}}\left(r^{CR}_t - r^{LT}_t\right) + \frac{E_{i,t}}{D_{i,t}+E_{i,t}}(ERP). \tag{13}$$

The WACC is a long-term interest rate, r^{LT}_t compounded by an average of a credit risk and equity risk premium (ERP), weighted with the structure of liabilities. r^{LT}_t is measured as the interest rate on 10-year government bonds (taken from Eurostat databases), available since 2001. For earlier periods, it was calculated using IMF data and ECB SDW databases.[7] Regarding quarterly data, the resulting series was intrapolated to quarterly frequency (in periods without quarterly data) using Chow and Lin (1971). As most of the external financing in the Polish economy is via the banking system, we use the average interest on enterprise loans, r_t^{CR} to measure the risk related to firms' liabilities. It as an average interest rate on loans to businesses (in local currency), derived from NBP's interest rate statistics.[8]

We use the estimate of Damodaran (2022) as a measure of equity risk premium for Poland, ERP. The share of liabilities $D_{i,t}$ and equity $E_{i,t}$ in assets of a sector i was calculated using the CompNet sectoral database (see CompNet, 2022), calculated for enterprises with more than 9 employees.[9] Regarding quarterly data, we use the GLS maxlog procedure from Chow and Lin (1971) to intrapolate variables to quarterly frequency.

The upper left panel of Figure 1 shows the time series of WACC for the total economy, whereas the lower left panel shows the resulting rental cost of capital, $R_{i,t} - 1$. It is worth noting that in the most recent quarters despite the rise in WACC (triggered mainly by an increase of nominal interest rates in the economy), the rental cost of capital (so the real cost of using capital from a firm's perspective) declined due to an abrupt increase of prices of investment goods of

[7] For the 1999-2000 period, we use the long-term real interest rate on government bonds published by the IMF in the Public Finances in Modern History Database (code: RLTIR), converted to nominal terms using the current inflation rate from the World Economic Outlook database (code: PCPIPCH). For the 1995-1998 period, for which there are no measures of interest rates on government long-term debt instruments, we use as a proxy 3-month money market interest rates from the ECB IRS database (code: IRS.M.PL.M.L20.MC.0000.PLN.N.Z), corrected by the average spread with the IMF long-term rate for the overlapping period 1999-2004.

[8] For the period starting from 2005, we use the average interest rate on total loan balances for non-financial enterprises. Due to a change in the methodology, we use the weighted average interest rate on loans in local currency to enterprise sector for the period March 2002-December 2004, adjusted with the average spread for the overlapping period of 2005-2006 (amounting to 0.16 pp.). For the earlier period, March 1999-February 2002, we use the average (over all maturities) interest rate for loans in local currency to the enterprise sector. Finally, for the earliest period (December 1998-February 2002), we use the average of loans with maturity of one, three and over five years, all adjusted by the abovementioned spread.

[9] We use variable with code: FR09_equity_ta_mn to measure equity-to-asset ratio. We use the economy wide-averages in the case of industries absent in CompNet databases, and last (or first in the case of distant years) observations to extrapolate data for out-of-sample periods (the industry-level structure of liabilities is relatively stable in time).

the magnitude comparable to consumption good inflation.

The profits, $\pi_{i,t}$ are calculated residually from gross operating surplus. In annual data we can distinguish all components in equation (9), except for mixed income in sectoral decompositions (it is then a part of profits). In quarterly data both taxes and mixed income are not separated from GOS, so they are attached to residual profits, except for total economy decompositions, where quarterly mixed income is observed and separated from profits.

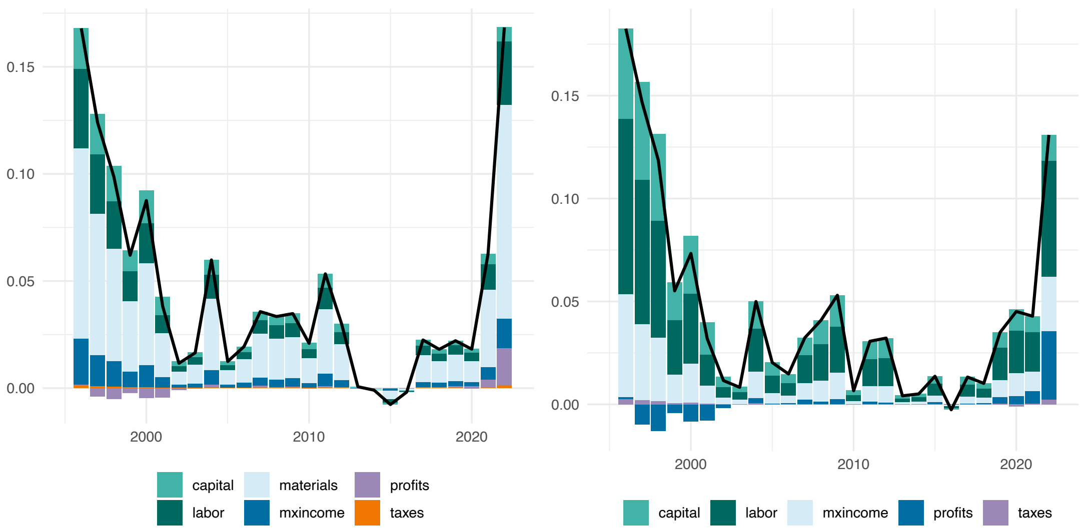
Figure A.1 in the Appendix show the shares of the nominal costs of production factors, taxes and profits in the nominal output and value added. The shares of materials, labor, taxes and mixed income are directly measured in the national accounts data, so profit and capital shares are the most interesting. The mean capital share in output amounts to 13% and has been declining since year 2013. The share of profits is close to zero on average. The profit share was negative till the year 2004, then it fluctuated around zero and have increased since 2016 to approximately 10% in the year 2022. The share of cpaital costs and profits in value added is 13% and 0%, respectively.

