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The Determinants of Productivity Growth in Manufacturing Industries: Evidence for 14 European Countries based on Local Projections*

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Abstract

In recent decades, anemic productivity growth has characterized many advanced countries. Starting from a demand-led growth perspective, the aim of this study is to provide an analysis of the determinants of labor productivity, focusing especially on the possible direct effects of real wages on productivity dynamics. We employ the Local Projections (LP) technique to estimate the Sylos Labini productivity equation for a panel of 14 European countries over the period 1995-2018. We analyze the dynamic effects on labor productivity at different levels of aggregation, applying the LP technique to a panel of three-dimensional data, and for different groups of countries, distinguishing between "core", "peripheral", and "East European" countries. Focusing on the effect of labor cost changes on productivity growth, we also analyze its possible asymmetrical behavior, differentiating between periods of prolonged expansion vs moderation of wages. Our results confirm Sylos' insights and, particularly, the direct effects of wage changes on productivity growth, both at the country and sectoral level. These effects also appear to be validated in terms of sustained wage expansion/moderation and have asymmetric behavior in terms of both intensity and timing. When comparing groups of countries, the main differences are in the incentive to introduce labor-saving innovations resulting from increased labor costs, which is more effective in core countries.

JEL Codes: C23; E12; E24; O47
Keywords: Labor Productivity, Wages, Local Projections, Paolo Sylos Labini, Spatial Disparities

* I am very grateful to Antonella Palumbo and Daniele Girardi for useful comments on earlier versions of the paper.
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1. Introduction

In recent decades, the anemic growth of productivity has characterized many advanced countries. Spatial disparities, which may be at national (e.g., Maudos et al., 2008; Carnevali et al., 2020) or regional level (see Deleidi et al., 2021; Guarini, 2007), emerge from various studies that have tried to solve the puzzle of such prolonged periods of low productivity growth. In Europe, productivity disparities have been identified in the prevailing literature as the main cause of trade imbalances between eurozone countries. This interpretation leads to indications in favor of a recovery of productivity and competitiveness in "peripheral" countries through reforms defined "structural", aimed at containing labor costs, increasing labor flexibility, and increasing competition in the markets. Policies to support labor productivity, however, can vary considerably in content and outcomes, depending on how productivity is defined and measured. While we agree that labor productivity is a key variable in a country's economic performance, we believe that policies supporting productivity are failing in their purpose because they are not identifying the main drivers of productivity growth.

The idea that structural reforms would be the main way to strengthen productivity stems from the mainstream interpretation which sees economic growth as explained and limited by the growth of productive factors, labor and capital, and the trend of technical progress. Low productivity growth, interpreted as a sign of productive inefficiency, would in turn be caused by imperfections or rigidities in the markets that hinder the free functioning of competition, i.e., it would be attributable to supply-side factors such as innovation, education and human capital, knowledge and labor flexibility. This prevailing view has been challenged by various strands of literature that see economic growth as driven by aggregate demand, which plays a central role in determining both output and resource growth. Hence, it is output growth that determines the accumulation of resources over time rather than the other way around, and the dynamics of productivity is seen as largely endogenous to the growth of output.

Starting from a demand-led growth perspective, the aim of this study is to provide an analysis of the determinants of labor productivity in selected European countries over the period 1995–2018. Particularly, this paper explores, from a post-Keynesian theoretical perspective, how stagnating real wages may affect productivity dynamics. In this context, wage dynamics may exert an influence on productivity not only indirectly, through their effect on aggregate demand, but also directly. Indeed, costs, and especially labor costs, are among the possible economic impulses that stimulate innovations and thus labor productivity. Our analysis is mainly grounded in Paolo Sylos-Labini's theoretic insights about the determinants of labor productivity (Sylos-Labini, 1984, 1993), which explicitly considers the direct effects of wages. We especially focus on the different developments in manufacturing industries of three groups of countries: "core" countries, "peripheral" countries, and "East-European" countries.

We employ the Local Projections (LPs) technique (Jordà, 2005) to estimate Sylos Labini's productivity equation for a panel of 14 Euro Area (EA) member states over the period 1995–2018. LPs allow the identification of the dynamic effects on labor productivity stemming from each of its determinants through impulse response functions (IRFs) that are calculated by estimating the effects on productivity over different time horizons. Based on this methodology, we analyze the direct effects of wages on productivity at different levels of aggregation and for different groups of countries. As a first step, we estimate the effects of the different determinants of productivity growth for manufacturing as a whole. As a second step, we focus on the effect of changes in labor costs on productivity growth and analyze its possible asymmetric character by differentiating for periods of prolonged expansion vs moderation of wages. As a third step, we apply the LP technique to a panel of three-dimensional data in which 8 manufacturing subsectors are analyzed for each country. Analysis at a higher level of sectoral disaggregation allows to verify the relationships identified by

Sylos Labini not only at the level of cross-country comparisons but also at the level of cross-sector comparisons. Finally, the higher number of observations allows us to further deepen our analysis by splitting the sample between three different groups of countries: core, peripheral, and East-European countries. Investigating these relationships by looking at spatial differences can be useful from a policy perspective because it allows to accurately define the content and purpose of policies by highlighting possible disparities between groups of countries with structural, social and institutional differences.

The structure of the paper is as follow. In Section 2, the theoretical framework and the main methodological features of the estimated model are discussed. Section 3 describes the data, the estimation strategy and the methodology used. In Section 4, we present the main findings of our empirical analysis. In Section 5, we address the issue of inconsistency of FE in dynamic panel data models. Section 6 is devoted to final remarks.

2. The theoretical framework

The theoretical reference for our empirical investigation is the analysis developed by Sylos Labini (1984, 1993), who studied the main determinants of productivity growth and proposed empirical estimates of his 'productivity equation'. According to the author, labor productivity growth depends primarily on three economic factors: market expansion, changes in labor costs, and investment.

The first factor refers to the mechanism originally identified by Adam Smith whereby an expansion of the domestic market allows for an increase in the division of labor and opens up space for technological change, encouraging productivity growth and the accumulation process itself. Accordingly, Sylos defines this effect as the "Smith effect". The same mechanism is formalized in the well-known "Kaldor Verdoorn's law", which postulates that the growth of labor productivity is largely endogenous to the growth of the economy (Kaldor, 1961; Verdoorn, 1949). The second factor is labor cost growth relative to either the general price level or the price level of capital goods such as machinery. According to the author, the increase in labor costs relative to the general level of prices would induce firms to save labor in absolute terms, i.e., to reduce labor per unit of output, through the reorganization of the labor input. The growth of labor costs relative to machinery prices, on the other hand, would incentivize firms to save labor in relative terms by replacing workers with machines,[1] thus resulting in an increase in machinery per unit of output and a reduction in labor per unit of output. In other words, an increase in labor costs leads firms to improve the allocation of labor inputs (either in absolute terms or in relation to other inputs) in order to increase efficiency, and the new, more efficient organization prompted by rising real wages should lead to an increase in labor productivity. The two effects are labelled respectively the "organization effect" and the "mechanization effect".[2] Finally, the third factor is the impact of the investment level on productivity, which is twofold: on the one hand, a "disturbance effect" arise in the short run, since new equipment takes time to be used effectively; on the other hand, investment is expected to improve labor productivity in the medium to long run.[3]

[1] It is important to note that the notion expressed by Sylos refers to a dynamic substitution between labor and machinery that occurs over time through the introduction of new technologies, and thus significantly differs from the neoclassical concept of static substitution between existing techniques, which refers to a continuum of efficient techniques and is unrelated to the notion of technical progress.

[2] The latter is also known as the "Ricardo effect" since the author derives this mechanism from Ricardo's analysis on the role of machinery. It should be noted, however, that other authors have interpreted Ricardo's analysis differently and have attributed the idea of dynamic substitution between labor and machines to Marx rather than Ricardo (e.g., Gehrke, 2003).

