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Permanent Scars: The Effects of Wages on Productivity

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ABSTRACT

This paper explores how stagnating real wages may have contributed to the slowdown of US productivity. Through shift-share analysis, we find that after a sharp change in distribution against wages, some historically high-productivity sectors (like manufacturing) switched towards slower productivity growth. This supports our hypothesis that the anemic growth of productivity may be partly due to the trend toward massive use of cheap labor. Our estimation of Sylos Labini's productivity equation confirms the existence of two direct effects of wages, one acting through the incentive to mechanization and the other through the incentive to reorganize labor use. We also show that labor 'weakness' may exert a further negative effect on labor productivity. On the whole, we find that a persistent regime of low wages may determine very negative long-term consequences on the economy.

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1. Introduction

The United States and most other advanced economies have been characterized in recent decades by a disappointing growth performance and a slow growth of labor productivity (Baily et al., 2020). In much literature, the two trends are closely associated, since mainstream theory generally sees productivity growth as a prominent cause of output growth. In its turn, the slow dynamics of productivity – regarded as exogenous to output growth – may have multiple explanations. Most fall back either on pure technological reasons or some institutional incapability of the economy to exploit its innovation potential (see for example Gordon 2016). Productivity growth is essential, the mainstream account argues, in determining the growth of living standards, which implies that sluggish productivity growth is seen as a relevant cause (although not necessarily the only one) of the slow growth of wages observed in the last decades.

In this paper we focus on the productivity slowdown and the parallel stagnation in wages, starting however from a demand-led growth perspective, in which aggregate demand, in contrast to mainstream accounts, has a prominent role in determining both output growth and the growth of resources. Reversing the mainstream causation, this view, though it acknowledges the impact of exogenous factors, emphasizes how the dynamics of productivity is heavily affected both by output growth and by the growth of wages.

Recent literature on the demand-led growth approach has emphasized two – not necessarily opposing – explanations of the productivity slowdown. The first one (Storm 2017, Taylor and Ömer 2020) focuses on structural factors, i.e., on the growing weight, in the production mix of advanced economies in the last decades, of low-productivity sectors at the expense of high-productivity and high-wage sectors (like manufacturing). Structural change implies an aggregate distributional shift against wages, which also adversely react on the growth of aggregate demand. The second explanation (see for example Fazzari et al 2020, Deleidi et al 2020, Storm 2017) emphasizes the endogeneity of productivity growth in relation to the growth of aggregate demand. Endogeneity is primarily analyzed through the so-called 'Kaldor-Verdoorn effect', which postulates a dependence of productivity growth on the growth of output through the action of induced technical progress that generates dynamic increasing returns.

Our contribution has both a theoretical and an empirical purpose. In regard to the first, we review the notion of productivity in the demand-led growth approach. We argue that, in this theoretical framework, productivity should not be interpreted merely as a measure of technological knowledge but also as a reflection of the intensity of the use of resources, an intensity which is determined endogenously by the conditions in which the economy operates. We use this notion to analyze the possible endogeneity of productivity growth to the dynamics of wages, which constitutes the main focus of our analysis.

Our analysis starts from a conception of distribution (inspired by the classical political economy of Smith, Ricardo and Marx) as affected by social and institutional forces that are at least in part exogenous both to output growth and to productivity growth. In this context, we maintain that the trend of wages may exert an influence on productivity not only indirectly, by fostering or depressing aggregate demand, but also directly. We especially take inspiration from the contributions of Paolo Sylos Labini (1984, 1993). Sylos Labini identified two direct effects of wages on productivity, one acting through induced technical progress – labor-saving innovations fostered by high wages – and a second one acting through the incentive that high wages represent towards a more efficient use of the labor input through re-organization of the production processes. The two direct effects of wages on productivity are labeled respectively the 'mechanization' and the 'organization' effects.

Our hypothesis is that these two effects of wages have each contributed to the productivity slowdown. The dramatic distributional shift against wages that has taken place in recent decades[1] has, in our view, reduced the incentive for technical innovation, at least in some sectors or sub-sectors of the economy. Moreover, it has constituted a strong incentive for firms in different sectors to build their business strategies by taking advantage of the mass availability of low-wage labor. As we shall see in more detail below, the reorganization has resulted in the profound transformation of business models, with some firms expelling labor by resorting to various forms of outsourcing and subcontracting, and many others (usually direct or indirect suppliers to the largest ones) making instead massive use of labor, generally with lower wages and fewer benefits (Weil, 2014). While in some cases this also implies longer working hours for the individual worker, in other cases the multiplication of hours worked is spread among many part-time jobs. This has contributed, in our view, to a slowing down of measured hourly productivity in the economy at large.

Our second purpose is to test empirically our theoretical hypothesis by using data on the US economy. We assess first the role of structural change. By applying a shift-share analysis to US data on the 1992-2018 period, we propose a sectoral decomposition across twenty sectors not only of the change in labor productivity, but also, as an original addition to the literature, of the change in wages. With a different technique, we also analyze the sectoral contribution to the change in the wage-productivity gap. We find that structural change may explain only a minor part of the weak dynamics of productivity, which is mainly due to factors acting *within* each sector. We also find a first possible confirmation of our main hypothesis about the possible direct effect of wages on productivity: the most relevant drop in productivity growth materializes after the occurrence of a sharp distributional shift against wages in the 2000-2008 period.