4 Price decompositions for the total economy

Figure 2 shows the results of the exact decomposition of both output and value added deflators, calculated with annual data covering the period 1996-2022. Intermediate consumption (materials) are the most important component of output deflator in all periods, but especially in 2022. The variance decomposition[10], calculated for the period 1996-2022, indicates that 55% of variance of output inflation is due to materials (see Table 1, column 'exact'). Labor is the second important component (explaining 21% of price volatility), also in the last periods. Interestingly, price variation due to capital costs is small, similar in magnitude to mixed income (the contribution to overall variance of both components is close to 10%). The contribution of profits to the variance of prices is only 2.5%, but it is relatively large in 2022. Changes in taxes are negligible for the evolution of output prices.

Figure 2: Exact decomposition of growth rates of output and value added deflators

(a) Gross output deflator $\frac{P_t^Y}{P_{t-1}^Y} - 1$ (b) Value added deflator $\frac{P_t^{VA}}{P_{t-1}^{VA}} - 1$



Source: own calculations using Eurostat databases

[10] Variance decomposition appplied for the price decompositions is based on a formula $Var(\sum_{i=1,...N} c_i x_i) = \sum_{i=1,...,N} \sum_{j=1,...,N} c_i c_j cov(x_i, x_j)$, where we assigned the covariances equally into components due to corresponding variables.

When we look at the evolution of inflation through the value added deflator, the story differs substantially. Labor is the most important component, accounting for 47% of variance of VA deflator in the period 1996-2022. Again the contribution of capital and mixed income are comparable and are both close to 25%. On average, the contribution of profits and taxes is close to 1.5% each. In 2022 most of the contribution that is assigned to gross operating surplus in the literature, is indeed due to profits and the contribution of capital costs is much smaller. The latter is due the evolution of capital costs - despite the rise of WACC, the accompanying surge of investment prices drives down the rental cost of capital, which combined with low growth rate of the stock of capital, results in a low contribution of costs of capital to both output and VA deflators (for details, see Figure 1 and Figure 3).

Table 1: Variance decomposition of gross output and value added deflators [in %], 1996-2022

		P^{GO}		P^{VA}	
cost	effect	exact	approx.	exact	approx.
capital	total	10.1	12.9	25.1	56.4
capital	price	-	5.8	-	31.1
capital	efficiency	-	7.1	-	25.3
hours	total	20.6	9.2	46.7	31.7
hours	price	-	14.5	-	33.6
hours	efficiency	-	-5.2	-	-1.9
materials	total	55.2	62.3	-	-
materials	price	-	58.2	-	-
materials	efficiency	-	4.1	-	-
mxincome	total	10.9	3.7	25.3	13.9
profits	total	2.5	-0.9	1.4	-25.7
taxes	total	0.7	2.8	1.5	2.0

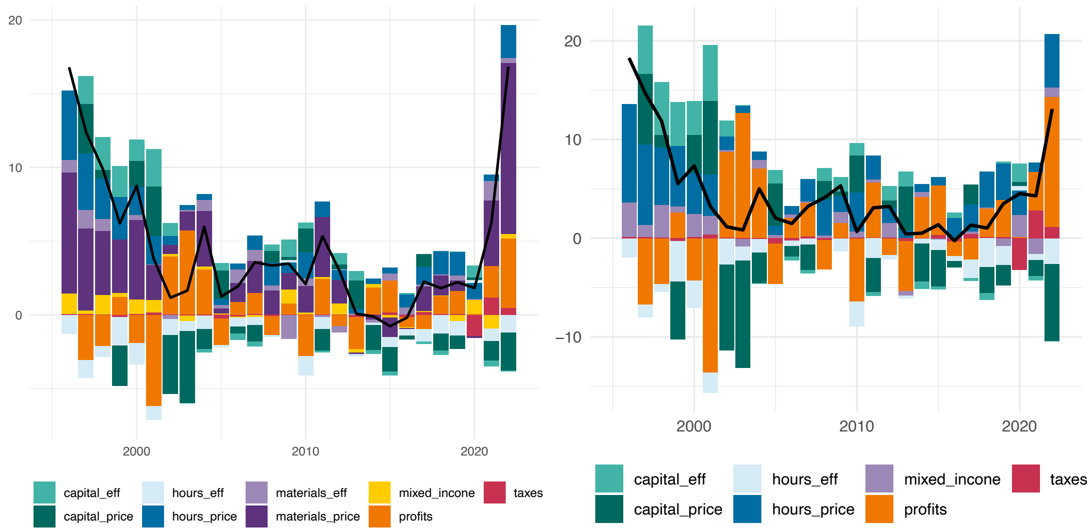
Remarks: In applicable cases of approximate decomposition the total in column 'effect' is additionally split into price and efficiency components. The numbers are in percent and totals sum up to 100%. The negative contribution are due to sizable and negative covariance components, attributed to a cost category.