[3] As it is not possible to determine exactly to what extent labor-saving investment is stimulated by an increase in wages relative to machinery prices and to what extent it is independent, in a first version of the productivity equation Sylos

Following the literature that estimated the Sylos Labini's productivity equation (see, among others, Guarini, 2007; Carnevali et al., 2020; Fontanari and Palumbo, 2022), we refer to a model containing all the determinants at the same time:

$$\Delta\pi_{i,t} = \alpha + a\Delta(W/P)_{i,t} + b\Delta Y_{i,t} + c\Delta(W/P_m)_{i,t-n} + dI_{i,t-n} - eI_{i,t} \quad (1)$$

where coefficient a captures the organization effect; coefficient b is the Smith effect; coefficient c captures the mechanization effect; coefficient e measures the short-run disturbance effect of new investment while coefficient d measures its long-run effect on labor productivity. Productivity growth is thus expressed as depending on output growth ΔY_t (representing the extent-of-the-market effect), labor cost growth relative to changes in the general price level $\Delta(W/P)_t$, and labor cost growth relative to changes in machine prices $\Delta(W/P_m)_{t-n}$, and the level of past and contemporary investment I_{t-n} and I_t. Notice that the difference between the two labor cost variables is given not only by the different price index at the denominator but also by the fact that the mechanization effect is considered a medium-to-long-run effect while the organization effect is assumed to be contemporaneous.

A few more words could be said about the role of labor cost changes. Sylos Labini's analysis has the advantage of exploring the possible direct effects of wages on productivity in addition to the better-known relationship between output growth and productivity growth. The organization effect acts by favoring the rationalization of the production process through a better exploitation of pre-existing innovations or a more intensive use of the workforce already employed. Hence, labor costs, together with regulatory elements that can make labor more or less rigid, affects the organization of the workforce: the more expensive and rigid labor is, the stronger the incentive to save it per unit of output, with a consequent positive effect on labor productivity (for an in-depth analysis on this effect see Fontanari and Palumbo, 2022). The mechanization effect, on the other hand, acts through the introduction of machinery incorporating new technologies and increases the mechanization of the production process; it thus operates through induced technical progress. It is worth noting that the dynamic substitution between machines and labor is understood here as an irreversible process that takes place gradually over time and involves changes in technology, and, as such, is different from the static substitution of marginalist analysis, which takes place between already known and available methods of production.[4]

These effects must be distinguished from the indirect ones, which pass through the depressive (expansionary) influence that low (high) wages can exert on aggregate demand and, in this way, on productivity. The effects of wages on productivity may in fact act *independently* and *in addition* to the possible stimulus to innovate coming from the growth of aggregate demand. Indeed, in a demand-led growth perspective, where there is no spontaneous mechanism that ensures the tendency towards full employment, since aggregate demand constrains both actual output and the long-term growth path of the economy, income distribution does not result automatically from the equilibrium between market forces, being instead substantially determined by social factors. This implies that the growth

(1984) include both the effect of relative labor cost and the effect of investments: the former, indeed, would not affect the level of investment (which depends primarily on demand pressure), but rather its composition. Yet, in a second formulation he does not include investment but only the mechanization effect, which accounts for the part of investment embodying technical change. Sylos (1989, p. 150; 1993, p. 258) claims that the two versions of the productivity equation are equivalent, if we refer to the time sequence revealed by the estimates. The data reveal that the increase in relative labor costs precedes the increase in investment, which in turn precedes the increase in productivity. The investment variable, although omitted in the second version, would thus be implicitly considered at least for the part of investment embodying technical innovations.

[4] The differences between the two types of substitution do not consist solely in the distinction between static and dynamic analysis, but stem from other factors attributable to the use of distinctly different theoretical approaches (referring, for example, to the use of the concept of marginal productivity and the different concept of capital).

of wages may be seen as (at least partially) exogenous to productivity. This direction of causality is less studied than the reverse direction, i.e., the possibility that productivity increases allow wage increases. There is, in fact, a bi-directional relationship between the two variables which, however, should not be understood as an automatic mechanism. Productivity growth opens a potential space for wage growth that does not affect the profit rate; however, filling this space will depend on the bargaining strength of workers. Similarly, the positive effect of higher labor costs on productivity will be greater the more difficult it is for firms to pass the cost increase on to prices because, for example, they operate in a highly competitive market or compete on price abroad (Sylos, 1984).

The study of such a complex indicator as labor productivity within the post-Keynesian approach allows for a greater degree of flexibility in analyzing the intricate network of interactions involving it. In fact, in this framework economic dynamics are understood as a tangle of causal links, which can be analyzed in isolation and then combined, considering the interrelation between strictly economic aspects and social and cultural ones (e.g., Roncaglia, 2007; Ginzburg, 2012; Fontanari and Palumbo, 2022). In the present empirical analysis, the focus on one direction of causality, from wages to productivity, does not imply the exclusion of the reverse direction; on the contrary, the goal of the analysis is to identify a specific relationship while considering the network of interactions in which it is embedded.

2.1 Empirical findings and methodological issues

The role of wages in affecting productivity dynamics has been investigated in various studies and in different frameworks. Some studies analyze the hypothesis of a positive causal link acting from wages to labor productivity *indirectly*, that is, through the effect of wages on aggregate demand (see for example Hein e Tarassow, 2010; Marquetti, 2004). Other studies analyze the *direct* effect of wages trough either the Sylos Labini's productivity equation (Guarini, 2007; Lucidi and Kleinknecht, 2009; Corsi & D'Ippoliti, 2013; Lucarelli and Romano, 2016; Lucarelli and Perone, 2020; Carnevali et al., 2020; Fontanari and Palumbo, 2022), or other models (e.g., Vergeer and Kleinknecht, 2011, 2014; Naastepad, 2006) and find general confirmation of both the direct effects of wages and the effect of aggregate demand on labor productivity. Analyses has been conducted for individual countries (e.g., Sylos 1984; Lucidi and Kleinknecht, 2009; Fontanari and Palumbo, 2022) and by studying spatial disparities, either at national (e.g., Lucarelli and Romano, 2016; Carnevali et al., 2020) or regional level (see Guarini, 2007). While the direct effects on productivity of both measures of labor costs are always confirmed, as is the effect of market expansion, the effect of investment is in many analyses insignificant or shows very small coefficients (Carnevali et al. 2020; Lucarelli and Romano, 2016; Sylos Labini, 1984).[5]

The two main issues that arise when estimating Sylos Labini's equation concern (i) the bi-directional nature of the relationship between wages and productivity and (ii) the possible endogeneity between productivity and output growth. To address the problem of reverse causality between wages and productivity, the labor cost variables are included with lags in the model, introducing either a specific lag structure (Vergeer and Kleinknecht, 2011; Lucarelli and Perone, 2020) or several lags for each variable (Guarini, 2007; Carnevali et al., 2020). Sylos' insights are confirmed with both approaches and using different estimation techniques, i.e., a direct positive effect of wages on productivity is found. The problem of the endogeneity between productivity and output growth is a well-known issue in the literature estimating the Kaldor-Verdoorn law that can be addressed with many different techniques which have generally confirmed the validity of the

[5] The negligible effect of investment may be partly related to the chosen indicator, i.e., the level of investment, to the point that Sylos himself in his 1984 estimates includes also the first difference of the capital stock. However, their small effect seems to confirm Sylos' concerns about introducing both investment and relative labor costs into the equation, as the effect of mechanization also captures the effect of investment incorporating technical change (see footnote 3 above).

Verdoorn effect (see McCombie et al. 2002 for a survey).

The productivity equation has been validated through different estimation techniques and based on different datasets in both spatial and temporal terms. However, to the best of our knowledge, a methodology such as LPs that estimate the dynamic effects on labor productivity stemming from each of its determinants has not been applied yet. This methodology allows to assess the dynamic effects on labor productivity through impulse response functions (IRFs) that are calculated by estimating the effects on productivity over different time horizons.

3. Data and methodology

To implement our analysis, we build two datasets: the first dataset contains yearly data for the manufacturing sectors of 14 European countries over the period 1995-2018; the second dataset includes yearly data for 8 sub-sectors of manufacturing for the same panel of countries. The source of the data is the STAN database of the OECD. Definitions and data sources are all provided by Table A1 in the Appendix.

