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THE SLOWDOWN OF PRODUCTIVITY IN THE EURO AREA AND THE ROLE OF INPUT PRICES

by Fabrizio Colonna*, Filippo Scoccianti* and Eliana Viviano*

Abstract

We examine how changes in the relative prices of intermediate goods, labour and capital between 2021 and 2023 contributed to the stagnation of labour productivity in the euro area. The evidence for Germany, Italy and France shows that in addition to a significant increase in the cost of intermediate goods in 2021-22, the cost of capital also rose sharply in 2022-23, affecting the relative prices of production factors. The substitution of inputs in favour of labour explains the slowdown in labour productivity observed between 2021 and 2023. Moreover, since firms adjust their use of production factors with some lag and the prices of intermediate goods and capital relative to labour were still very high in 2024 compared with pre-pandemic levels, this substitution channel may hinder the rapid return of labour productivity to its pre-pandemic trend.

JEL Classification: E24, E31, J23, J30.

Keywords: productivity, factor input prices, cost of capital, euro area.

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* Bank of Italy.

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1 Introduction

In the euro area the post-pandemic recovery has been characterised by strong labour market resilience, in contrast to anaemic value added growth. This has occurred despite a period of substantial fiscal stimulus and transfers across Member States. As a result, productivity has stagnated, sparking debates on its underlying causes.

Several analysts have explored potential long-term factors behind the lacklustre productivity dynamics. One argument is that the COVID-19 pandemic accelerated the adoption of remote and hybrid work models, particularly in service sectors. While these models offer flexibility, they may have introduced inefficiencies due to challenges in managing remote teams and reduced opportunities for face-to-face collaboration. Recent literature (Brynjolfsson (2020), Criscuolo et al. (2021)) suggests that remote work, while beneficial in some respects, can impair productivity in sectors that rely on in-person interactions for innovation, knowledge exchange, and team cohesion.

Furthermore, productivity dynamics may be influenced by the ongoing digital and green transitions. These transformations require costly adjustments to production processes and workforce structures in the short term, with potential benefits becoming evident only in the medium to long term (Lopez-Garcia et al. (2024)). Additionally, demographic and labour market shifts play a significant role. Pre-existing trends, such as an ageing workforce and declining population, have likely dampened productivity growth. The pandemic has also left lasting effects on worker preferences, as some individuals are increasingly unwilling to accept low wages or poor working conditions (Krumel Jr et al. (2023)). Structural mismatches between workers' skills and employers' demands may have further compounded these challenges (Hurley et al. (2022)).

On the other hand, Arce and Sondermann (2024) examine cyclical components of productivity, focusing on firms' labour hoarding strategies. In response to a perceived temporary slowdown in demand, many firms opted to retain their workforce, often by reducing working hours rather than engaging in layoffs. Such strategies were facilitated by relatively low labour costs, recovering profit margins, and tight labour markets, which increased recruitment costs.

This note examines the potential impact of another short-term, supply-side shock: changes in relative input prices. Disruptions caused by the COVID-19 pandemic, the energy crisis, and shifts in global trade have led to substantial increases in the relative prices of key production inputs, such as capital and intermediate goods, compared to labour. This shift in relative input prices may have incentivized firms to adopt more labour-intensive production processes, which, *ceteris paribus*, could result in lower average labour productivity.

The concept of input substitutability — the extent to which firms can replace one input with another in the production process — has long been a cornerstone of production theory. Classical growth theory links productivity growth to the efficient combination of capital and labour, with technological progress serving as the primary driver of long-term growth. However, more recent literature has expanded these models by incorporating the role of intermediate goods and exploring the elasticity of substitution between capital, labour, and these goods. For instance, Acemoglu and Restrepo (2020) demonstrate that changes in the relative prices of production inputs can significantly influence firms' resource allocation decisions between labour and capital, thereby shaping productivity outcomes.

The remainder of this short note is structured as follows: Section 2 examines the evolution of production input prices and their usage intensity over the past decade. Section 3 introduces a simple quantitative model to illustrate the impact of input price shocks on labour productivity. The model is estimated, and the results are presented in Section 4.