We then estimate on US data the 'productivity equation' originally proposed by Sylos Labini. The Sylos equation focuses on the wage-productivity nexus, but also allows a control for the effects on productivity both of aggregate demand and investment. Moreover, it distinguishes between the mechanization effect and the organization effect of wages, by taking into consideration two different relative prices of labor and taking advantage of the lag structure. We estimate the equation at the sectoral level on a panel of 19 US manufacturing sub-sectors over the period 1950-2018. After addressing issues of causality and

[1] Both the size and the systematic character of such shift have induced Taylor and Ömer (2020) to describe it in terms of 'wage repression'.

potential endogeneity, we find confirmation of the hypothesis that wages exert direct effects on productivity. Both the mechanization effect and the organization effect prove positive and significant in our data. By negatively affecting productivity, it turns out, low wages inflict long-run damage to the economy.

As a final point, we also try to test a potential negative effect of labor 'weakness' on productivity, by augmenting the Sylos equation with two indicators that we find in the literature as possible measures of such weakness, i.e. the ratio between temporary lay-offs and permanent job losses, and the long-term unemployment rate. Both indicators, we find, significantly affect productivity growth.

The paper is structured as follows. Section 2 is devoted to theoretical discussion. In section 3 we present the data on US labor productivity and address the possible role of structural change through the above-mentioned decomposition analyses. Section 4 presents our estimate of the Sylos Labini productivity equation, both in its original specification and with the addition of the indicators of labor weakness. Section 5 sums up the results.

2. The notion and measurement of productivity in the demand-led growth approach

According to a very general definition, productivity represents the 'efficiency at which inputs are turned into outputs' (Baily and Montalbano 2016, p. 2). Different theoretical frameworks, however, offer not only different explanations of the determinants of productivity and its relationship with output growth, but even different definitions and measures of the notion itself.

Mainstream theory sees economic growth as determined and limited by the growth of resources and the evolution over time of their productivity, the latter essentially due to the pace and quality of technical progress. This conception of growth is based on the idea that the economic system tends spontaneously to reach, at least averaging across fluctuations, an equilibrium between supply and demand at the level where all available resources are fully utilized, lacking any demand-side constraint, in the long period, on output growth. In this perspective, economic growth describes a long-run path in which the system gravitates towards positions of full employment (or, equivalently, equilibrium unemployment), and the fundamental constraints that the increase in output may encounter over time are supply constraints.

It follows that along its growth path the system tends normally to operate close to the efficiency frontier. This is represented through the neoclassical production function, defined by Prescott (1988 p. 532) as the 'cornerstone' of the theory, also commonly used in applied aggregate analyses. At each moment of time, the production function represents the level of output that can be obtained through efficient combinations of the available inputs, based on available technical knowledge. The change in productivity over time is thus seen as the effect of technical improvements, essentially in the form of innovations aimed at saving inputs per unit of output.[2]

The Post-Keynesian or demand-led growth approach offers an entirely different perspective. No spontaneous mechanisms ensure the tendency of the economic system towards full employment since aggregate demand both constrains output in each single period and determines the long-run path of growth. Reversing the direction of causation with respect to the mainstream account, the accumulation of resources over time is seen as the effect rather than the cause of output growth. In each period, there is no guarantee that the resources that have been accumulated on the basis of previously expected demand are actually fully utilized. In other words, the growth trajectory need not coincide with the optimal use of resources and especially with full employment of labor.[3] Instead the growth path is a sequence of actual realizations, with the path of potential output heavily influenced by (but not coincident with) the growth path of actual output. In this perspective, it is always possible to say that the level of output corresponds to the amount of inputs (employed, rather than available) and the efficiency with which they are combined. Resources and efficiency, however, do not *explain* the achieved level of production but are rather the *result* of it. Phases of strong demand induce both resource accumulation and the adoption of technical innovations which increase the production capabilities of the system. Moreover, given the possibility of systematic underutilization of resources, efficiency may be increased not only through technological advancement but also because a higher level of demand and production allows the system, in each period, to get closer to the efficiency frontier. The ways in which productivity may be endogenously affected by demand will be discussed in some more detail in section 2.1.

A further difference between the two approaches has to do with the indicators employed and their interpretation. The simplest productivity measure is labor productivity, usually defined as output per hour worked. Mainstream theory, however, defines and employs largely a second indicator, called 'multifactor productivity' or 'total factor productivity' (TFP), theoretically defined as the output obtained for each unit of a composite input representing all the inputs used in the economy. Such measure should represent the best approximation to technological efficiency (precisely, to the sort of technical efficiency that is not embodied in productive resources).[4] Its measurement relies however on a series of very strict hypotheses, which include constant returns to scale and the validity of the marginalist theory of distribution.

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[2] If in the traditional version of the neoclassical model of growth (Solow 1956) technical progress was seen as entirely exogenous not only to output growth but also to the growth of resources, later models of endogenous growth (Romer 1994, Lucas 1988, Rebelo 1991) have emphasized its dependence on capital accumulation. Thus, the dynamics of productivity are seen as exogenous to output growth, and attributable to such supply-side factors as the economy's capability for innovation, investments in human capital and knowledge.