The comparison of both figures shows the importance of costs of materials for the evolution of prices after the COVID-19 pandemy. Output deflator started to rise substantially in 2021, and the increase originated in rising costs of materials. Mućk and Postek (2023) pointed at the important role of disruptions in Global

Value Chains for the aggregate inflation in Poland, in particular for the post-pandemic period. [11] These shocks are transmitted to the economy through the costs of materials. However, the rise of value added deflator in 2021 was limited. Only in 2022, the even higher increase of costs of materials, including an exceptional rise of energy costs, translated into a much larger rise of both labor costs and profits. The increase of capital costs was contained due to a decrease of the rental cost of capital. A left panel of Figure 4 shows a similar decomposition of a value added deflator using quarterly data (data availability does not allow to decompose output deflator for the quarterly frequency), up the 2Q2023. It shows that after a peak in 4Q2022, VA deflator started to decrease, due to slightly lower contribution of all components, but mainly profits.

Figure 3: Approximate decomposition of growth of output and value added deflators

(a) Gross output deflator $\frac{P_t^Y}{P_{t-1}^Y} - 1$ (b) Value added deflator $\frac{P_t^{VA}}{P_{t-1}^{VA}} - 1$



Source: own calculations using Eurostat databases

Figure 3 shows the results of the approximate decomposition, calculated using by the equation (11). It allows to additionally decompose the production factors into price and unit efficiency effects[12], and Table 1 (columns 'approx.')

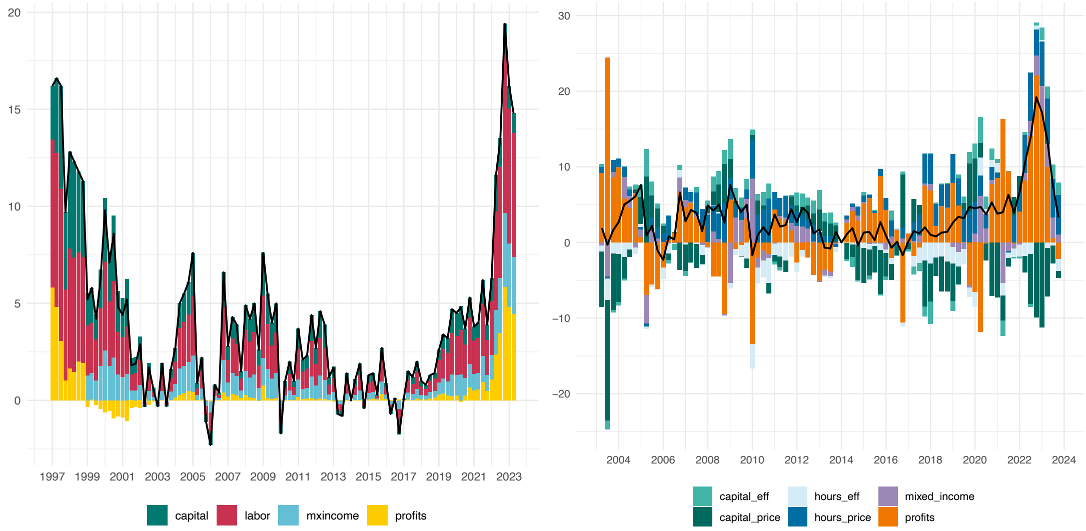
[11] Similarly, Szafranek et al. (2024) showed that external shocks played a major role in explaining inflation in Poland since the COVID-19 pandemic.

[12] The drawback of this approach is an approximation error which increases with the mag-

shows the result of a variance decomposition of price changes. The approximate decomposition puts less weight on labor costs and mixed income in the variance decomposition and increases the contributions of capital (especially in the decomposition of value added deflator) and materials.

Figure 4: Exact and approximate decompositions of annual growth of value added deflator - quarterly data

(a) Exact decomposition $\frac{P_t^{VA}}{P_{t-4}^{VA}} - 1$ (b) Approximate decomposition $\frac{P_t^{VA}}{P_{t-4}^{VA}} - 1$



Source: own calculations using Eurostat databases

The approximate decompositions confirms the dominant contribution of materials to chnages in output prices in the period 1996-2022, and indicates that most of the variation in this component originates in the prices of materials. Moreover, most of the contribution of labor costs to both gross output and value added deflators originates in the variation of hourly wages. Regarding the costs of capital, different results emerge in the decomposition of value added and output prices. The contribution of capital costs to volatility of value added prices exceeds 50% and is quite evenly distributed between prices and unit efficiency, with a slightly larger contribution of the former. Variation in capital unit efficiency

nitude of changes. Thus, it is especially evident for the last years, with large price changes. We spread out any approximation error proportionally across all the components. Figure A.2 in the Appendix shows the extent of the approximation error, for both annual and quarterly cases.

is on the contrary more important in the decomposition of output prices. Contrary to the exact decompositions, approximate decompositions put relatively more weight on capital costs than on labor costs in the variance decomposition. Moreover, approximate decompositions attach negative contribution of profits to prices (due to its highly negative comovement with the other cost components), although the visual inspection of both panels of Figure 3 and the right panel of Figure 4 shows that the contribution of profits to year-on-year proce changes is quite high, especially after 2020.

It is worth emphasizing that the highly discussed large contribution of unit profits to value added deflator in the 2022-2023 is mostly based on approximate decompositions. These decompositions are depicted in the right panels of both Figures 3 and 4, and they both show a very high contribution of profits to a value added deflator in this period. However, at least in Poland, the contributions calculated without the approximation error (with an exact decomposition, see both the right panel of Figure 2 and the left panel of Figure 4) show a more muted contribution of profits in the period 2022-2023. It is also worth noting that the labor costs seem to played much bigger role in the exact decompositions than in approximate ones. Moreover, accounting for materials and measuring prices as output deflator puts material costs at the most important component of price changes in all periods, also in the period 2022-2023.