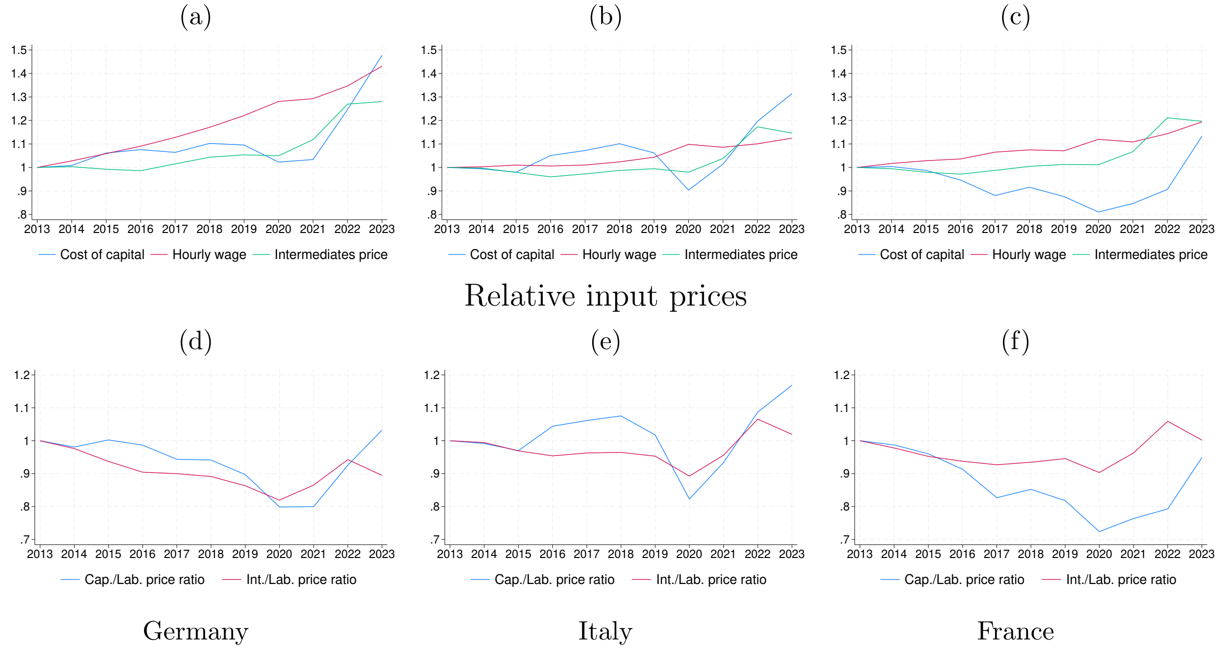
2 Relative recently Input Prices

An exceptional surge in inflation has marked the post-pandemic recovery from 2021 to 2023. This spike can be attributed to a shortage of intermediate goods after the pandemic and the sharp rise in energy prices triggered by the invasion of Ukraine. As central banks adopted a restrictive monetary policy, raising the cost of capital, the slower adjustment of nominal wages led firms to substitute intermediate inputs and capital for labour. Data from the annual national accounts of Germany, France, and Italy support this conclusion.

In Figure 1, panel a, we report the dynamics of hourly wages, the deflator for intermediate goods, and estimates of the cost of capital for the three countries from 2013 to 2023. The cost of capital is calculated as the product of the investment deflator and the nominal rental rate of capital[1]. The latter is a measure of the long-term cost of funding faced by a firm. It equals the market cost of equity and debt weighted by the firm's share of equity and debt, calculated at market values. The figure shows that after the pandemic there was a significant increase in both intermediate input prices and the cost of capital. The surge in the cost of capital was primarily driven by rising prices for investment goods (by approximately 5, 6, and 7 percentage points respectively in France, Italy, and Germany), alongside an increase in the expected rate of return on investments. In contrast, nominal hourly wages exhibited a more subdued trend during the same period. Consequently, the relative prices have diverged

[1]The methodology to estimate the rental rate of capital is described in the Appendix 1.

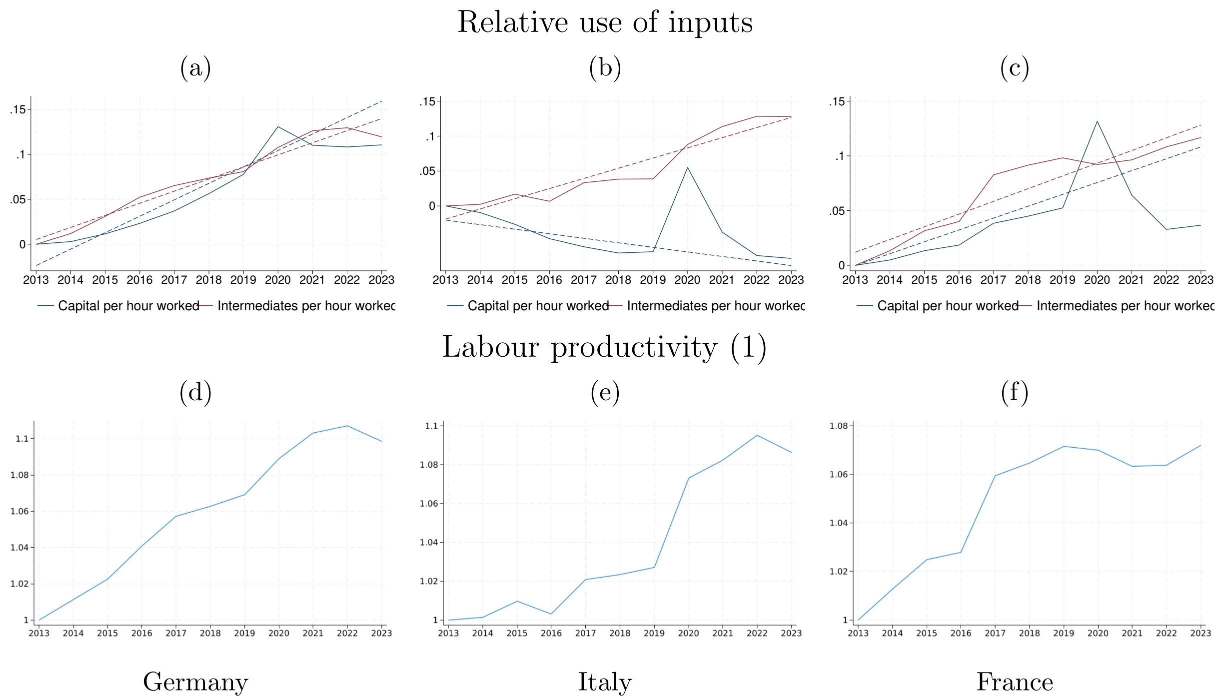
Figure 1:
Dynamics of input prices



Source: Authors' calculations on National Accounts data. For Germany: Destatis; for France: Insee; for Italy: Istat.