[3] As regards the stock of capital, this is accumulated by firms on the basis of expected demand aiming at the minimum production costs. There is no automatic guarantee, however, that all capacity installed is used in each period. It is precisely such possible different-from-normal utilization that triggers the mechanism of adjustment of capacity to demand.

[4] Reference is to the so-called neutral variety of technical progress that supposedly induces shifts in the production function without affecting the marginal rates of substitution but simply affecting the output attainable from given inputs (see Solow, 1957, p. 312).

These allow interpreting the observed income shares of labor and capital as good approximations of the corresponding output elasticities of a Cobb-Douglas production function representing the economy's aggregate production, so that the residual of the regression of actual output growth on the growth of capital and labor weighed by the respective shares is identified with TFP growth and regarded as a proxy of the growth of technological efficiency.[5]

The literature has highlighted several critical issues related to this indicator. Even from a neoclassical standpoint, the pervasive presence in reality of variable returns points to the unrealism of the hypotheses required to define the TFP. Moreover, Felipe and McCombie (2014) show that, although the indicator may be obtained through simple differentiation of an accounting identity with no particular theoretical assumptions, it in fact has simply a tautological meaning. Being defined in value terms, it bears no definite relation to the quantity variables, so that its interpretation as an index of technological efficiency is entirely spurious.

Due to the controversial and theory-laden nature of the notion, we refrain entirely from reference to TFP in our analysis. Instead, we refer exclusively to labor productivity.[6] But this latter indicator, while neutral from the point of view of measurement, has different interpretations in the different approaches. Under the same assumptions that allow definition of TFP, labor productivity in the mainstream approach can be defined as a function of the capital/labor ratio and the TFP. As already noted, this implies that increases in productivity over time are seen as the exclusive effect of these supply factors. Such interpretation is founded however on the unwarranted assumption that measured value added per hour worked is a good approximation of the technical relationship between physical quantities supposedly expressed by the production function.

In contrast to this view, the demand-led growth approach refrains from reference to the production function and recognizes the complex nature of the productivity indicator, which has not only a purely 'technological' dimension but is also affected both by the intensity of use of available resources as determined by the state of demand and by changes in the structure of relative prices. At the firm level, for example, high measured productivity may be related to the ability to obtain low-cost intermediate inputs from outsourced phases of production or to effective marketing policies that warrant high prices for its final output (Birolo 2012). At the same time, product innovations and more generally quality improvements which increase the firm's market share and have generally positive effects on its profitability, do not necessarily imply relevant increases in measured productivity, depending on the structure of costs (Ginzburg 2012). Aggregate measures of productivity at the economy-wide level, in addition, are likely to be composite effects of different parts of the economy undergoing different transformations.[7]

[5] As is well-known, the procedure was originally proposed by Solow (1957), so that the TFP is also labeled as 'Solow's residual'.

[6] Starting from the kind of criticism mentioned in the text, some analyses in the demand-led growth approach (for example Storm 2017) use the TFP notion but reinterpret it entirely, showing its dependence on demand and capacity utilization.

[7] Analyzing the Italian economy of the 2000s, Ginzburg (2012) notes that, under the surface of aggregate stagnation, processes of transformation and reorganization were going on, with medium-size high-performing firms taking the lead in some

Complexity in the interpretation of the productivity indicator and plurality of possible influences do not exclude, however, that some relations may be established, and some determinants identified. Particularly, the Post-Keynesian literature emphasizes two main influences on productivity growth, namely the growth of aggregate demand and the dynamics of wages.

2.1. The effects of aggregate demand on productivity

Even in its purely technological dimension, productivity, though partly subject to exogenous forces, is liable to be affected by the level and growth of aggregate demand. In the 18th century, Adam Smith made the argument that the 'extent of the market' is positively associated with a greater division of labor, thus allowing the adoption of more productive techniques. Smith's argument especially referred to manufacturing, and the same applies to the analyses of Verdoorn (1949) and Kaldor (1966), who proposed the analytical and empirical relationship between productivity growth and output growth in the manufacturing sector known as the Kaldor-Verdoorn law. It is worth noting that both Smith's argument and the initial formulation of the Kaldor-Verdoorn law did not refer to the effects of *aggregate* demand but rather to increases in *sectoral* production. The expanding size of the production of a specific good implies both the possibility of exploiting static increasing returns and the incentive to adopt cost-reducing innovations in that production (dynamic increasing returns). However, the notion is not only perfectly compatible with a demand-led growth perspective, but, as maintained by Kaldor (1972), even more consistent with the latter since the very presence of pervasive increasing returns in the economy deprives the notion of resource-constrained growth of its meaning.

The flexibility of output to demand changes and the possibility of underutilization of resources also implies, as already noted above, that increases in aggregate demand may foster measured productivity through a more intense use of existing resources, even independently of induced technical change. Intermediate between the two categories of effects are such phenomena as organizational innovations and learning-by doing, which may be said to involve technical change of a particular kind, also likely to be fostered by fast-growing demand.

A third effect of demand on productivity has an exquisitely cyclical character, which is connected to the different timing of output and employment changes and to the tendency of some sectors or some firms to implement labor hoarding.[8] Falls in output are generally followed by employment reductions only with

subsectors of manufacturing, while bigger firms in other sectors were declining. For their size, sectors and business models, such well-performing firms need less investment per unit of output compared to bigger firms, thus producing a negative impact on the aggregate measure of labor productivity. However, such medium-sized firms were highly productive in terms of value added per unit of investment in fixed capital. Once more, this points at the complexity of the productivity indicator, and the fact that it cannot be regarded as a genuine measure of technical efficiency.