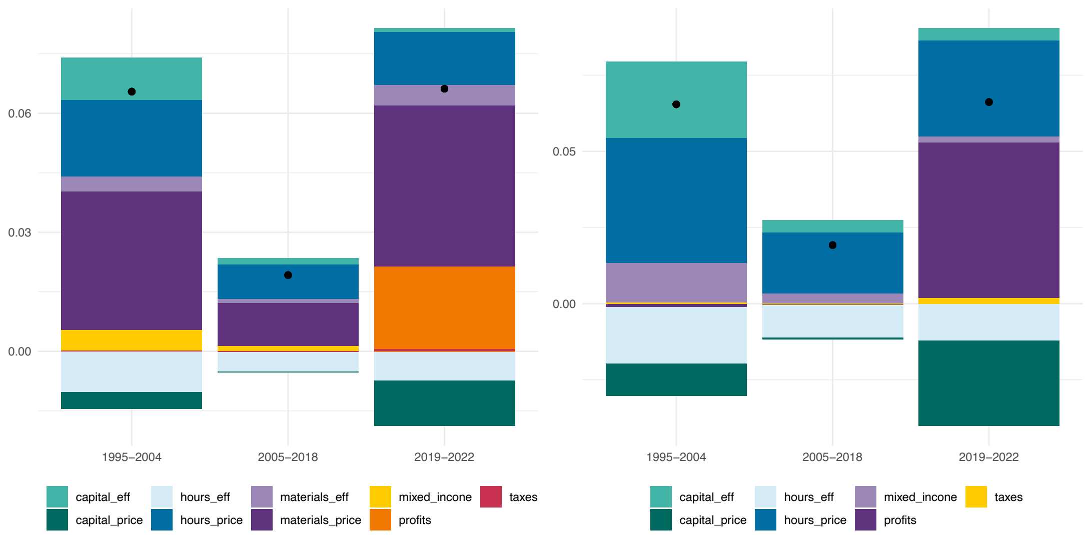
Note, that inflation is defined as a change of an index of consumer prices. Both value added and output deflators are alternative indices of economy-wide prices. Still, when measuring consumer prices, we refer to the prices of specific goods and from the cost perspective they consists of all the costs of producing that goods and the profits realized by the producer. However, the value added deflator is a specific construct, containing directly only the costs of the primary factors of production (labor and capital), taxes and profits, exclusive of materials and intermediates. Thus, the value added deflator reflects only inasmuch information about material costs as is reflected in the current costs of the primary factors of production and profits. This remark is important in the context of the source of inflation. If the price increases originate in e.g. wage increases, then on impact both output and value added deflators increase (the latter should increase more as the labor share in value added in higher than the labor share in output). However, the reaction of both deflators can differ if the price increase originates in rising material costs, either as a result of disruptions in value chains, as suggested by Mućk and Postek (2023), or rising energy prices, as highlighted by Sokolowski et al. (2022). In these situations the output deflator should react immediately, as it directly include material costs, but the reaction of value added deflator can be muted on impact, as it reflects only the extent to which rising prices of intermediates translate into prices of primary production factors and profits. Moreover, given the rigidities in wages, the immediate reaction of labor costs can be muted, translating into relatively high increases of profits (and costs of capital). However, when time passes the contribution of labor costs, and wages in particular increases (if the shock was important from the macroceconomic perspective), as real wage needs to rebuild. This story is consistent with Figures 2-4 and it is also highlighted in Lorenzoni and Werning (2023b). Moreover, the reaction of value added deflator will be lagged compared to the reaction of output deflator, which is also depicted in Figures 2 and 3.

4.1 Medium term tendencies

Figure 5 shows the approximate decomposition of annual growth of both gross output and value added deflators, cumulated into three distinct subperiods. The first subperiod, covering years 1995-2004, corresponds to the transition period before the entrance of Poland to the European Union in 2004. The second subperiod, covering years 2005-2018, corresponds to a stable and relatively low inflation of both output and value added deflators. The last period, starting in 2019, covers various shocks resulting in higher inflation of both price indices. It is striking that wages (prices of hours worked) contribute in a relatively stable way to the growth of both deflators in all three subperiods. It reflects the fact that wages have an increasing tendency and steadily contribute to inflation. More-

Figure 5: Approximate decompositions of cumulated growth of output and value added deflator in periods 1995-2004, 200-2018, and 2019-2022

(a) Gross output deflator (b) Value added deflator



Source: own calculations using Eurostat databases

over, the second component related to labor, hours efficiency (hours per output), contribute steadily to the growth of prices in all three periods, but the contribution is negative. The prices of materials are the common factor, contributing significantly to high growth of gross output deflator in both subperiods 1995-2004 and 2019-2022. It is related to the fact that during high inflation episodes all prices of in the economy, both for final goods and intermediates, are increasing. What is distinctive for the inflation rise in the period 2019-2022 is the significant contribution of profits to the growth of both gross output and value added deflators. On the contrary, the role of profits in the transition period 1995-2004 was negligible and instead inflation was significantly and positively affected by the efficiency of capital (and to a lesser extent by mixed income). Both periods of high inflation were additionally accompanied by a negative contribution of capital price, which is related to changes in the stance of monetary policy.

It is also worth to stress how treating gross operating surplus as as proxy for profits biases the assessment of the contribution of profits in the growth of prices. The exact decomposition shows that in the period 2019-2022 the contribution of gross operating surplus (net of mixed income and taxes) to the average growth of value added prices (which amounts to 6.35%) was 2.12 pp., whereas the contribution of profits is just 1.15 pp., half the size. Similar proportion emerges from the approximate decompositions of both measures of prices in the economy.