notably from their pre-pandemic trajectory, particularly for the cost of capital. Figure 2 shows the changes in input quantities relative to hours worked and their long-term trend, calculated over the period 2013-19. By 2020, capital deepening (the ratio of capital - in real terms - to labour) increased sharply in Germany and France, while it stagnated in Italy; in all countries, it reached a temporary peak in 2020, as firms were unable to quickly adjust their capital in response to the pandemic shock, and declined significantly in the following years, falling below its pre-pandemic trend in both France and Germany. The figure shows also that the real value of intermediate inputs relative to hours worked reacted similarly. The more intensive use of labour with respect to both intermediate input and capital translated into a sharp increase in hours worked per unit of output, which in turn led to a decline in hourly productivity growth (Figure 2,panel d). After increasing between 2013 and 2020 by an average annual growth rate of approximately 1% in France and Germany and 0.5% in Italy, labour productivity (defined as the ratio of real output to the total number of hours worked) exhibited a notable slowdown in 2021, essentially stagnating in the two following years (Figure 2,panel b). Finally, while Figure 2 refers to the economy as a whole, the decline in productivity has been widespread across all sectors[2].

Figure 2:



Source: Authors' calculations on National Accounts data. For Germany: Destatis; for France: Insee; for Italy: Istat. (1) Labour productivity is defined as the ratio between output, in real terms, and the total number of hours worked

3 A Simple Model for Productivity Dynamics

To quantitatively determine to what extent input substitution impacted labour productivity after the pandemic, we adopt a simple two-step procedure in which (i) we relate changes in input utilization to changes in relative prices; (ii) based on estimates, we analyze how hourly productivity reacts to changes in the relative use of inputs (and ultimately to changes in relative prices). Details can be found in Appendix 2. First, we model the substitution between labour and intermediate goods as a function of their relative prices. In this way, we can construct a composite good of labour and intermediate goods and we can model the

[2]Value added per hour worked, another measure of productivity (more commonly used for reasons of data availability), followed similar trends; it is now slightly above the pre-pandemic trend in Italy and below the trend in Germany and especially in France.

substitution of capital with it. More in detail, we estimate the parameters of a nested CES production function with constant returns to scale and three factors of production: capital (K), labour (L), and intermediate goods (M). We assume that L and M are combined to obtain a composite production input C, that is:

Production Function Equations

The CES production function is defined as:

$$C = (\alpha L^{\rho} + (1-\alpha)M^{\rho})^{\frac{1}{\rho}}, \tag{1}$$

where C is a composite input of labor L and intermediate goods M. Output Y is then given by:

$$Y = (\beta K^{\sigma} + (1-\beta)C^{\sigma})^{\frac{1}{\sigma}}. \tag{2}$$

The optimality conditions imply that relative prices affect the ratios of intermediates and labor as well as capital and the composite good. Optimality conditions imply that relative prices affect the ratio of intermediates and labour in equation (1), and the ratio between capital and the composite good in equation (2) (see Appendix 2). We also assume that all inputs adjust slowly to price shocks and then we estimate:

$$\ln\left(\frac{L_t}{M_t}\right) = \pi\left(\frac{1}{1-\sigma}\ln\left(\frac{q_t}{w_t}\right) + \frac{1}{1-\sigma}\ln\left(\frac{\beta_t}{1-\beta_t}\right)\right) + (1-\pi)\ln\left(\frac{L_{t-1}}{M_{t-1}}\right) + \epsilon_t \tag{3}$$

Then, we plug in the estimates of β and σ to compute λ_t and C_t, and then estimate:

$$\ln\left(\frac{K_t}{C_t}\right) = \eta\left(\frac{1}{1-\rho}\ln\left(\frac{\lambda_t}{r_t}\right) + \frac{1}{1-\rho}\ln\left(\frac{\alpha_t}{1-\alpha_t}\right)\right) + (1-\eta)\ln\left(\frac{K_{t-1}}{C_{t-1}}\right) + \nu_t \tag{4}$$

where q_t, w_t, and r_t are the price of the intermediate good, wages, and the cost of capital, respectively, and λ_t is the price of the composite good, which in turn depends on q_t, w_t, and the parameters of equation (1). To estimate the model parameters, we rely on sectoral variability (1-digit NACE, due to data limitations). Estimates are carried out country by country. Several robustness checks of the model specifications are reported in Appendix 2.