[8] The treatment of labor, on the part of the firms, as a 'quasi-fixed' factor in the short period was originally noted by Oi (1962); a similar mechanism also underlies Okun's law (particularly, the fact that the Okun coefficient is usually very different from unity: see Fontanari et al, 2020).

a lag, and they might not produce changes in employment – at least in some occupations – until output reductions are regarded as persistent. Thus, during fluctuations, productivity tends to fall dramatically during recessions and to increase immediately afterwards, either when the crisis in output also brings about employment reductions, or when the recovery in output starts initially with no changes in employment.[9]

2.2. The effects of wages on productivity

In the mainstream theoretical context, the relationship between wages and productivity is seen as unidirectional. Based on the neoclassical postulate according to which each factor is remunerated, in equilibrium, based on its contribution to production, a tendency is assumed of wages to grow in line with labor productivity, at least in a frictionless economy. The exogenous growth of productivity over time is what creates the space for the growth of wages, while disappointing productivity growth may be a prominent cause of slow wage growth (Baily and Montalbano 2016). The fact that wages have failed to reap the benefits of labor productivity increases in recent decades, as shown in the fall of the labor share, has been the object of much discussion, which has explained the phenomenon by invoking either structural changes linked to globalization and offshoring (Elsby et al 2013) or the tendency to concentration and the increase in firms' market power (Covarrubias et al 2019).[10] In many contributions the possible role of technical progress is explored. While in some cases (Autor and Salomons 2018, Acemoglu and Restrepo, 2017) automation is found responsible for part of the fall in the labor share in the last decades, in other cases (Acemoglu and Restrepo, 2020) its effect is seen especially on wage differentials rather than the average wage rates.

If productivity growth may fail in some circumstances to be transmitted to wages, the possibility of reverse causation, whereby the dynamic of wages may be an important determinant of productivity growth, is generally little explored in the mainstream approach due to the conception of distribution as the endogenous effect of market forces, relative scarcity of factors, and their productivity. Not being exogenous, wages cannot exert, in this context, an independent influence on productivity. Rather, if imperfections in the market mechanism or the interference of labor market institutions determining excessive workers' power should cause wages to grow exogenously, this would imply increasing unit labor costs for the firms, loss of competitiveness and loss of employment, with negative effects on growth.

In the post-Keynesian perspective, the system does not automatically tend to realize optimal outcomes and distribution is not the automatic result of market forces but is rather heavily determined by social forces, with conflict between workers and profit-earners playing a crucial role. This implies that the

[9] See however Gordon (2010, p.15) who challenges this view, arguing that US data do not show evidence of procyclical changes in productivity after the 1980s. He advances the hypothesis that this is due to the enormous increase in labor flexibility associated with immigration and globalization, which has destroyed the short-term quasi-fixed nature of the labor input, inducing firms to 'treat workers as disposable commodities'.

[10] See however Stansbury and Summers (2017) maintaining that the positive relationship between wage growth and productivity growth is actually much stronger in the data than it can appear at first sight.

growth of wages may be seen as (at least in part) exogenous to productivity, and thus liable to influence the latter. Our reference theoretical framework, particularly, is the Classical-Keynesian approach, which combines the analysis of growth as a demand-led phenomenon with the conception of distribution proper to the classical political economy of Smith, Ricardo and Marx. Classical economists devoted much attention to the social forces determining distribution, which, in their view, were not considered as interferences in the market mechanism but rather as essential determinants of economic outcomes. The growth of productive forces over time, an integral part of the process of accumulation and growth, was not seen as exogenous, but rather as deeply influenced by other magnitudes. Adam Smith, as mentioned above, had seen the essential role that the progressive extension of the market exerts on productivity growth, by inducing a greater division of labor also in the form of induced technical progress.[11] As regards the effects of wages, both David Ricardo and Karl Marx had analyzed the circumstances in which the change in the relative price of labor constitutes an incentive to mechanization. Marx explicitly referred to what in modern terms may be defined as induced labor-saving technical progress.[12]

It is precisely by drawing inspiration on these analyses that Paolo Sylos Labini (1984, 1993) has offered an insightful perspective on the wages-productivity nexus, as part of his more general analysis on the determinants of productivity. Sylos also provides an empirical analysis of the question, based on a 'productivity equation' that we will illustrate and use as basis for our own estimates in section 4 below. Here we focus on his theoretical analysis.

Sylos identifies two main direct effects. The first one operates through induced technical progress and is triggered by an increase in the price of labor relative to the price of machines. Sylos especially underlines the role of competition,[13] both in the domestic and in the international market, that forces firms, in a high-wage environment, to innovate in order to defend or increase their market shares.[14] For its characteristics and its dynamic character, such an effect is very different from the neoclassical substitution mechanism based on the production function. To stress its derivation from classical political economy, Sylos labels such an effect as the 'Ricardo effect'.[15]

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[11] As noted by Kurz (2021), the division of labor is 'Smith's catch-all term for technological and organizational progress'.