4.2 Correlation with prices

Additional insights on the role of various costs components in the evolution of prices may be read from a correlation analysis. Figure 6 presents the rolling correlations[13] of cost components (and profits) and output price in the exact decomposition of output prices. Moreover, Figure 7 presents the cross correlations of cost components and profits (lagged/lead of up to -/+ 2 years) with current output prices. The contemporary correlation of capital costs with output prices is slightly negative and tends to decrease in recent years. A positive correlation are observed for positive leads, on average, suggesting that the capital costs tend to follow output price changes. Labor costs are positively, contemporaneously and significantly correlated with output deflator and the correlation seems to be relatively stable in recent years. Material costs are also significantly and positively correlated with output deflator (contemporaneously). The correlation tend to increase, and is close to unity in recent years.

On average, profits are positively correlated with output deflator, but the correlation coefficient is small. The rolling correlations show that the contemporaneous correlation is not homogeneously spread in time and it increased considerably in periods close to year 2008 and in recent years, which is clearly visible in the left panel of Figure 2. The correlation of mixed income and taxes with output prices is moderate and rather tends to follow than lead prices, especially in the case of mixed income. In recent periods the correlation of mixed income with output price tends to get smaller.

[13] We use a 10-years length of window. The results are qualitatively similar with the window size of 8-12 years.

Figure 6: Rolling correlations with output deflator

Source: own calculations using Eurostat databases

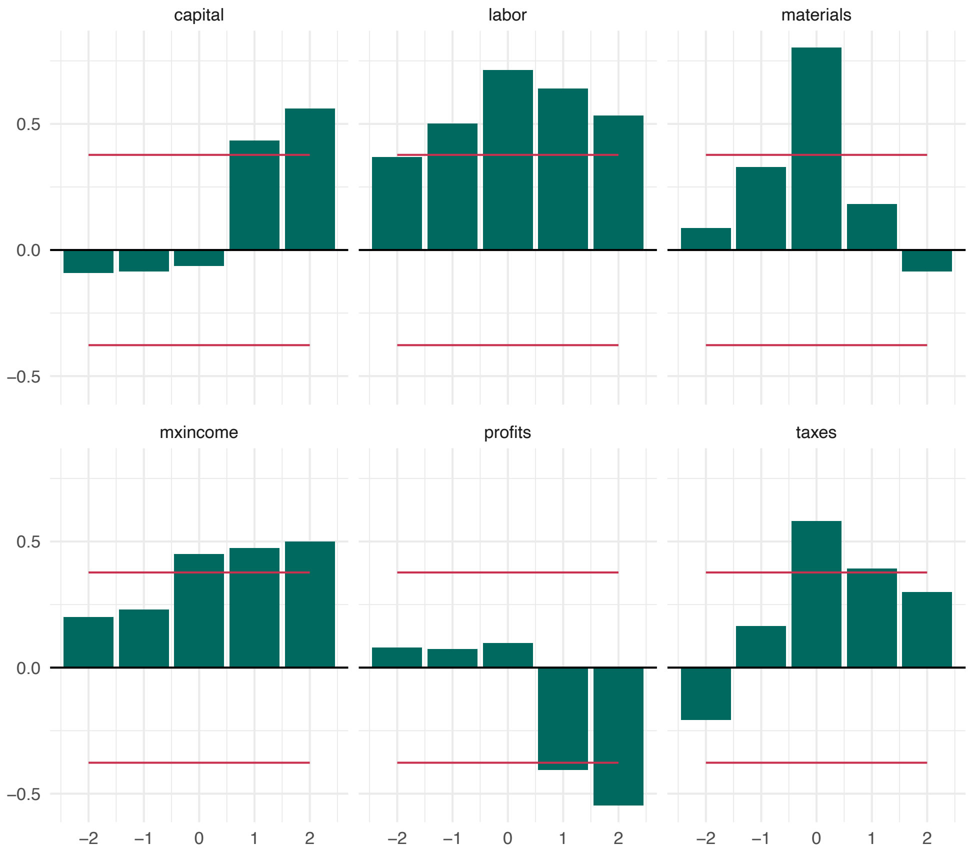
Remarks: correlations based on a rolling 10-years windows with a year on a horizontal axis indicating year in the middle of the window. Red lines mark a 95% significance band.

4.3 Sectoral decomposition

Our methodology allows to perform both decomposition on a industry level. Although the national accounts data are published by Eurostat at almost full 2-digit NACE disaggregation, the investment and capital data for Poland are available only for 1-digit NACE industries. Thus, we present the results at this disaggregation level.

Figure 8 presents the exact decomposition of industries output deflators, whereas Table 2 shows the variance decomposition of industrial output deflators. Material costs tend to have a dominant contribution to prices in most industries, notably in manufacturing, energy generation, but also in some services like science or administering. Labor costs are especially important in mining, utilities, and in most public services. Capital costs do not have a sizable contribution