4 Results

By dividing both sides of equation 2 by L, we can carry out a decomposition of labour productivity to outline the role of changes in input composition and in turn of relative prices. In a first exercise we calculate a counterfactual hourly productivity growth, by applying the estimated elasticities of substitution among inputs to the observed ratio of capital and hours worked and to the ratio of intermediate goods and hours worked and by assuming that technological parameters remain constant from one period to another. We label this statistic as "quantity effects" since it is determined only by changes in input quantities. The distance between this estimate and the observed productivity is labeled as "residual effects" and it captures changes in productivity that are not due to relative input adjustments. The residual component generally reflects both neutral (e.g. increases in TFP) and biased technological changes (e.g. innovations that favor more capital-intensive production). However, the residual component may also capture elements of model misspecification or data approximation. In particular, in this framework, it may capture also the discrepancy between the measure of installed capital and the capital actually used. This residual in turn reflects also the fact that in cyclical downturns capacity utilization declines, with impact on the cyclical behavior of TFP. The results of this exercise are shown in Figure 3. The dark blue bars correspond to the contribution of the changes in the observed relative use of inputs to aggregate productivity ("quantity effects"). The red bars instead represent the residual effect. Comparing the three countries, it is clear that Italy's disappointing productivity performance - relative to Germany and France - is due to the subdued dynamics of capital deepening and intermediate goods relative to labour that partly offset the TFP gains captured by the residual component. In all countries, input substitution (capital and intermediate goods relative to labour) contributes to the slowdown in labour productivity in 2021-23. To better understand the role of quantities and residuals, note that the capital-to-labor ratio spiked in 2020 at the onset of the pandemic (Figure 3), as firms were forced to rapidly adjust their variable inputs (labour and intermediate goods) due to lockdown measures. Firms however could not adjust capital. In our model, such a change in k_t and c_t (capital and intermediate consumption per hours worked) would have been compatible with a substantial decline in the cost of capital relative to other input prices, and substantial labour productivity gains (as hours worked dropped). Since such productivity gains failed to materialize, as firms actually reduced the utilization of their capacity[3], we detect a notable negative residual effect.

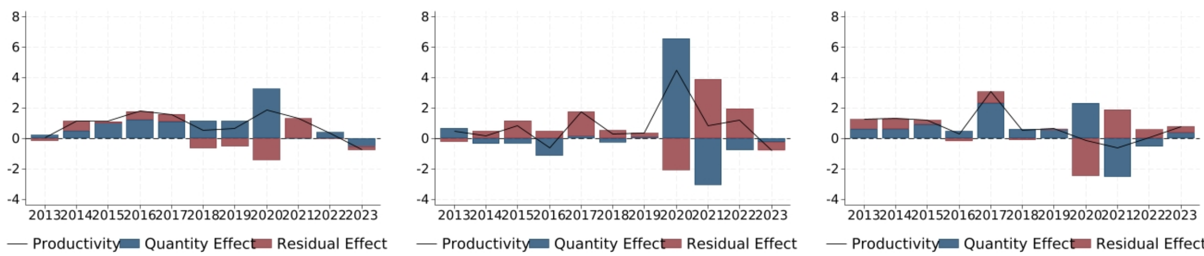
[3]More in general, to interpret the residual effect one should bear in mind that national accounts record installed capital, and that the quantity of capital used in production is measured by the indices of capacity utilization. In turn capacity utilization is influenced by demand factors, that in our model we capture only

However, between 2021 and 2023, the residual effect diminishes as firms begin to adjust their input mix in response to changing relative prices, curbing the growth of the capital stock and thus returning capital utilization to pre-pandemic levels. As shown by equations (3)

Figure 3:

Productivity decomposition

(d) (e) (f)



Germany Italy France

Source: Authors' calculations on National Accounts data. For Germany: Destatis; for France: Insee; for Italy: Istat.

and (4) the input mix depends on the relative prices of inputs and its own lagged value. We can then carry out a second exercise, reported in Figure 4, in which we assume that firms' input mix responds with some lag to changes in input relative prices. We can therefore further decompose the "quantity effect" into two parts: (1) one depending on the immediate changes in prices; (2) one depending on past values of the input used in production. We effectively construct a counterfactual "input quantity effect" in which the input mix reacts immediately to changes in prices (labeled as "price effect"). The remaining part is labeled as "lag effect" as it depends only on sluggishness in the response of inputs to relative prices. The light green bar represents the impact of current price changes, and the light blue bar measures the impact of the previous year's input mix (and ultimately the previous year's factor prices). The results show that current changes in relative prices help explain a large portion of the productivity decline observed between 2022 and 2023. As discussed earlier, the lag effect is generally positive because the lagged component of the capital-labour ratio prevents firms from rapidly substituting capital for labour in response to changes in their relative prices. The lag effect is particularly large during unexpected shocks, such as the onset of the pandemic in 2020 and the sudden rise in the cost of capital and intermediate goods in 2022. During these periods the lag effect helped mitigate large labour productivity