[12] According to Marx, mechanization creates unemployment, (i.e., in his terms, it increases the size of the "reserve army of the unemployed"), with the effect of reducing workers' power and claims, thus increasing firms' profitability and making continuous expansion possible (see the reconstruction in Kurz, 2021). As regards Ricardo's analysis, Gehrke (2003) shows that his remarks on the circumstances in which it is convenient to substitute machines for direct labor cannot correctly be interpreted as involving technical progress. Rather, Ricardo analyzes the case in which the action of diminishing returns in agriculture produces an increase in the money price of wage goods (thus not in the real wage, which remains constant, but in the value of wages relative to the price of manufactured goods), thereby reducing the general rate of profit. In this circumstance, depending on the technical conditions of production of machines, it may happen that a technique using more machines and less direct labor per unit of output may become convenient. This kind of static problem of 'choice of technique', Gehrke (2003) notes, has nothing to do with the generalized factor substitutability later postulated by neoclassical analysis, since no definite relationship exists in the classical framework between distributive variables and factor proportions.

[13] Competition should be understood in a Schumpeterian sense. For the strong influence of Schumpeter on Sylos Labini's thought, see Vianello (2007).

[14] By affecting positively the demand for consumption, high wages may also stimulate product innovations.

[15] For the considerations in footnote 12 above on the possibility that Ricardo had actually a different mechanism in mind, we will label this effect as the 'mechanization effect'. As noted in the text, the mechanization effect necessarily involves technical progress, thus being entirely different from the static factor substitution postulated in neoclassical theory.

The second effect is instead induced by an increase in wages relative to the prices of output (rather than machinery). This implies that firms have an incentive towards a more efficient use of labor, through reorganizing production processes or work practices. Sylos labels this effect as the ‘organization’ effect. This effect is also conceived of as acting dynamically, since it entails a particular kind of innovation, i.e. ‘organizational’ innovation. Differently from the innovations entailing increased mechanization, these organizational innovations do not necessarily involve high investments in fixed capital and may thus take place more immediately.

Building on Sylos Labini’s insight, we maintain that the organization effect may likely occur in both directions (i.e. both for rising wages and for declining wages) and may take different forms, depending on the technical characteristics of the different sectors. While high wages constitute an incentive towards a more efficient use of the working time, for example through re-organization of inventory management or the workspace, low wages, may both imply little incentive towards efficiency and induce such phenomena as the lengthening of the working day or the working week, or the multiplication of hours worked through a massive use of part-time and other reduced-time jobs, with a consequent reduction in measured hourly productivity. If wages stagnate for a protracted period, this may encourage firms to build their business strategies counting on mass availability of low-wage labor. Such strategies may also involve redistribution of employment, within the same sector, between firms with different work arrangements and different levels of productivity, thus entailing transformations along the various phases of the value-chains.

By analogy with agricultural techniques, where *intensive* farming is a method that uses higher and better inputs per unit of land in order to obtain more output per unit of land, while *extensive* farming implies the use of more land with a smaller amount of less efficient inputs (and thus a lower output) per unit of land, we propose to label these strategies as ‘extensive’ vs ‘intensive’ use of labor in the production processes and the business organization. Extensive farming implies abundant and relatively inefficient use of cheap land, and similarly ‘extensive use of the labor input’ may be employed to label the practice of using cheap labor abundantly (in terms of heads or working time).[16] Although such phenomena cannot have affected all sectors equally, we believe that the drift towards a more extensive use of the labor input is not limited to traditionally low-wage and low-productivity sectors, but may well have affected all those sectors which are susceptible to different forms of organizing production, including some important sectors in manufacturing, traditionally a high-productivity branch that has lately shown a slowdown of its productivity dynamics.

Similarly to what was remarked on above for the mechanization effect, it should be noted that this kind of analysis has nothing in common with the postulate of factor substitution at the basis of the neoclassical theory of distribution. Neoclassical substitution implies the possibilities of varying continuously the

[16] In a somewhat different sense, Kurz (2021) employs the term ‘extensive’ to characterize the features of the slow expansion of production that took place in the early phases of capitalist development preceding the industrial revolution, based on ‘lengthening of the working day, an abolition of holidays, and an intensification of labor at fairly constant real wages per worker’.

proportions between factors of production along a production function that supposedly shows a continuum of efficient techniques. In the alternative framework we are describing, as Sylos himself points out, no continuum of techniques is postulated, the possibility of choosing among different methods of production need not be generalized (it may concern only few alternative methods and be relevant only for some sectors), and the coexistence, in the economy, of efficient and less efficient techniques may be contemplated. In addition, the effect of wages on productivity is not regarded as automatic, as it may depend, for example, on the ease with which firms are able to pass cost increases on to prices. Neither is it a static effect but rather a dynamic one, arising from organizational innovations.

The fact that low wages may induce firms to adopt a business model based on the extensive use of labor does not imply that the economy moves along a neoclassical decreasing demand curve for labor. In our theoretical framework, growth in output is determined by the dynamics of aggregate demand. The structure of costs, however, may be such as to induce firms to realize output growth with different techniques. In the medium period, the same output growth may give rise either to sustained productivity gains or to wider use of labor. The possibility of sustained growth *both* of employment and productivity depends on the realization of a high rate of growth of demand and output. In the longer period, a strategy of growth based on low growth of wages and of productivity may both produce low incomes and impact negatively on the very capability of the system to capture international demand for its products – both possible causes of a lower long-run growth in demand and output.