Figure 7: Cross-correlations with output deflator

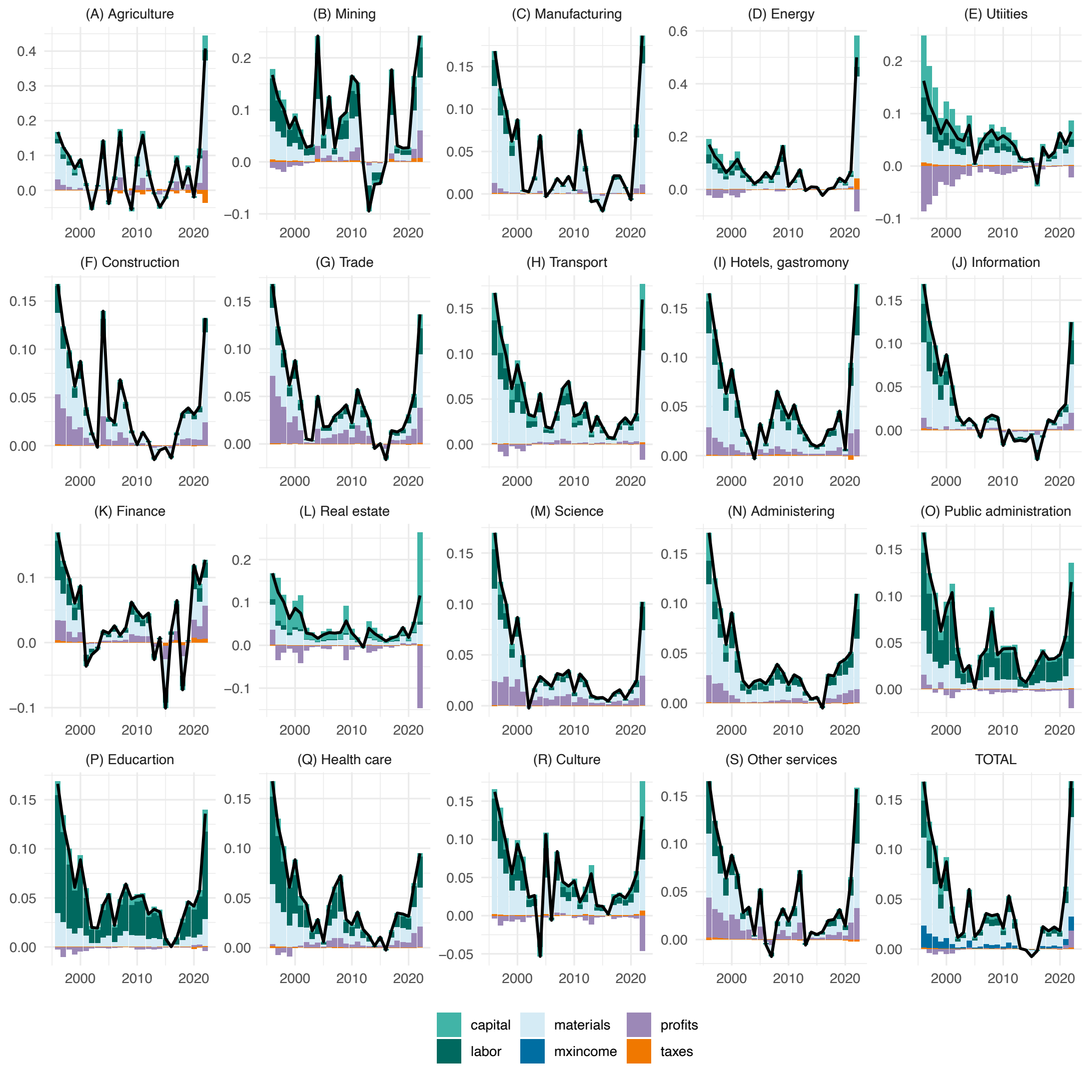


Source: own calculations using Eurostat databases
Remarks: the numbers on the horizontal axis denote the years of lag (negative) or lead (positive) years for a cost component.

to the variance of output prices in most industries, except for utilities and real estate. Similarly, profits are not very important component of price variation in most industries, but its contribution is particularly important in agriculture, construction, trade and finance. Taxes do not have a significant impact on price variation in any industry.

Figure 8 shows that the considerable increases of output deflators in the years 2021-2022 was present in almost all industries, and these upswings were mainly due to rising contributions of material costs. It was especially evident in agriculture, manufacturing, energy, construction, transport, gastronomy and information. Labor costs were also contributing positively to higher output prices in many industries, but it was a dominant factor only in some services, like

Figure 8: Exact decomposition of growth of the output deflators $(\frac{P^Y_t}{P^Y_{t-1}} - 1)$ in 1-digit-NACE industries