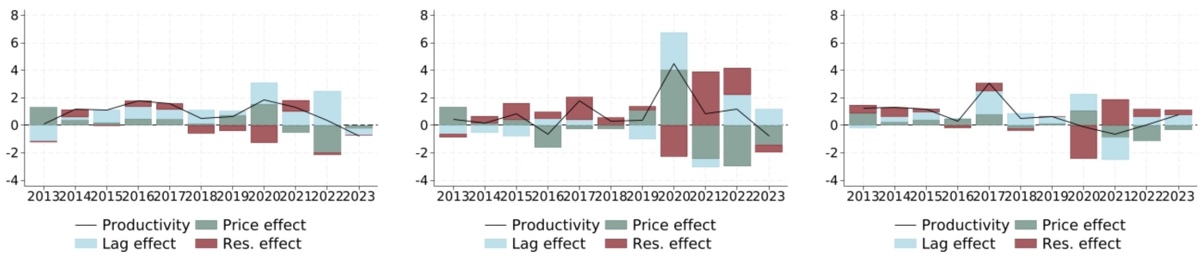
as a residual

losses. However, by 2023, this effect becomes negligible (turning negative in Germany), as firms adapted their input mix and adjusted their stock of fixed capital per worker. The high costs of capital and intermediate inputs relative to labour prevailing in 2022 and still in 2023 are expected to exert upward pressure on labour demand and downward pressure on capital and productivity well into 2024. This is due to firms' input mix still being influenced by past input prices: as long as the cost of capital remains high compared to prices of intermediate goods and wages, these pressures will not abate.

Figure 4

Productivity decomposition

(d) (e) (f)



Germany Italy France

Source: Authors' calculations on National Accounts data. For Germany: Destatis; for France: Insee; for Italy: Istat.

Appendix 1

The cost of capital

The cost of capital is given by the product of the deflator of capital goods with their rental rate. The deflator of capital goods is available in national accounts, whereas the rental rate must be constructed. For our exercise, we are interested in calculating a proxy for the rental rate of capital for French, German and Italian non-financial corporations. However, European national accounts do not provide a measure of the cost of capital services. If all fixed assets were leased on the market, rental values would be directly observable, and national accounts could use this data to estimate the cost of capital services. In practice, many fixed assets are owned by their users, and rental transactions are not observable.

Thus, to estimate the costs of capital services to owner-users, an imputation must be made. Following the current consensus among major statistical institutes[4], we proxy the rate of return on equity with the gross operating surplus and mixed income in national accounts. The Rental Rate of Capital (RRC) is then defined as the weighted average of the cost of debt (C_d) and the cost of equity (C_e):

$$\text{RRC} = \frac{C_d \cdot \text{Debt}}{\text{Debt} + \text{Equity}} + (1 - \text{tax rate}) \cdot \frac{C_e \cdot \text{Equity}}{\text{Debt} + \text{Equity}} \tag{3}$$

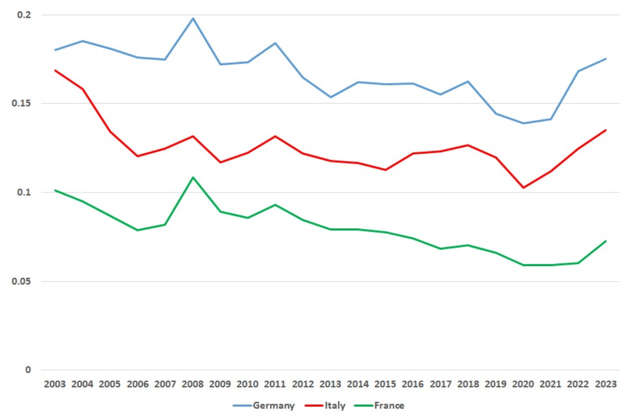
We calculate the aggregate equity and debt shares by using the consolidated current value of equity and loans for non-financial corporations from Eurostat. For the cost of debt (C_d), we use ECB data on the borrowing costs on loans for non-financial corporations[5]. Lastly, the return on equity (C_e) is set equal to the "gross operating surplus plus mixed income" of non-financial corporations minus "current taxes on income and wealth," over the amount of "equity and investment fund shares." These aggregates are drawn from Eurostat for non-financial corporations.

Figure 5 shows the dynamics of the capital rent rate in France, Germany, and Italy from 2003 to 2023. After hitting a low point in 2020, rental rates experienced an upward trend in both Germany and Italy, while remaining relatively stable in France. Furthermore, a notable disparity in the levels of rental rates is observed among the three countries, with Germany experiencing the highest rates, followed by Italy and France.

[4] Our measure of the rental rate of equity corresponds to that used by major statistical institutes around the world, see for instance: Schreyer, Diewert, and Harrison (Schreyer et al.)

[5] Interest rates on new loans, calculated as the sum of A2A (loans other than revolving loans and overdrafts, convenience, and extended credit card debt) and A2Z (revolving loans and overdrafts, convenience and extended credit card debt). Both aggregates are related to non-financial corporations.