3.1 Estimation strategy

As a first step of our empirical analysis, we use Local Projections to estimate the Sylos Labini's productivity equation for total manufacturing. The LP approach allows to assess separately the impact of each individual determinant of productivity growth, using the other determinants as controls. Indeed, under this methodology, the coefficients of the control variables are not used to construct the IRFs, but rather are used to clear the coefficient of the variable of interest from the dynamic effects of the control variables.

Using the same data, we then focus on the direct effects of wage changes on productivity growth by analyzing the impact of periods of wage expansion/moderation, as defined below. By splitting the analysis between expansions and moderations in wage growth, we can assess whether the effects of the two measures of labor costs have an asymmetrical behavior. Indeed, one might think that while increases in wages may encourage the introduction of innovations, thereby increasing productivity, moderate wage growth has no significant impact (or very little impact) on productivity, or *vice versa*. Moreover, differentiating the effect between increases and reductions could also bring out possible differences in the timing and intensity of the two measures of labor cost.

Following Girardi et al. (2020), we define periods of expansion/moderation as those years in which:

a) wage growth is higher/lower than its country mean by at least one standard deviation and

b) wage growth is higher/lower than one-half of the country mean in the year preceding the expansion

c) or, only for moderations, wage growth is negative for at least two consecutive years.

Condition a) ensures that we are dealing with episodes of sizeable changes in wages, while condition b) ensures that the high (low) growth experienced in the expansion (moderation) year is not a stand-alone data but instead comes from a period of prolonged expansion (moderation). In this way, we can distinguish the effect of sizeable changes from that of increases (decreases) of lesser magnitude and/or duration. Analyzing the effect of wages on productivity in terms of wide and sustained changes allows to verify that those effects persist over time and do not change sign if the intensity and duration are larger. Indeed, it could be thought that, while a sporadic increase in wages can stimulate innovation and productivity, a sustained growth in wages, and therefore in costs, could instead reduce competitiveness and, in this way, be detrimental for productivity. This interpretation is precisely the thesis in support of political indications aimed at solving the competitiveness problem

in peripheral countries through the reduction of labor costs. On the other hand, one might expect that a moderate reduction in wages may has no (or little) effect on productivity, while prolonged wage moderation could be detrimental to productivity growth.

The third step of our analysis consists in the application of LPs to a 3-dimensional panel dataset to analyze the determinants of productivity at the sectoral level. With reference to Sylos Labini's analysis, we are interested in verifying whether an increase in labor costs in a specific sector constitutes an incentive to innovate for that sector. This allows us to distinguish even more accurately between direct and indirect effects of wages on productivity. The indirect effect of wages on productivity, which acts through aggregate demand, is captured to some extent by the presence of the Smith effect in the productivity equation. However, working on manufacturing as a whole means that we might not be able to account for the fact that higher wages in some sub-sectors might lead to higher demand that results in higher productivity even in subsectors where wages have not increased. If, in fact, it turns out that the relationship is confirmed at the country level but not at the sectoral level then doubt might arise that we are indeed capturing (at least in part) an indirect effect of wages. By shifting the unit of analysis from the whole of a country's manufacturing to the individual sector, it is therefore possible to verify whether the direct effect of wages also works at the sectoral level, i.e., whether the sectors with higher wage growth are those in which productivity grows the most.

Finally, using data at the sectoral level, we analyze the different developments in manufacturing industries of the three groups of countries to evaluate possible spatial disparities in the different effects.

3.2 Methodology

The Local Projections method considers local approximations for each forecast horizon of interest. As argued by Jorda (2005), this method presents multiple advantages over more conventional VAR-based approaches. First, LPs can be estimated by single-equation technique, and they are more robust to misspecification. Conversely, VAR estimations are extremely sensitive to misspecification of the data-generating process since they impose a single parametric model to determine the outcome variables, and IRFs are calculated by recursive extrapolation of the same estimated coefficients. Second, this method can be extended to estimate potentially nonlinear relations. Third, it allows to handle error terms correlated across countries and time.

Following Auerbach and Gorodonikencho (2017) and Deleidi et al. (2020), in our first empirical exercise we implement a dynamic two-way fixed effects model:

$$\Delta y_{i,t+h} = \sum_{j=0}^{p} \beta_j^h \Delta W_{i,t-j} + \sum_{j=1}^{p} \gamma_j^h \Delta y_{i,t-j} + \sum_{j=1}^{p} \theta_j^h X_{i,t-j} + \alpha_i^h + \delta_t^h + \varepsilon_{i,t+h} \qquad (2)$$

where i and t index countries and time (measured in years), $\Delta y_{i,t+h}$ measures the cumulative change of the dependent variable between time *t–1* and time *t+h*,[6] $W_{i,t-j}$ represents the selected independent variable, $y_{i,t-j}$ are the lagged values of the dependent variable, $X_{i,t-j}$ is a set of control variables, and α_i^h and δ_t^h are country and time fixed effects.

In our model we include two lags of the dependent variable (p=2), but we then checked that varying the number of lags does not alter the results. The set of control variables $X_{i,t-j}$ contains the regressors of Sylos Labini's productivity equation different from $W_{i,t-j}$. For all variables, the rate of change of the selected independent variable is considered, and it is measured as follow: $ln(W_{i,t}) - ln(W_{i,t-1})$. The only exception is investments which, following Sylos' analysis, are expressed in

[6] The outcome variable is defined as $\Delta y_{t+h} = ln(y_{t+h}) - ln(y_{t-1})$.

levels.[7] The coefficient β^h is the *h*-years response of *y* to the shock at time t. The impulse response functions (IRFs) are directly built from the β^h coefficients: they are constructed as $\{\hat{\beta}_0^h\}_{h=0}^H$ estimated from a sequence of regressions of *y* for each horizon *h* from zero to a maximum horizon H. The sum of coefficients $\sum_{h=0}^{p} \hat{\beta}^h$ is the *p*-years cumulated effect on labor productivity, while the average response is given by $(1+H)^{-1} \sum_{h=0}^{H} \hat{\beta}_0^h$ (Auerbach and Gorodonikencho, 2017; Girardi et al. 2020).

In our second step of the empirical analysis, to study the effects of wage expansions/moderations on labor productivity we change the specification of the model as follow:

$$\Delta y_{i,t+h} = \beta^h D_{i,t} + \sum_{j=1}^{p} \gamma_j^h \, \Delta y_{i,t-j} + \sum_{j=1}^{p} \theta_j^h X_{i,t-j} + \alpha_i^h + \delta_t^h + \varepsilon_{i,t+h} \qquad (3)$$

where $D_{i,t}$ is a dummy variable which is equal to 1 if there is a wage expansion/moderation in the country i at time t, and 0 otherwise (see definition of expansion/moderation in section 3.1). Again, the set of control variables $X_{i,t-j}$ contains the regressors of Sylos Labini's productivity equation different from the wage variable whose change is considered.

For our third empirical exercise, we divide manufacturing into eight sub-sectors for each country. The model used for the three-dimensional panel is as follows:

$$\Delta y_{i,k,t+h} = \sum_{j=0}^{p} \beta_j^h \Delta W_{i,k,t-j} + \sum_{j=1}^{p} \gamma_j^h \, \Delta y_{i,k,t-j} + \sum_{j=1}^{p} \theta_j^h X_{i,k,t-j} + \delta_{it}^h + \varepsilon_{i,k,t+h} \qquad (4)$$

where i, k and t index countries, sectors, and time, while δ_{it}^h are fixed effects constructed as country-year effects, i.e., holding countries fixed in each year and allowing comparisons between different sectors.[8] The within transformation which clears the bilateral fixed effects is thus $\left(y_{i,k,t} - \bar{y}_{i,t}\right)$ where $\bar{y}_{i,t} = 1/N \sum_k y_{i,k,t}$. As a robustness check we also try to see how the results change if we vary the type of fixed effect, and we get that all the results are basically confirmed.

Finally, we estimate equation (4) separately for each group of countries and assess whether spatial differences emerge in the analysis of the effects of the different determinants of labor productivity growth.