Source: own calculations using Eurostat databases

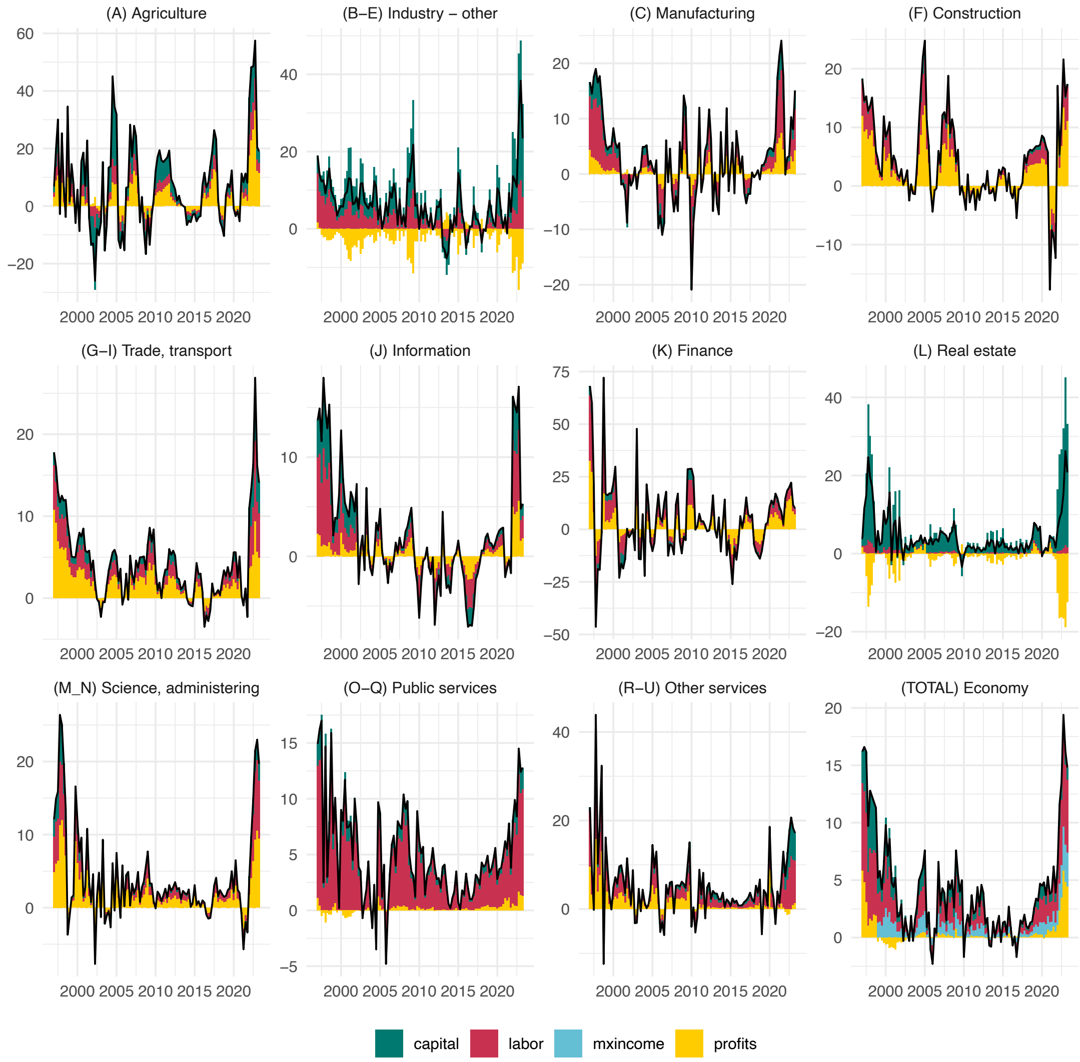
education or public administration. The costs of capital were an important driver of prices increases only in some industries (energy, transport, real estate and culture). Rising profits were significant in the case of agriculture, trade, hotels and gastromony, finance, science, but simultaneously in real estate, transport, utilities, public administration and culture they contributed negatively to price increases. Figure 9 presents the results of the exact decomposition of sectoral quarterly value added deflators, at the feasible level of disaggregation.

Table 2: Variance decomposition of sectoral gross output deflator [in %], 1996-2022

NACE code	materials	labor	capital	profits	taxes
(A) Agriculture	63.0	7.7	11.3	24.8	-6.8
(B) Mining	41.4	32.4	13.9	10.0	2.3
(C) Manufacturing	72.0	15.1	5.7	6.7	0.4
(D) Energy	74.8	8.8	13.7	-4.6	7.1
(E) Utilities	47.2	28.6	71.3	-50.7	3.6
(F) Construction	56.3	15.0	2.5	25.5	0.6
(G) Trade	42.8	15.3	2.6	38.7	0.5
(H) Transport	60.0	21.3	15.9	2.2	0.7
(I) Hotels, gastromony	56.8	19.2	4.5	19.8	-0.2
(J) Information	50.9	24.5	14.7	9.1	0.8
(K) Finance	39.2	27.2	8.2	22.0	3.3
(L) Real estate	35.9	8.0	46.3	8.8	1.0
(M) Science	51.0	20.8	8.7	19.3	0.3
(N) Administering	51.4	15.3	15.2	17.7	0.3
(O) Public administration	29.0	52.2	13.8	4.6	0.3
(P) Educartion	20.2	70.8	9.0	-0.2	0.4
(Q) Health care	36.4	51.3	11.3	0.1	0.9
(R) Culture	53.4	34.9	12.6	-2.7	1.8
(S) Other services	42.6	29.0	1.6	26.3	0.5

Remarks: The numbers are in percent and totals sum up to 100%. The negative contribution are due to sizable and negative covariance components, attributed to a cost category.

Figure 9: Exact decomposition of annual growth of the value added deflators at the available level of 1-digit-NACE industries in quarterly frequency [in %]



Source: own calculations using Eurostat databases

Conclusions

A lot of discussion on sources of inflation surges in recent periods concentrates on and finds an important contribution of profits, defined as value added net of labor costs, to value added deflators in various countries. It introduces a problem with the interpretation, as profits defined in this way include also the costs of capital and the other components. We address this issue and we use the methodology discussed in Comin et al. (2023) to separate the cost of capital and profits from the gross operating surplus. We present two distinct price decompositions: exact, allowing to highlight the role of unit cost and unit profits, and approximate (commonly used in the literature), allowing to additionally extract the contribution of prices of materials, labor and capital, but at the cost of an approximation error. Moreover, we present the results for value added and gross output deflators, to stress the differences in the contributions of materials and profits to the changes of prices.

Our analysis suggests that the unit costs of materials (and especially the prices of materials) contribute the most to the variance of gross output deflator in the period 1996-2022 and the contribution of material costs increased substantially in the year 2022. Moreover, labor costs (and especially hourly wages) are also an important contribution to both output and value added deflators. The contribution of capital is less important, with a more balanced role of capital price and the unit efficiency of capital. Profits are even less important in the variance decomposition. However, in the period 2022-2023, the contribution of profits to both value added and output deflators increased substantially. The positive contribution of costs of capital to prices in the period 2022-2023 means that our measure of profits contributes less to prices compared to the contribution of gross operating surplus, commonly used in the literature. Moreover, we show that the calculations without the approximation error mute the contribution of profits to prices in the period 2021-2023. We also showed that the costs of materials were the most important contributor to the growth of output deflator in both 2021 and 2022, followed by profits and labor costs.