Figure 5: Rental rate of capital

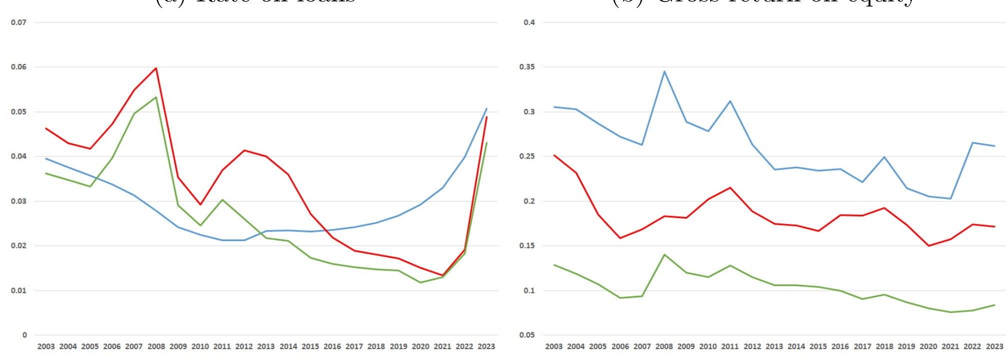


Source: Authors' calculations on Eurostat and ECB data.

The different levels and trends in the rental rates can be attributed to the predominant role played by the equity returns, which differ significantly between the three countries; see Figure 6, panel (b). Throughout the period under consideration, the equity share in the capital structure averaged around 60% for both Germany and Italy and nearly 70% for France. Given this significant reliance on equity, fluctuations in its returns, which are lower than those on loans rates, directly affect the rental rate of capital. In particular, the increase in rental rates has been less pronounced than what the surge in loan rates would have predicted; see Figure 6, panel (a).

Figure 6: Rates on loans and return on equity

(a) Rate on loans (b) Gross return on equity



Source: Authors' calculations on Eurostat and ECB data.

Throughout the last decade, Germany maintained the highest capital rental rate, largely due to its superior returns on equity. This suggests that factors such as investment strategies, risk profiles, and industry profitability specific to each country have significant implications for the return on equity and consequently the rental rate of capital.

Appendix 2

The Basic Model

To assess how variations in input prices affect the relative quantities of production inputs and productivity, we estimate the parameters of a nested CES production function with constant returns to scale and three factors of production: capital (K), labour (L), and intermediate goods (M). We assume that L and M are combined to obtain a composite production input (C):

$$C = [\beta L^{\sigma} + (1-\beta)M^{\sigma}]^{1/\sigma} \tag{1}$$

Output (Y) is then produced according to the following production function:

$$Y = [A\,(\alpha K^{\rho} + (1-\alpha)C^{\rho})]^{1/\rho} \tag{2}$$

The parameters ρ and σ, both less than 1, determine the elasticity of substitution between inputs: the higher they are, the easier it is to substitute one input for another. Firms maximize:

$$\text{Max } pY - wL - qM - rK \quad \text{s.t. (1) and (2).}$$

The first-order conditions imply:

$$\ln\left(\frac{L}{M}\right) = \frac{1}{1-\sigma}\ln\left(\frac{q}{w}\right) + \frac{1}{1-\sigma}\ln\left(\frac{\beta}{1-\beta}\right) \tag{3}$$

$$\ln\left(\frac{K}{C}\right) = \frac{1}{1-\rho}\ln\left(\frac{\lambda}{r}\right) + \frac{1}{1-\rho}\ln\left(\frac{\alpha}{1-\alpha}\right) \tag{4}$$

where λ is the implicit price of the composite good:

$$\lambda = \left[\left(\frac{w^{\sigma}}{\beta}\right)^{\frac{1}{\sigma-1}} + \left(\frac{q^{\sigma}}{1-\beta}\right)^{\frac{1}{\sigma-1}}\right]^{\frac{\sigma-1}{\sigma}}. \tag{4}$$

To assess the extent to which price changes explain the slowdown in German productivity, we estimate the parameters $\sigma, \rho, \alpha, \beta$.

We define the following econometric model, denoting the economic sector by j and the year by t:

$$\ln\left(\frac{L_{jt}}{M_{jt}}\right) = \frac{1}{1-\sigma}\ln\left(\frac{q_{jt}}{w_{jt}}\right) + \frac{1}{1-\sigma}\ln\left(\frac{\beta_{jt}}{1-\beta_{jt}}\right) + \epsilon_j^1 + \nu_t^1 \tag{3bis}$$

$$\ln\left(\frac{K_{jt}}{C_{jt}}\right) = \frac{1}{1-\rho}\ln\left(\frac{\lambda_{jt}}{r_{jt}}\right) + \frac{1}{1-\rho}\ln\left(\frac{\alpha_{jt}}{1-\alpha_{jt}}\right) + \epsilon_j^2 + \nu_t^2 \tag{4bis}$$

Parameters λ_{jt} and C_{jt} are nonlinear functions of our dependent variables. Therefore, we estimate equations (3bis) and (4bis) simultaneously using the maximum likelihood method, accounting for sectoral heterogeneity and common time shocks. The results are robust to changes in the period used for the trend calculation. From our estimation, we can identify σ, ρ, α_{jt}, β_{jt}. The results are reported in Table A1: all parameters are significantly higher than 0, rejecting the hypothesis of fixed-coefficient technologies where the input mix is unresponsive to input price changes. Moreover, they are significant below one, the value consistent with a Cobb-Douglas technology: this implies that a specific input share would increase when its price increases (for example, the capital share increases when the cost of capital increases).