4. Results

4.1 Productivity determinants in total manufacturing

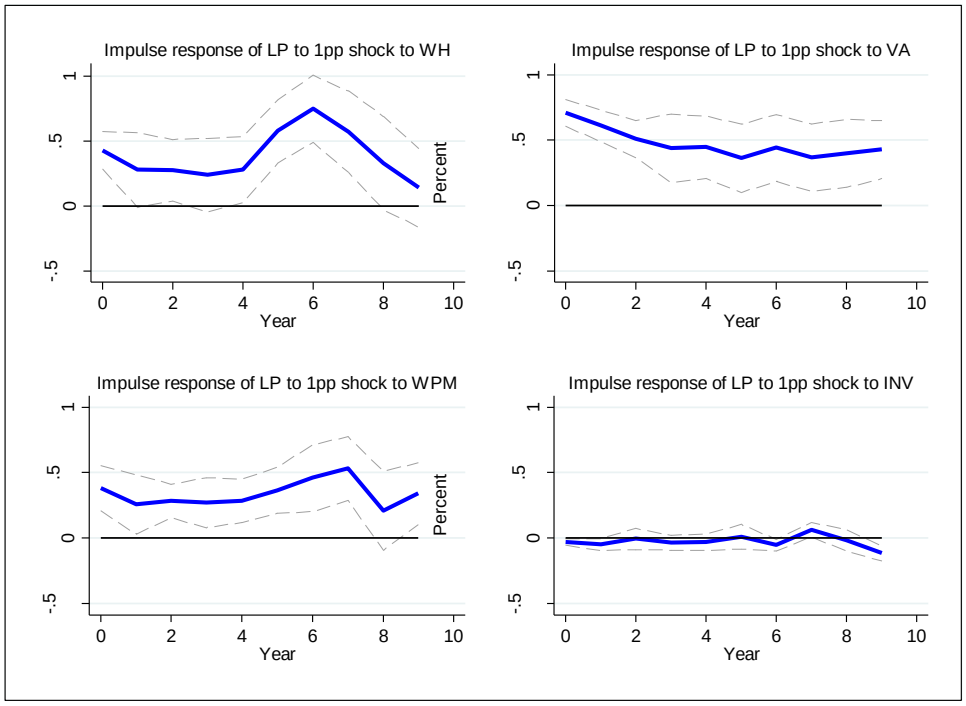
In the first step of our empirical analysis, we estimate four specifications of model (2), focusing on each regressor of the Sylos Labini's productivity equation. Our results, reported in Figure 1, confirm Sylos' insights (see also table A2 in the Appendix). All the determinants, except investment, exert positive and long-lasting effects on the growth of labor productivity. The organization effect is significant in the short to medium run, it reaches a peak around the 6th year (0.75 percent) and after that decreases. The 10-years cumulated effect is 4.0, while the average effect over 10 years is 0.4 percent. The mechanization effect tends to rise until the 7th year (0.53 percent) and presents a slightly lower cumulated (3.7) and average (0.3) effect on productivity. This means that a 1 percent increase in wage growth relative to finished goods prices or machinery prices generates an average increase of about 4% in cumulative productivity growth over 10 years (0.35% per year). Not surprisingly the strongest effect on productivity is the one arising from the growth of value added. Indeed, the Smith effect is significant at all time horizon and shows persistently high effects on productivity. The 10-

[7] For each variable of interest up to 3 lags were included to control for its lagged values (varying the number of lags does not substantially change the results).

[8] Adding the fixed effects of the third dimension (industry effect) does not substantially change the results.

year effect is around 0.72 percent while the 10-year cumulated effect is 5.4 and the average effect is 0.5. Finally, the effect of investment on productivity is barely significant: the 3-year effect is around -0.05, however on average the effect is negligible. This last result is in line with other findings in the literature (see Carnevali et al. 2020; Lucarelli and Romano, 2016; Sylos, 1984), where the effect of investment is found to be negligible or not significant.

Figure 1. Estimated effect on productivity growth of total manufacturing (two-way FE model).



Notes: The graphs display impulse-response functions for the effect on productivity growth of four determinants: hourly labor cost growth relative to changes in the general price level (WH), hourly labor cost growth relative to changes in machine prices (WPM), value added growth (VA), and the level of past investment (INV). They are obtained through local projections, controlling for country and time fixed effects, two lags of the dependent variable and using the other determinants as controls. Robust standard errors clustered by country. Years on the horizontal axis and percentage points on the vertical axis. Dashed lines denote 90 percent confidence bands.

The results of the second set of estimates obtained by estimating model (3) are reported in Figure 2 and Table A3 in the Appendix.[9] Our estimates show that episodes of sustained wage expansion have positive effects on productivity and, on the other hand, that prolonged wage moderation negatively affects productivity. It follows that even large and sustained wage changes exert a persistent effect on productivity that does not vary in sign over time. Confirming the direction of causality and the sign of the effect for both positive and negative shocks seems to contradict the idea that wage cuts are the best way to enhance competitiveness and productivity: not only does consistent and sustained wage growth boost productivity over time, but furthermore a prolonged wage moderation would be detrimental to productivity growth.

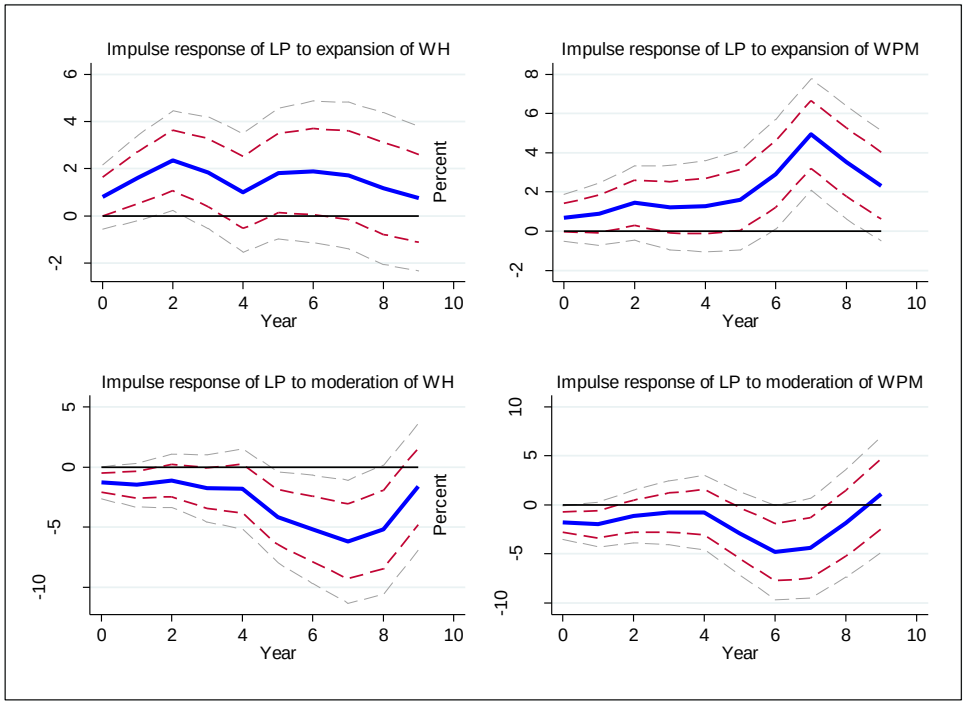
An asymmetrical behavior emerges for both indicators. The organization effect appears to have a more pronounced effect on productivity in episodes of moderate or negative growth than in expansionary phases. The effect of a positive shock peaks around the 2nd year (2.4 percent) and the average effect over the whole period is 1.5, while the average negative effect of wage moderation is -2.7. On the contrary, the mechanization effect presents a more pronounced impact in expansive

[9] Following Deleidi et al (2020), in Figure 2 we have also reported for these estimates error bands at one standard deviation, namely at 68% confidence bands.

phases than in moderate ones: it peaks in the 7th year (4.9 percent) and the average effect of positive shocks on productivity is around 2.0, while the effect of negative shocks is barely significant (-1.8 on average). This result seems to indicate that negative effect on productivity of intense wage moderation is most pronounced when wages fall in relation to the average price level, while stagnating wages in relation to machinery prices appear to have little effect on productivity dynamics. Conversely, the sharpest positive effect on productivity comes from the expansion of wages relative to the price of machinery and, thus, from the incentive to introduce labor-saving innovations.