As a final point, it must also be noted that according to Sylos (1993, p. 109) both positive influences of high wages on productivity may be effective only within limits. In a classical framework, indeed, high wages necessarily mean a lower rate of profit. If the latter however should fall below a certain low limit, this would imply the cessation of any stimulus to accumulation.

In applying our theoretical framework, in the next sections, to the interpretation of historical trends, a word of warning is necessary. As maintained above, the demand-led approach invites an analysis of productivity that attends to the complex nature of labor productivity and the plurality of its determinants. It admits, in addition, the possible existence of various types of interrelations between the relevant magnitudes. Indeed, some relations may be highly context-sensitive: for example, not all differences in growth rates of aggregate demand in different historical phases cause parallel differences in productivity growth rate – that will depend on the structure of the economy and the kind of transformations it is undergoing. Moreover, other interrelations, even with an opposite direction of causation, may exist. Productivity gains may foster demand, for example through cost reductions and enhanced competitiveness on international markets (as in the Kaldor-Myrdal process of cumulative causation). They may also, in some circumstances, be favorable to the growth of wages, again depending on the specific historical situation especially in terms of workers' relative strength.

Such complex conception invites much caution in empirical analysis and its interpretation, yet it seems more apt to capture the actual nature of the phenomena under scrutiny. Far from trying to offer a complete picture of all the possible interrelations, we will rather focus in our empirical analysis on the possible role of the influences on productivity we have described theoretically, i.e., those of aggregate demand

and wages. We will particularly highlight the possible role of the organization effect, which has received comparatively little attention in the literature, apart from a number of empirical contributions directly stemming from Sylos Labini's analysis (see below, section 4.1). Yet in our opinion, as we will try to show, it may provide useful insights on the recent dynamic of productivity growth.

3. The productivity slowdown in the USA: assessing the role of structural change

We now apply our theoretical framework to the analysis of the productivity slowdown that has materialized in the US economy in recent decades. As many studies suggest, this came in two stages with a sequence of revived productivity in between (Baily and Montalbano, 2016). The first slowdown occurred in the period between the mid-1970s to the mid-1990s. This was followed by a phase of sustained productivity growth and then a second slowdown in the 2010s. The explanation of these long-run changes has puzzled economists and has been the object of much literature. Based on the mainstream theoretical approach, the slowdowns have commonly been explained in terms of exogenous reductions in innovation and investment opportunities. However, this famously contrasted with the evidence of a strong wave of IT innovations in the 1980s, giving rise to the much discussed 'productivity paradox' (first noted by Solow, 1987). Interestingly, some contributors to that debate noted the possibility that the standard indicator of (real) labor productivity tends to underestimate quality changes, and consequently overestimate inflation and underestimate productivity gains (see for example Brynjolfsson and Hitt 1996, Feldstein 2019), a point that contrasts with the standard interpretation of productivity as a purely technological indicator.

Gordon (2016) sees the change in the *quality* of technical progress in recent decades as the main force behind the productivity slowdown. In a series of contributions devoted to the impact of automation, Acemoglu and Restrepo (2017, 2018, 2020) explore its contrasting effects and surmise that most investment in automation, especially in the service sectors, displace many jobs without having sizeable effects on productivity.

Disappointing productivity growth has been also explained through other, non-technological, factors, for example a biased reward structure of the economy that produces incentives for entrepreneurs to engage in unproductive (or even destructive) activities (Baumol 1990) or the existence of inefficient institutions created by the society's elites in order to secure themselves a greater income share (Acemoglu 2006). Changes in the structure of the economy are also invoked as potential explanations. Starting from Baumol's well-known idea that productivity in the service sector is bound to grow more slowly than in manufacturing, the growing weight of the service sector has been proposed as a major cause of the first productivity slowdown (Nordhaus, 2006). More recently, an increasing dispersion of productivity performance is observed at the firm level (Baily and Montalbano 2016) and explained either in terms of uneven dynamism of different sectors (Chatterji et al. 2020) or unequal distribution of innovation dynamism across firms and lack of sufficient competition (Stansbury and Summers 2017). On the whole, however, the productivity slowdown is a puzzling question to which mainstream literature does not give unanimous answers.[17]

With the prominent role it assigns to the dynamics of aggregate demand and wages as determinants of productivity, the classical-Keynesian approach may offer, in our view, some answers to the productivity puzzle of the recent decades. The role of long-run changes in demand in affecting productivity growth, especially in reference to the Kaldor-Verdoorn effect, has been confirmed in much empirical research (see for example Girardi et al 2020; Deleidi et al 2020; Fazzari et al., 2020);[18] while the role of wage dynamics has been especially treated in models assuming that low wage growth slows the growth of aggregate demand, thus affecting negatively productivity through an indirect channel (Storm, 2017). The diffusion of low-wage jobs in the US economy has also given rise to interpretations, among critical economists, that focus on the changing structure of the economy (see for example Storm 2017; Taylor and Ömer 2020). The productivity slowdown would be associated, according to such interpretations, to the growing 'dualism' or polarization between on the one hand low-wage and low-productivity sectors (like food preparation, healthcare and the like), and on the other hand high-productivity and high-wage sectors (like manufacturing). The expansion of the former at the expense of the latter would explain the parallel stagnation of productivity and wages in the aggregate.