Table A1

Parameter	Germany	Italy	France
σ (elasticity M, L)	0.30	0.19	0.31
ρ (elasticity ML, K)	0.27	0.25	0.17

To assess how much of the recent slowdown in productivity can be accounted for by changes in the input mix, we propose the following decomposition. Using small letters to denote per hour worked terms, and omitting the j subscript for convenience, we can express the observed average labour productivity as:

$$y(k, m; A, \alpha, \rho, \beta, \sigma) = A\left[\alpha k^\rho + (1-\alpha)c^\rho\right]^{1/\rho} = Af(k, m; A, \alpha, \rho, \beta, \sigma)$$

where

$$c(m; \beta, \sigma) = \left[\beta + (1-\beta)m^\sigma\right]^{1/\sigma}.$$

Productivity growth is defined by:

$$\frac{y_{t+1}}{y_t} = \frac{y(k_{t+1}, m_{t+1}; A_{t+1}, \alpha_{t+1}, \beta_{t+1}, \rho, \sigma)}{y(k_t, m_t; A_t, \alpha_t, \beta_t, \rho, \sigma)}.$$

We can compute a counterfactual productivity growth driven only by changes in the input mix, the so-called "quantity effect":

$$\frac{y_{t+1}^{q}}{y_t} = \frac{y(k_{t+1}, m_{t+1}; A_t, \alpha_t, \beta_t, \rho, \sigma)}{y(k_t, m_t; A_t, \alpha_t, \beta_t, \rho, \sigma)}.$$

For Germany and France, we compute such counterfactual productivity dynamics for each sector, which are appropriately aggregated to compute overall productivity trends. For Italy, disaggregated sectoral data are not available for 2022 and 2023, so we plug the elasticity parameters σ, ρ directly into the series for the whole economy.

The Model with Lags

In our second exercise, we want input quantities to depend also on their lagged values:

$$\ln\left(\frac{L_{jt}}{M_{jt}}\right) = \pi\left(\frac{1}{1-\sigma}\ln\left(\frac{q_{jt}}{w_{jt}}\right) + \frac{1}{1-\sigma}\ln\left(\frac{\beta_{jt}}{1-\beta_{jt}}\right)\right) + (1-\pi)\ln\left(\frac{L_{jt-1}}{M_{jt-1}}\right) + \epsilon_j^1 + \nu_t^1 \tag{3ter}$$

Then, we plug in the estimates of β and σ to compute λ_t and C_t, and then estimate the following equation:

$$\ln\left(\frac{K_{jt}}{C_{jt}}\right) = \eta\left(\frac{1}{1-\rho}\ln\left(\frac{\lambda_{jt}}{r_{jt}}\right) + \frac{1}{1-\rho}\ln\left(\frac{\alpha_{jt}}{1-\alpha_{jt}}\right)\right) + (1-\eta)\ln\left(\frac{K_{jt-1}}{C_{jt-1}}\right) + \epsilon_j^2 + \nu_t^2 \tag{4ter}$$

The parameters π and η capture how long it takes for the price shock to be transmitted to quantities. This allows us to interpret the observed relative demand for input as the weighted average of two components: its lagged value and the optimal value implied by relative prices:

$$\ln\left(\frac{L_{jt}}{M_{jt}}\right) = \pi\ln\left(\frac{L_{jt}^*}{M_{jt}^*}\right) + (1-\pi)\ln\left(\frac{L_{jt-1}}{M_{jt-1}}\right)$$

$$\ln\left(\frac{K_{jt}}{C_{jt}}\right) = \eta\ln\left(\frac{K_{jt}^*}{C_{jt}^*}\right) + (1-\eta)\ln\left(\frac{K_{jt-1}}{C_{jt-1}}\right)$$

Our counterfactual productivity growth, which would have occurred if firms were able to immediately adjust their input mix to the optimal value (price effect), is therefore defined as:

$$\frac{y_{t+1}^{p}}{y_t} = \frac{y\left(k_{t+1}^*, m_{t+1}^*; A_t, \alpha_t, \beta_t, \rho, \sigma\right)}{y\left(k_t, m_t; A_t, \alpha_t, \beta_t, \rho, \sigma\right)}$$

Parameter estimates are reported in Table A2.