This analysis allows also to highlight different timing of the two effects. In the case of negative shocks, the effect on productivity becomes more severe in the medium to long term, after at least 4 years. In the case of positive shocks, instead, a difference emerges between the two indicators, which has been already highlighted by Sylos himself. The expansion of wages in relation to the average price level has indeed a positive effect mostly in the short term and then decreases, while the positive effect of the expansion of wages relative to the price of machinery is higher in the medium to long run. The different behavior of the organization effect could be due to the fact that subsequent wage increases could induce firms, after an initial reorganization in the short term, to implement other labor-saving and productivity-enhancing strategies in the longer term; in the case of prolonged wage stagnation, on the other hand, firms would have an incentive to use labor extensively, turning an initial short-term reaction into standard practice (see Fontanari and Palumbo, 2022). This tendency will obviously be stronger the slower the growth of aggregate demand; if, instead, demand grows rapidly, the increase in output can be achieved both by increasing productivity and employment.

Figure 2. Estimated effects of expansions/moderations of wages on productivity growth of total manufacturing (two-way FE model).



Notes: The graphs display impulse-response functions for the effect on productivity growth of periods of expansion and moderation of labor costs. They are obtained through local projections, controlling for country and time fixed effects, two lags of the dependent variable and using the other determinants as controls. Robust standard errors. Years on the horizontal axis and percentage points on the vertical axis. Dashed grey lines and dashed red lines denote respectively 90 percent and 68 percent confidence bands.

4.2 Productivity determinants at the sectoral level

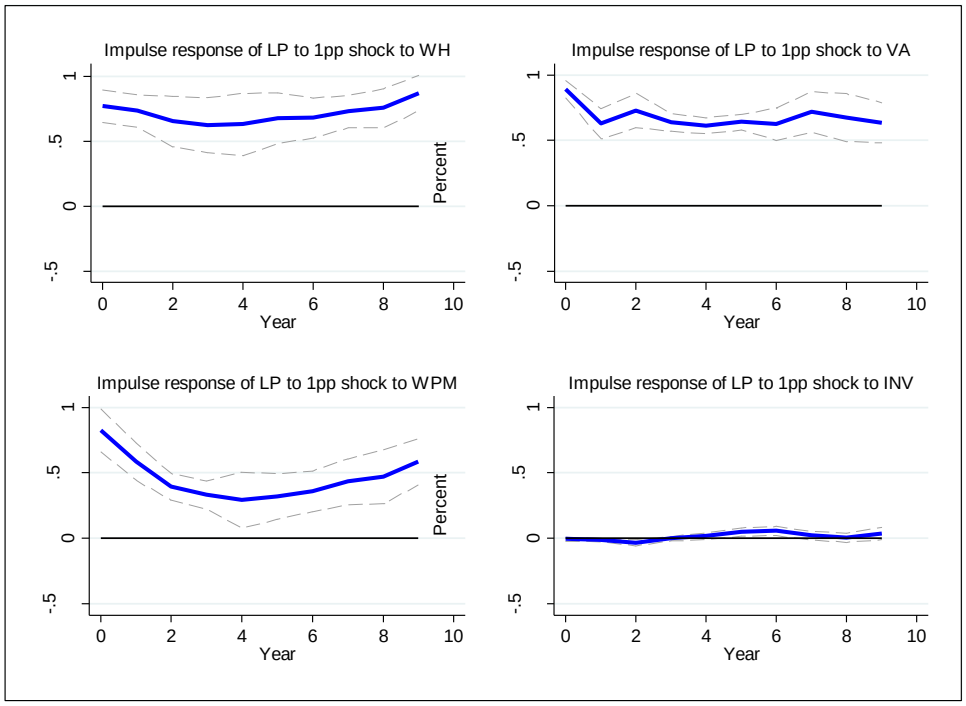
To assess whether the direct effect of wages on productivity is confirmed at a higher level of sectoral disaggregation, we apply the LP methodology to a three-dimensional panel. We estimate model (4) which, by holding countries fixed in each year, allows comparisons between different sectors. Figure 3 presents the results.

The estimated IRFs show that Sylos' insights are confirmed for the manufacturing sub-sectors as well. The organization effect exhibits a stable positive effect on sectoral productivity: the 9-th year effect is around 0.87 percent while the 10-year cumulated effect is 7.9 and the average effect is 0.7 (see also Table A4 in the Appendix). Hence when we shift the unit of analysis from total manufacturing to its subsectors, the average magnitude of this effect tends to almost double. The mechanization effect, on the other hand, has a decreasing trend in the first 4 years and then returns to increase. A 1 percentage point increase in the growth of this indicator generates, on average, a 0.5 increase in productivity growth, while its cumulative effect over ten years is around 5.1, somewhat higher than at the aggregate level. Confirmation of the positive effect of labor cost on productivity both at the country and sectoral level suggests that we are identifying a direct effect of wages: an increase in wages in a specific sector boosts productivity in that sector not only through the possible positive effect on aggregate demand, but also through the incentive to introduce innovations (organizational or labor-saving).

The Smith effect is also confirmed at the sectoral level. Market expansion generates an average effect of 0.7 percent and a 10-years cumulated effect of 7.5 on productivity growth, while the level of investment appears to have negative effects in the first 3 years and then become positive, albeit small on average (0.02 percent).[10]

Figure 3 - Estimated effects on productivity growth in eight manufacturing sectors

[10] We assess possible differences in the response of productivity to the considered shocks depending on the dimension kept fixed. If we use different formulations of fixed effects, all results are essentially confirmed and only some differences in the trends of IRFs emerge (see Figure A1 in the Appendix). Hence, the results indicate that the impact of the analyzed variables is confirmed in each case: when heterogeneity is considered across countries, across sectors, and across years. However, the path of the response of productivity growth to the growth of its determinants may vary depending on the dimension held fixed. When the within transformation is based on each sector in each country, thus the effect is identified by the variability over the years, the trend of IRFs is decreasing for all determinants (except investment).



Notes: The graphs display impulse-response functions for the effect on productivity growth of four determinants: hourly labor cost growth relative to changes in the general price level (WH), hourly labor cost growth relative to changes in machine prices (WPM), value added growth (VA), and the level of past investment (INV). They are obtained through local projections, controlling for bilateral country-year fixed effects, two lags of the dependent variable and using the other determinants as controls. Estimates are made for 8 sub-sectors of manufacturing. Robust standard errors clustered by country. Years on the horizontal axis and percentage points on the vertical axis. Dashed lines denote 90 percent confidence bands.