We believe that the direct effects of wages that we have analyzed in section 2.2 above may have played a relevant role of their own in affecting the trend of productivity. The diffusion of low-wage jobs in the economy, highlighted in the literature on dualism, may be seen, according to the penetrating analysis by Weil (2014, 2019), as the product of a profound restructuring of the organization of business in a variety of industries and firms in the USA since the 1990s, that included practices of outsourcing activities and workers towards firms in which labor is comparatively less protected, and use of work agencies. According to Weil (2014, p. 10), these practices – originated in turn by the pressure of capital markets on big corporations to produce 'value for investors' and 'enabled by the falling cost of coordinating business transactions through information and communication technologies' – have led to the diffusion of jobs characterized by low wages, non-compliance with basic workplace standards, limited benefits, more contingent employment, greater exposure to risk and weakened bargaining power for workers in general. While in some sectors and occupations these conditions result in longer working hours for the individual worker, in other cases the re-organization implies the use of many workers on different forms of part-time contracts. Weil especially focuses on the effect of these organizational changes on wages; we maintain however that the persistence of these new organizational models over the years and their effect on wages could, in turn, have prompted firms, in the aggregate, to make a more extensive use of labor than they would have done with more expensive and more protected in-house workers.

[17] "There has been considerable frustration felt by many researchers, commentators and policymakers trying to understand and do something about slow productivity growth" (Baily and Montalbano, 2016, p.2). See also Byrne et al. (2016), who assess critically the idea that the productivity slowdown is a statistical artifact entirely due to mismeasurement.

[18] A further indirect empirical confirmation is offered by Fontanari et al., (2020) who, studying Okun's Law on US data, show that lower levels of unemployment tend empirically to be associated with faster productivity increases.

Differently from the 'dualistic' interpretation, we contend that these changes may also have affected, at least in part, high-productivity sectors determining a generalized productivity slowdown. Before testing empirically the direct effects of wages on productivity, we thus assess in this section, as a preliminary step, the contributions of the different sectors to the productivity slowdown and the idea that the latter depends essentially on the growing weight of low-productivity sectors in the economy.

3.1 Data and descriptive analysis

The data used in this paper are drawn from the Industry Accounts Database, supplied by the Bureau of Economic Analysis (BEA), except for data on working hours, which come from the Labor Productivity and Costs Database of the Bureau of Labor Statistics (BLS). We use annual data from 1987 to 2018, due to the absence of earlier industry data on compensation of employees and working hours. The level of disaggregation is up to 3 digits for almost all sectors. The total economy is divided into twenty sectors (see Table A1 in the Appendix for the full list of sectors).

We aim to compare the most recent data on productivity and wage growth with previous trends. Within the available data, we especially focus on three periods of equal duration, i.e. the years 1992-2000; 2000-2008 and 2010-2018. The first and the third of these periods, particularly, are expansionary phases characterized by high employment growth, both in terms of heads and hours. The intermediate period includes the 2001 recession and a shorter expansionary phase.[19] Table 1 illustrates the annual growth rates of output, employment, wages and productivity in the three periods. Following the general use, we define productivity as value added per hour worked at constant (chain-linked) prices. The full list of variables and definitions is to be found in Table A2 in the Appendix.

Table 1. Average annual growth rates. Total Economy

	1992-2000	2000-2008	2010-2018
Output	3.6	2.0	2.2
Hourly productivity	1.4	1.8	0.5
Hours worked	2.2	0.1	1.6
Hourly wages	1.4	1.3	0.5

Source: BEA and BLS.

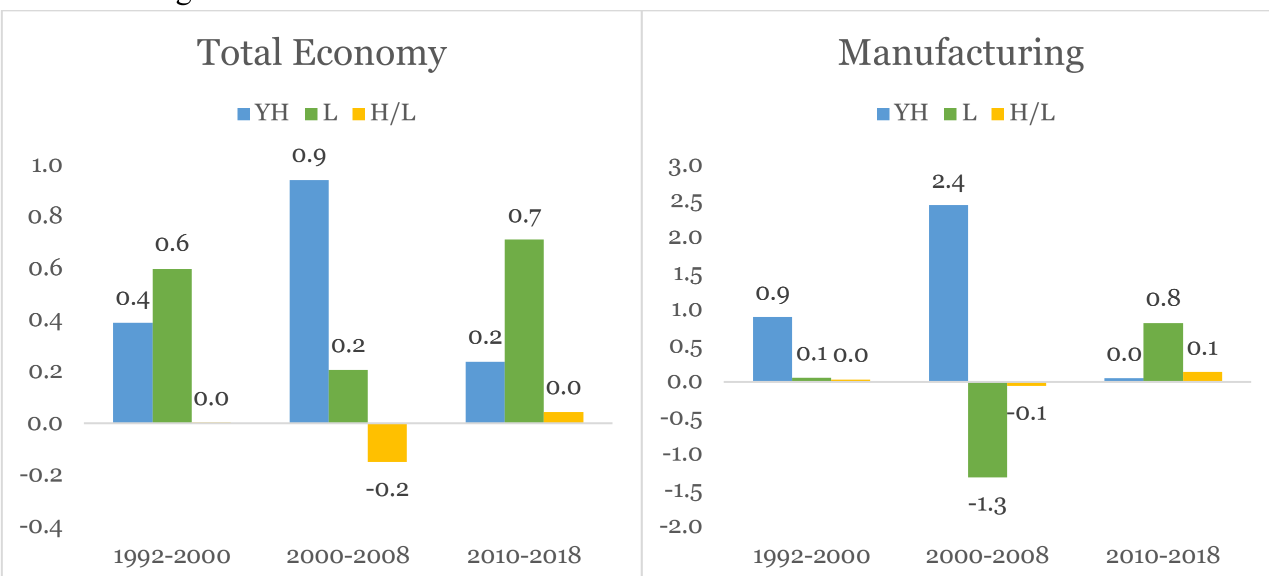
As is apparent, output growth slows down considerably between the first and second periods, while recovering slightly in the third one. The two high-employment-growth periods (first and third phases) have in common not only a higher annual growth of hours worked, if compared with the intermediate phase, but also the fact that hourly wages grow in line with hourly productivity. The 2000-2008 phase has different characteristics: it shows the biggest productivity gains, with the marked slowdown in output growth with respect to the previous phase entirely passed on to employment. Moreover, it shows a dynamic of wages different from (and slower than) that of productivity. Productivity growth accelerates considerably from the first to the second phase, and then shows a marked deceleration in the third phase.