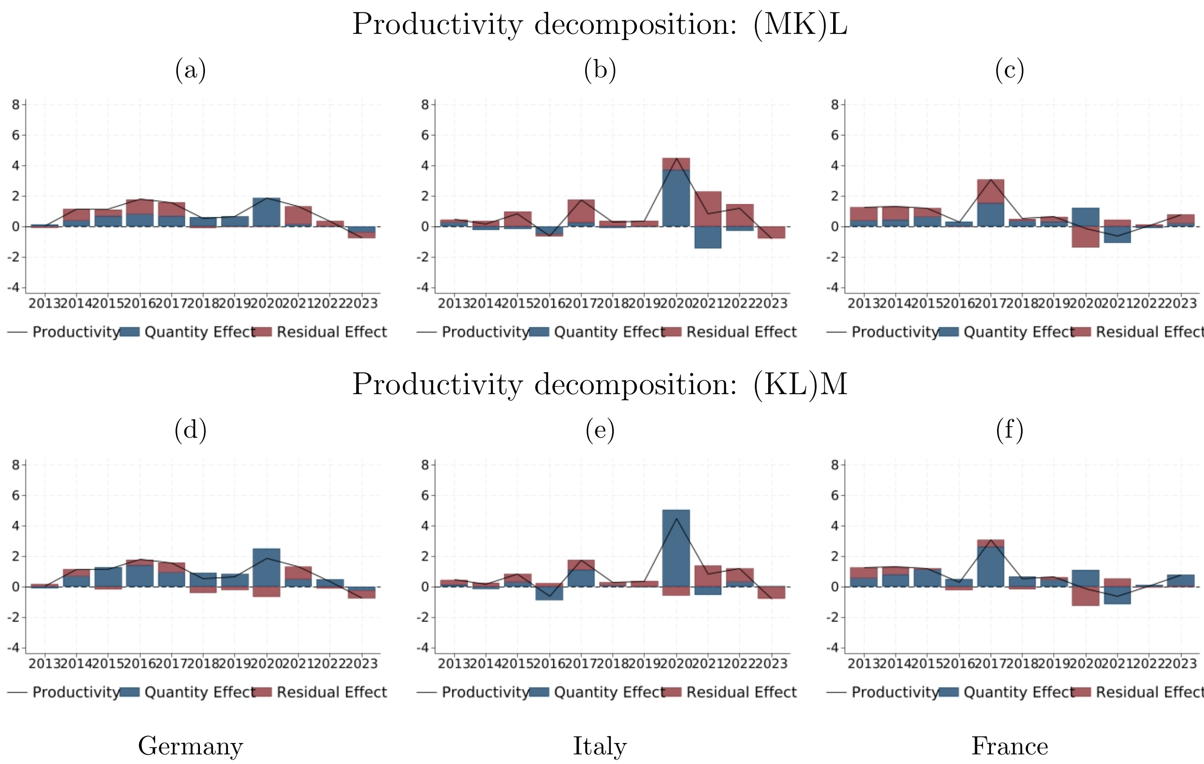
Table A2

Parameter	Germany	Italy	France
σ (elasticity M, L)	0.20	0.28	0.18
π (lag M, L)	0.50	0.43	0.33
ρ (elasticity ML, K)	0.25	0.39	0.17
η (lag ML, K)	0.38	0.33	0.23

Robustness Checks

We reported the results of the main model in which labor and intermediate goods produce an intermediate composite good (inner nest), which is in turn combined with capital to produce the final good (outer nest). Nevertheless, we tested different specifications of the CES function, namely different nesting structures. While the estimation of the $(ML)K$ structure fits the data best, showing higher adjusted R^2 values, the main conclusions of the note hold also with the $(MK)L$ and $(KL)M$ specifications, as shown in Figure A3. Estimates

Figure A3



Source: Authors' calculations on National Accounts data. For Germany: Destatis; for France: Insee; for Italy: Istat.

of parameters are reported in Table A4. Again, all parameters lie in the $(0, 1)$ interval.

Table A4

Parameter Estimates by Model and Country

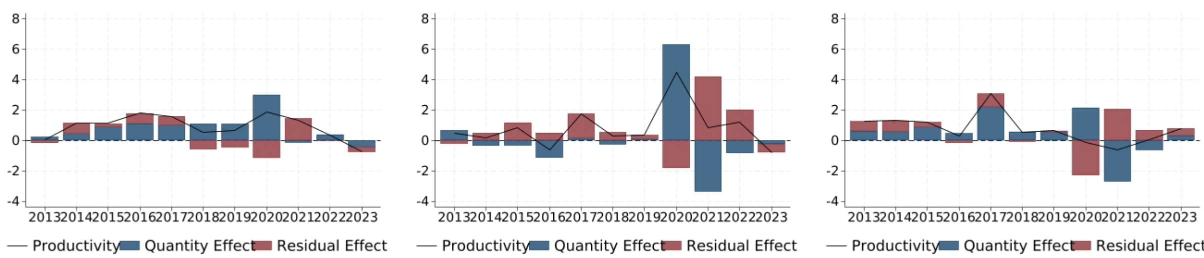
Model	Parameter	Germany	Italy	France
(ML)K	Elasticity M, L	0.30	0.19	0.31
	Elasticity ML, K	0.27	0.25	0.17
(MK)L	Elasticity M, K	0.57	0.25	0.33
	Elasticity MK, L	0.40	0.31	0.32
(LK)M	Elasticity L, K	0.57	0.32	0.37
	Elasticity LK, M	0.71	0.24	0.35

To further test the robustness of our results, we estimate the model following the methodology proposed by van der Werf (2008), that use the implied elasticity of input shares with respect to relative input prices (Figure A5).

Figure A5

Productivity decomposition: (ML)K, Van der Wer (2008)

(a) (b) (c)



Germany Italy France

Source: Authors' calculations on National Accounts data. For Germany: Destatis; for France: Insee; for Italy: Istat.

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