4.3 Spatial disparities: a comparison between core, peripheral and East-European countries

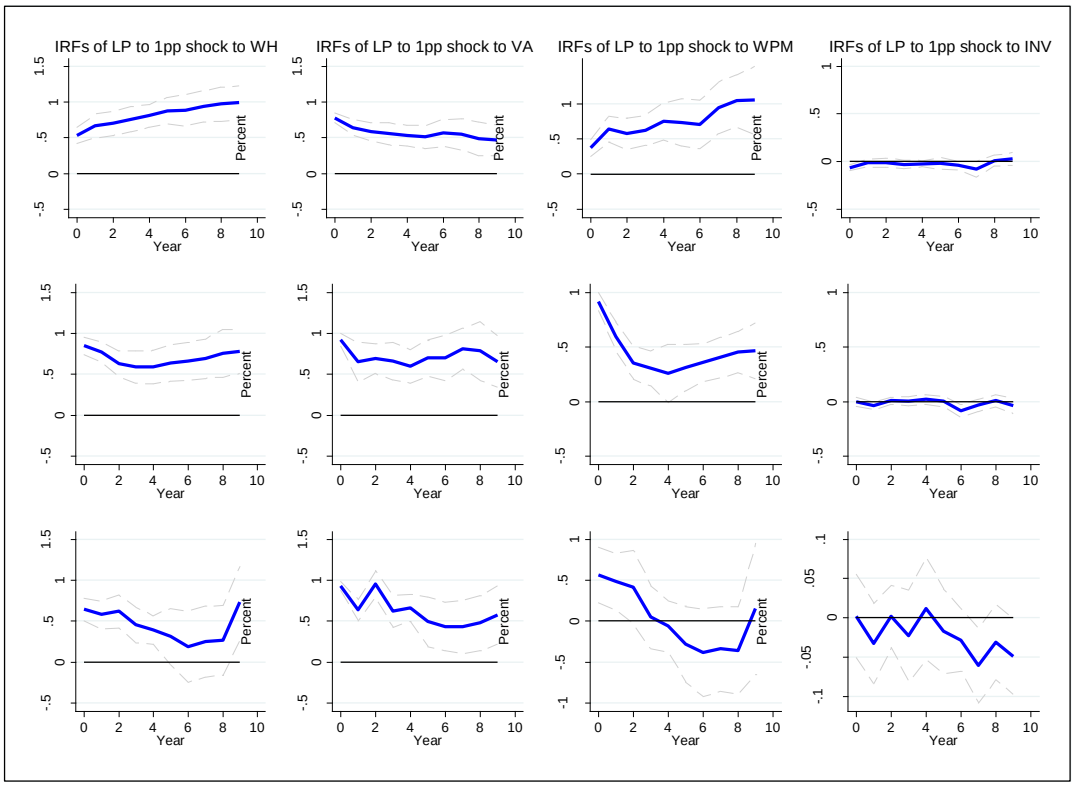
As a final step of our analysis, we now focus on the different productivity trends of periphery, core and East-European economies. The first group includes the Mediterranean countries (i.e., Italy, Greece, Spain Portugal), the second group includes the two leading European nations (Germany and France) and other EA members that are related to these economies (Austria, Belgium, Netherlands) plus Finland, the third group include some Eastern European countries (Estonia, Lithuania, Slovak Republic, Slovenia). On closer inspection, the latter group could be defined, following Celi et al. (2018), as a "new periphery". Indeed, the economies of Eastern European countries are strongly intertwined with that of Germany, which has reaped the benefits of wage cuts and productive outsourcing to these countries. Unlike the southern periphery, the eastern periphery has therefore become part of a value chain, predominantly in manufacturing, based in Germany, expanding and strengthening its production base (see Celi et al., 2018).

Since the mid-1990s, many Eastern European countries have been given the opportunity to integrate into the supply chains of the EU countries. As described by Celi et al. (2017), the gradual elimination of barriers to trade and investment, but not to labor, has generated incentives to outsource to Eastern European countries only some stages of manufacturing activity, favoring the more labor-intensive ones. German industry, in particular, has invested heavily in neighboring countries, integrating new industries into its value chain. In so doing, de-localization to emerging Europe would have actually contributed to job creation in the home country, supporting productivity in the manufacturing sector and contributing to the decline in Germany's relative ULC (see Celi at al. 2017).

The estimated IRFs for each country group of the indicators in Sylos Labini's productivity equation are shown in Figures 4. We perform model (4) estimates for each determinant of productivity

growth, using both the bilateral country-year fixed effect and the bilateral industry-year fixed effect (for ease of reading we report here only the results of the former formulation, as sector-level relationships are our main focus, and no substantial differences emerge). Starting with the organization effect, its positive impact on productivity growth is confirmed for all groups. The 10-years cumulated effect is higher in northern and eastern countries (respectively 9.0 and 7.7), while in southern countries the cumulated effect is almost halved (4.7). However, while in the core countries the response of productivity to a positive absolute wage shock is increasing over the years, in the eastern countries it is essentially constant and in the southern countries it is decreasing, except for the last years. The peak of this effect is respectively for each group 0.99 percent in the 9th year, 0.85 percent in the 1st year, and 0.73 percent in the 9th year (see Table A5 in the Appendix).[11]

Figure 4. Estimated effects on productivity growth in eight manufacturing sectors of three groups of countries



Notes: The graphs display impulse-response functions for the effect on productivity growth of four determinants: hourly labor cost growth relative to changes in the general price level (WH), hourly labor cost growth relative to changes in machine prices (WPM), value added growth (VA), and the level of past investment (INV). They are obtained through local projections, controlling for bilateral country-year fixed effects, two lags of the dependent variable and using the other determinants as controls. Estimates are made for 8 sub-sectors of manufacturing and separate for three groups of countries: core, eastern and southern countries. Robust standard errors clustered by country. Years on the horizontal axis and percentage points on the vertical axis. Dashed lines denote 90 percent confidence bands.

[11] It may be interesting to note that when the impact is defined in terms of deviation from the average among countries for each sector in each year, i.e., when considering fixed industry-year effects, the differences among the three country groups are less apparent, meaning that sector-varying common factors account for a very large share of the observable differences between country groups.

The incentive to introduce labor-saving innovations resulting from the increase in labor costs relative to machinery prices exerts a positive and increasing effect on the productivity of core countries, with an average effect around 0,8 percent, close to the effect of the other labor cost indicator. The positive mechanization effect in the countries of the new periphery decreases dramatically after the first 2 years and then stabilizes around an average value of 0.37 percent, almost half the organization effect. In the Mediterranean countries, the effect of the relative cost of labor on productivity is instead significant only in the first 2 years and then becomes non-significant and negative with a 10-years cumulated effect of -0.2 and a null average effect over ten years.

The more persistent effect in core countries can be explained by the fact that research intensity is higher in these countries. In a dynamic environment, manufacturing firms may be more willing (and able) to replace workers with machines when the growth rate of wages exceeds the growth rate of machine prices (for a similar result see Carnevali et al., 2020). The decline in the initial benefit in Eastern countries could be explained by the interlinkage between their manufacturing industry and that of other core countries, especially Germany. Indeed, it is possible that lower labor costs encourage the introduction of innovations but that the benefits of this in terms of value added produced are not seen in the country itself. This would be especially true for those sectors that cover the intermediate stages of production processes. Conversely, the organization effect – and thus the introduction of organizational innovations - is more relevant in boosting productivity. In southern countries the mechanization effect is non-significant, indicating that in most sectors the increase in relative labor costs does not translate into productivity gains. This probably reflects the general lower ability of these countries to react to increases in labor costs through the introduction of innovations (see also Lucarelli and Romano, 2016). For peripheral countries the organization effect is therefore more relevant, apparently because the easiest way to increase productivity is to reorganize the workforce through, rather than to introduce innovations. Looking from the negative side, the greater sensitivity to the organization effect can also be seen as a greater tendency in these countries to cut wages in order to strengthen competitiveness, causing instead negative effects on productivity.

The positive effect on productivity of a market expansion is confirmed for all the different groups of countries. The effect is strongest in the first two years and then tends to settle at a constant value just below the initial impact. Only in the case of Eastern European countries is the trend in IRFs slightly increasing. The average impact of the growth of value added is 0.6 percent for core and peripheral countries, while it is 0.7 percent for the eastern countries (a value of the Kaldor-Verdoorn effect that differs between countries at different stages of development has also been found in other work, see for example Deleidi et al., 2022)

Comparisons across country groups also confirm that the past level of investment does not seem to have a major effect on productivity growth. Striking although not significant, in Figure 4, is the decreasing trend of IRF when estimating the effect for southern countries.

5. Robustness analysis: Nickell bias

We now address the problem of the inconsistency of FE in dynamic panel data models. In a dynamic panel, lags of the dependent variable are correlated with the error by construction, and this generates an estimation bias that is called Nickell bias (see Nickell, 1981). Several different techinques may be used to construct a debiased FE estimator (see Chen et al., 2019). We implement the split-sample method to remove the bias. To do so, we determine the partition of the data by splitting the panel along the time series dimension because the source of the bias is the estimation of the unit fixed effects. Once we have divided the sample into two parts, we compute the estimator on the two parts and we obtain the mean of the estimated coefficients. We then calculate the unbiased effect as:

$$\check{\beta} = \hat{\beta} - (\bar{\beta}_{1,2} - \hat{\beta})$$

Where $\hat{\beta}$ is the estimated coefficient for the whole sample while $\bar{\beta}_{1,2}$ is the mean of the estimated coefficients of the two sub-samples.

We apply this methodology to the estimates for total manufacturing (section 4.1) and we focus on the contemporaneous effects β^0 of the determinants of productivity. Results are reported in Table 1 below.