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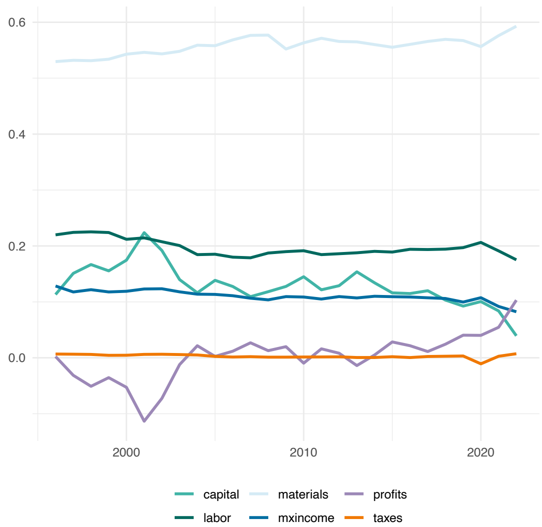
Appendices

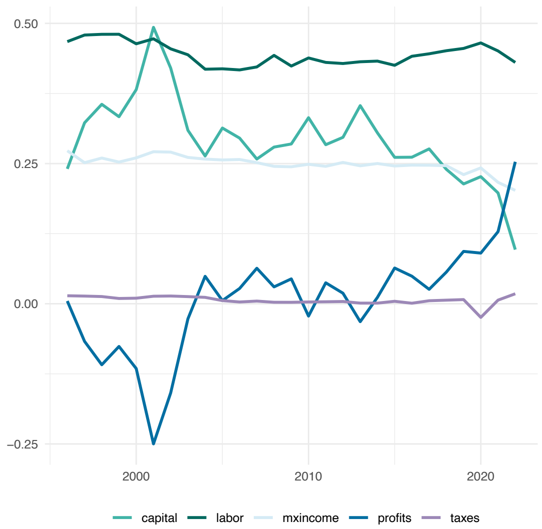
A Additional figures

Figure A.1: Shares of the nominal costs of production factors, taxes and profits in the nominal output and value added

(a) Shares in output



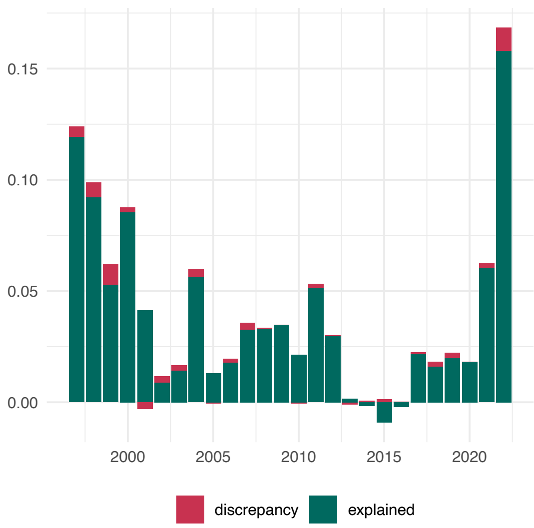
(b) Shares in value added



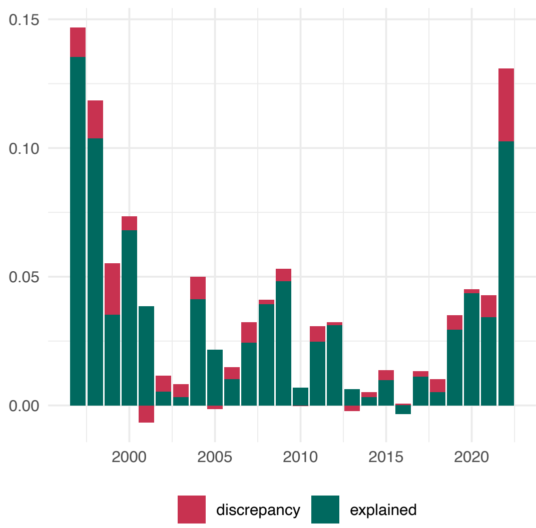
Source: own calculations using Eurostat databases

Figure A.2: Discrepancies in approximate decomposition

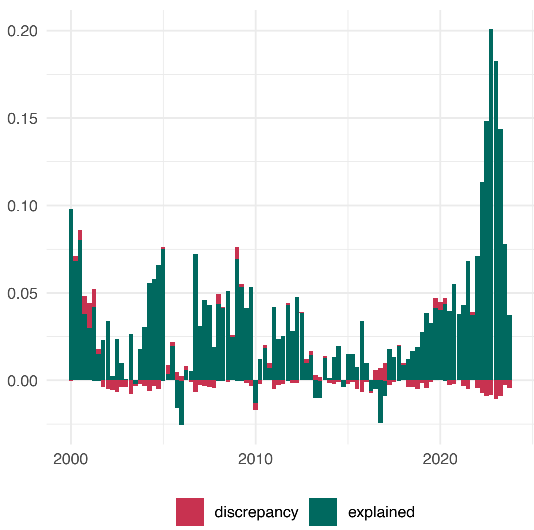
(a) Output deflator



(b) Value added deflator



(c) Value added deflator - quarterly



Source: own calculations using Eurostat databases

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