Table 1. Results of the split-sample method for Nickell's bias correction – contemporaneous effect				
	Coefficients of labour productivity determinants			
	WH	WPM	VA	INV
biased	0,43	0,38	0,71	-0,03
unbiased	0,44	0,41	0,72	-0,03
	Expansions		Moderations	
	WH	WPM	WH	WPM
biased	0,8	0,7	-1,3	-1,8
unbiased	1,6	1,2	-0,1	-2,3

Concerning the first set of estimates, the results show that the bias is very small and determines a slight underestimation of the effects, all of which remain, however, confirmed. Yet, when looking at the effects of expansions/moderations of wages on productivity, the bias is more relevant. The positive effect of prolonged wage expansions, measured with both indicators, is almost doubled when adjusted for Nickell's bias; the same is true for the negative effect of relative labor cost moderation which is significantly more intense than the biased estimated effect. Conversely, the contemporaneous effect of absolute labor cost moderation results overestimated.

6. Conclusion

Our paper contributes to the debate on the determinant of productivity growth from a post-Keynesian perspective, in which economic growth is conceived as driven by aggregate demand, that plays a central role in determining both output and resource growth, and productivity dynamics is seen as largely endogenous to output growth. Within this theoretical framework, we have particularly focused on the possible direct effects of the growth of wages on productivity growth, seeking to identify this relationship at both the aggregate and sectoral levels, and evaluating the effect of large and lasting wage changes and possible spatial differences. Consistent with the principle that no automatic mechanism ensures to fully use available resources, we regard costs, and especially labor costs, as possible economic impulses that stimulate innovations and thus labor productivity, and that may act not only indirectly, through their effect on aggregate demand, but also directly. Based on Sylos Labini's contribution, we identified two direct effects, the mechanization and the organization effect, which act through the stimulus that an increase in wages represents for the introduction of technical innovations and organizational innovations, respectively.

Using the Local Projection technique, we estimate the determinants of labor productivity within a sample of 14 EA member states over the period 1995–2018. Estimates are made both at the aggregate level, by comparing manufacturing sectors in different countries, and at the disaggregate level, applying the analysis to a three-dimensional panel dataset of 8 sub-sectors for each country. By defining periods of sustained wage growth and wage moderation, we also analyze the possible asymmetrical nature and different timing of the effect of wages on productivity. Finally, we focus on the divergent dynamics of core, east European and peripheral countries.

Our findings confirm Sylos Labini's main insights. Labor productivity in manufacturing industries across countries is positively affected by the extent of the market (Smith effect), the relative cost of labor (mechanization effect) and the absolute cost of labor (organization effect), while the effect of past and present investment tend to offset each other. All these relationships are also confirmed at a higher level of disaggregation. By shifting the unit of analysis from the entire manufacturing to the individual subsector, we ensure that we capture a *direct* effect of wages, whereby an increase in wages in a specific sector increases productivity in that sector, and not an *indirect* effect, whereby higher wages in some subsectors could lead to an increase in demand that results in higher productivity even in subsectors where wages have not increased.

We find that episodes of both sustained wage expansion and sustained wage moderation exert a persistent effect on productivity that does not vary in sign over time. On the one hand, this result allows to rule out the possibility that intense wage growth could be detrimental to productivity growth in a longer run (because it could, for example, erode competitiveness); on the other hand, it shows that prolonged wage moderation is detrimental to productivity growth, and thus confutes the widespread idea that wage cuts are the best way to increase competitiveness and productivity.

An asymmetrical behavior emerges for both indicators. The organization effect seems to have a more pronounced effect on productivity in moderate or negative growth episodes, while the mechanization effect has a more pronounced impact in expansionary phases. Thus, the negative effect on productivity of intense wage moderation seems to be more pronounced when wages fall relative to the average price level (and not as much relative to machinery prices); in contrast, the most pronounced positive effect on productivity comes from the expansion of wages relative to machinery prices and, therefore, from the incentive to introduce labor-saving innovations. A different timing of the effects of the measures of labor cost also emerges, confirming the findings of Sylos (1984). In the case of positive shocks, the organization effect acts mainly in the short run and then weakens, while the mechanization effect is greater in the medium to long run. In the case of negative shocks, the effect of both measures of labor costs becomes more severe in the medium to long run.

Our findings hold for all the groups of countries. Yet, while the positive effect on productivity of market expansion is equally confirmed for all the different groups of countries, some spatial disparities emerge for the effect of labor cost. In core countries, the response of productivity to positive wage shocks is persistent and increasing over the years: both the organization and the mechanization effect are indeed strong and long-lasting. In contrast, the effect is weaker and less persistent for the two peripheries, which also show a predominance of the organization effect over the mechanization effect. In the countries of the new periphery, the mechanization effect decreases dramatically after the first years and it is almost half the organization effect, which exerts instead a constant positive effect over time. The effect of the relative cost of labor in the Mediterranean countries is significant only in the first years and then becomes non-significant, while the absolute cost of labor exerts a significant, although decreasing, effect on productivity. Productivity of both eastern and southern countries seem to be more sensitive to changes in the absolute cost of labor, probably because the easiest way to increase productivity in those countries is to reorganize the workforce rather than to introduce innovations. Instead, the more persistent effect of wage shocks in core countries can be explained by a higher research intensity, which would result in a general higher ability of these countries to react to increases in labor costs through the introduction of innovations (see Lucarelli and Romano, 2016; Carnevali et al., 2020).

Our analysis suggests that a strategy of growth based on structural reforms aimed at increasing productivity and competitiveness by containing labor costs is in danger of failing in his own purpose and achieving, indeed, the opposite effect. Policies that address a higher growth of wages, on the contrary, would be more effective in improving long-term growth since not only act as a stimulus for demand growth, but also provide an incentive for firms to innovate and thereby increase their productivity.

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APPENDIX

Table A1. Data description				
Variable	**Name**	**Frequency**	**Unit/measure**	**Source**
$\boldsymbol{Y_{i,t}}$	Real Value Added	Annual	Millions of Euros	STAN OECD
$\boldsymbol{W_{i,t}}$	Labor costs (compensation of employees)	Annual	Millions of Euros	STAN OECD
$\boldsymbol{H_{i,t}}$	Total Hours	Annual	Millions of hr	STAN OECD
$\boldsymbol{I_{i,t}}$	Real Gross Fixed Capital Formation	Annual	Millions of Euros	STAN OECD
$\boldsymbol{P_t}$	Value Added Deflator	Annual	Index	STAN OECD
$\boldsymbol{Pm_{i,t}}$	Implicit Deflator of Investment in Machinery and Equipment	Annual	Index	Capital formation by activity, OECD
$\boldsymbol{\pi_{i,t}}$	Labor productivity	Annual	Real value added per hour worked	Authors' calculation
$\boldsymbol{(W/P)_{i,t}}$	Organization effect	Annual	Real labor cost per hour worked	Authors' calculation
$\boldsymbol{(W/P_m)_{i,t-n}}$	Mechanization effect	Annual	Real relative labor cost per hour worked	Authors' calculation

Table A2. Estimated effects on productivity growth of total manufacturing (two-way FE model)				
	WH	WPM	VA	INV
year 0	0,43***	0,38**	0,71***	0,01
year 1	0,28	0,26*	0,61***	-0,02
year 2	0,28*	0,28**	0,51***	-0,05**
year 3	0,24	0,27**	0,44**	-0,03
year 4	0,28*	0,29**	0,45**	-0,03
year 5	0,58**	0,37**	0,36**	-0,05
year 6	0,75***	0,46**	0,44**	0,01
year 7	0,57**	0,53**	0,37**	-0,03
year 8	0,33	0,21	0,40**	0,06
year 9	0,14	0,34**	0,43**	0,03
year 10	0,09	0,27*	0,72**	-0,03
Cumulated	**4,0**	**3,7**	**5,4**	**-0,1**
Average	**0,4**	**0,3**	**0,5**	**0,0**

Table A3. Estimated effects of expansions/moderations of wages on productivity growth of total manufacturing (two-way FE model)				
	expansions		moderations	
	WH	WPM	WH	WPM
year 0	0,81	0,69	-1,29	-1,77*
year 1	1,62	0,89	-1,48	-1,99
year 2	2,35*	1,45	-1,12	-1,15

year 3	1,84	1,22	-1,76	-0,79
year 4	0,99	1,29	-1,79	-0,76
year 5	1,81	1,60	-4,16*	-2,89
year 6	1,87	2,92*	-5,16*	-4,83
year 7	1,72	4,93***	-6,18**	-4,39
year 8	1,17	3,52**	-5,18	-1,86
year 9	0,75	2,32	-1,59	1,12
year 10	1,46	1,33	-0,21	-0,90
Cumulated	**16,39**	**22,16**	**-29,9**	**-20,2**
Average	**1,5**	**2,0**	**-2,7**	**-1,8**

Table A4. Estimated effects on productivity growth in eight manufacturing sectors

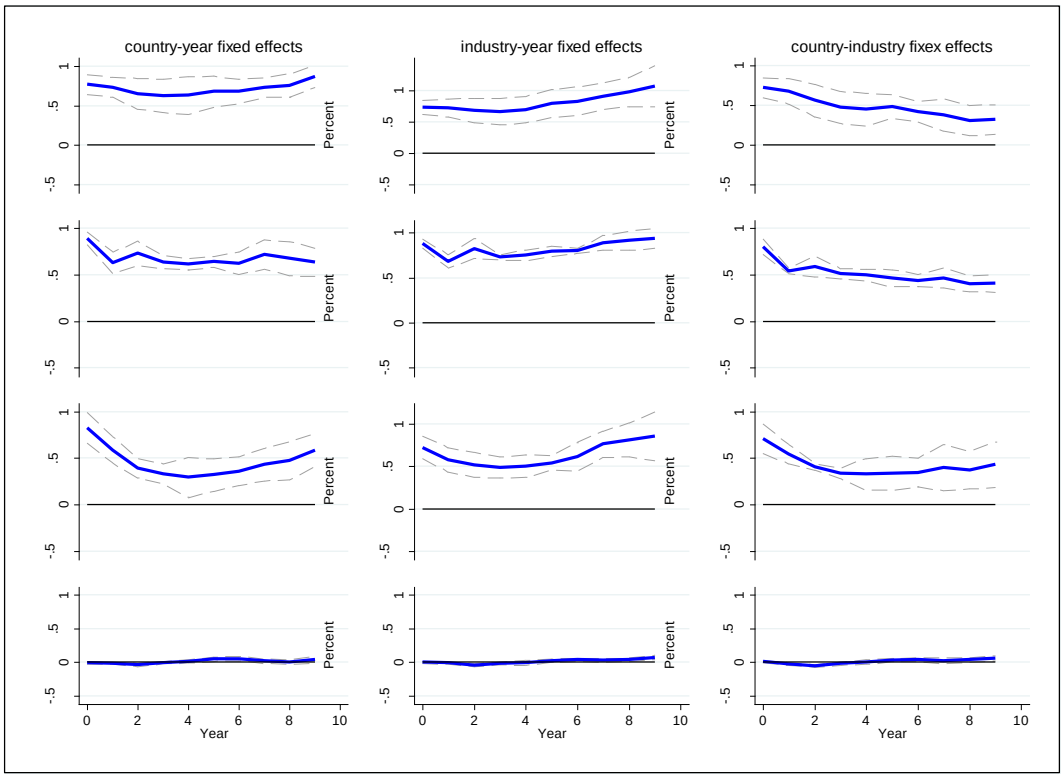
	WH	WPM	VA	INV
year 0	0,77***	0,83***	0,89***	-0,01
year 1	0,74***	0,59***	0,63***	-0,01*
year 2	0,66***	0,39***	0,73***	-0,03**
year 3	0,63***	0,33***	0,64***	0,00
year 4	0,63***	0,29**	0,61***	0,02
year 5	0,68***	0,32**	0,64***	0,05**
year 6	0,68***	0,36**	0,63***	0,06**
year 7	0,73***	0,43***	0,72***	0,02
year 8	0,76***	0,47**	0,68***	0,01
year 9	0,87***	0,59***	0,64***	0,04
year 10	0,80***	0,47**	0,70***	0,04
Cumulated	**7,9**	**5,1**	**7,5**	**0,17**
Average	**0,7**	**0,5**	**0,7**	**0,02**

Table A5. Estimated effects on productivity growth in eight manufacturing sectors of Core, Peripheral and Est-European countries

	WH			WPM			VA			INV		
	North	East	South	North	East	South	North	East	South	North	East	South
year 0	0,53***	0,85***	0,64***	0,37***	0,91***	0,56***	0,78***	0,92***	0,93***	-0,1***	0,0	0,0
year 1	0,66***	0,77***	0,58***	0,64***	0,60***	0,49**	0,64***	0,65***	0,64***	0,0	0,0*	0,0
year 2	0,70***	0,63***	0,62***	0,57***	0,36***	0,41	0,59***	0,69***	0,95***	0,0	0,0	0,0
year 3	0,76***	0,59***	0,45**	0,62***	0,31**	0,05	0,56***	0,66***	0,62***	0,0	0,0	0,0
year 4	0,81***	0,59***	0,39***	0,74***	0,26	-0,06	0,53***	0,60***	0,66***	0,0	0,0	0,0
year 5	0,88***	0,64***	0,31	0,73**	0,31**	-0,28	0,51***	0,70***	0,49**	0,0	0,0	0,0
year 6	0,89***	0,66***	0,19	0,71**	0,36**	-0,39	0,57***	0,70***	0,43**	0,0	-0,1**	0,0
year 7	0,94***	0,69***	0,25	0,94***	0,40**	-0,34	0,55***	0,81***	0,43**	-0,1	0,0	-0,1**
year 8	0,97***	0,76***	0,27	1,04***	0,46**	-0,36	0,48**	0,78**	0,48**	0,0	0,0	0,0
year 9	0,99***	0,78***	0,73**	1,05***	0,47**	0,16	0,47***	0,65**	0,57**	0,0	0,0	0,0
year 10	0,88***	0,77**	0,29	1,38**	0,38	-0,2	0,52***	0,72**	0,33	0,0	0,0	-0,1**
Cumulated	**9,0**	**7,7**	**4,7**	**8,8**	**4,8**	**0,1**	**6,2**	**7,9**	**6,5**	**-0,2**	**-0,2**	**-0,3**
Average	**0,8**	**0,7**	**0,4**	**0,8**	**0,4**	**0,0**	**0,6**	**0,7**	**0,6**	**0,0**	**0,0**	**0,0**

Table A6. Estimated effects on productivity growth of total manufacturing using – reverse causation correction				
	Adjusted estimates		Unadjusted estimates	
	WH	WPM	WH	WPM
year 0	0,48***	0,47***	0,43***	0,38**
year 1	0,31**	0,24*	0,28	0,26*
year 2	0,23*	0,22**	0,28*	0,28**
year 3	0,32**	0,35**	0,24	0,27**
year 4	0,34**	0,29**	0,28*	0,29**
year 5	0,54***	0,25	0,58**	0,37**
year 6	0,74***	0,39**	0,75***	0,46**
year 7	0,35*	0,28**	0,57**	0,53**
year 8	0,40**	-0,01	0,33	0,21
year 9	0,46**	0,44**	0,14	0,34**
year 10	0,26	0,06	0,09	0,27*
Cumulated	**4,4**	**3,0**	**4,0**	**3,7**
Average	**0,4**	**0,3**	**0,4**	**0,3**

Figure A1. Estimated effects on productivity growth with different fixed effects formulations



Notes: The graphs display in each line impulse-response functions for the effect on productivity growth of four determinants: hourly labor cost growth relative to changes in the general price level (WH), hourly labor cost growth relative to changes in machine prices (WPM), value added growth (VA), and the level of past investment (INV). They are obtained through local projections, controlling for two lags of the dependent variable, and using the other determinants as controls. Each column shows estimates with different forms of fixed effects. Estimates are made for 8 sub-sectors of manufacturing. Robust standard errors clustered by country. Years on the horizontal axis and percentage points on the vertical axis. Dashed lines denote 90 percent confidence bands.