[19] To avoid influencing the analysis with the cyclical effects of the Great Recession, we decided to omit the year 2009.

Employment growth, on the contrary, slows down almost to zero in the second phase, and then shows a marked acceleration.

Figure 1 compares the 'elasticity of productivity to output growth' with the 'elasticity of employment to output growth' in the three phases. The former is defined as the ratio between productivity growth and output growth and the latter as the ratio of employment growth and output growth.[20] The growth of total hours is split between growth of the number of employees and growth of hours worked per employee. When an elasticity is greater than one, this means that the corresponding variable is growing faster than output. The same elasticities are shown for the manufacturing sector.

Figure 1. Output elasticities of productivity, employment and hours per worker. Total Economy and Manufacturing



Source: our calculations on BEA and BLS data. Notes: output elasticities = ratio between the growth of the reference variable and the growth of output. Legend: YH= hourly productivity; L=number of employed; H/L= hours per worker.

As regards the 2000-2008 phase, we may notice the high elasticity of productivity both in manufacturing and the total economy, and the slight reduction in hours per employee. The significant elasticity of productivity to output growth goes together with a very low elasticity of employment, which for manufacturing is even negative. In the third phase the situation is completely reversed: productivity shows low elasticity (which becomes zero for manufacturing) while employment, especially in terms of numbers of employed, shows a much higher elasticity. It is interesting to note, as regards manufacturing, that the employment gains of the 2010-2018 period are quite unusual in the post-1980 era: even in the 1992-2000 phase, in which output growth was the highest, growth in employment in the manufacturing sector was close to zero.

[20] We label the ratios defined in the text as 'elasticities' since, in accordance with our theoretical framework, we regard both employment and productivity as determined, or at least heavily influenced by, demand and output growth.

3.2 Shift-share analysis

In order to assess the impact of structural change on productivity growth we employ the empirical methodology called 'shift-share analysis'. This is a descriptive technique that breaks down the change of an aggregate into a structural component, which reflects changes in the composition of the aggregate, and a component reflecting changes within the individual units that make up the aggregate (Syrquin, 1984; Fagerberg et al., 2000; Paci and Pigliaru, 1997). Applied to labor productivity growth, this technique allows decomposition of the overall change in productivity into the intra-sectoral (or within sector) effect, due to productivity changes within each sector, and the structural change effect. The latter is further decomposed into two different effects: the static sectoral effect, due to the varying weight in the economy of sectors characterized by different *levels* of productivity, and the dynamic sectoral effect, due to the varying weight of sectors with different *growth rates* of productivity (Maudos et al., 2008, Deleidi et al., 2020). More precisely, we make use of the following formula:

$$\frac{\pi_t - \pi_0}{\pi_0} = \sum_{i=1}^{n} \left[\frac{s_{i,0}\left(\Delta\pi_{i,t}\right)}{\pi_0} + \frac{\pi_{i,0}\left(\Delta s_{i,t}\right)}{\pi_0} + \frac{\left(\Delta\pi_{i,t}\right)\left(\Delta s_{i,t}\right)}{\pi_0} \right] \tag{1}$$

Where π represents labor productivity (i.e., real value added per hour worked) of the aggregate; π_i is productivity in sector *i* and s_i denotes the share of each sector *i* in total employment, measured in terms of hours worked. $\Delta\pi_{i,t}$ and $\Delta s_{i,t}$ represent respectively the changes (first differences) in productivity and in the employment share of sector *i* from time *0* to time *t*.

On the right-hand side of equation (1), the first term represents the within effect, obtained as the weighted sum of changes in productivity within individual industries, where weights are represented by the initial shares of individual industries in total employment. It measures the productivity gains due to improvements internal to each sector. The second term represents the static sectoral effect, obtained as the weighted sum of changes in the employment shares of individual sectors, with weights represented by the initial productivity levels. It measures changes in the average productivity of the aggregate due to reallocation towards more productive (or less productive) sectors. The third term is the dynamic sectoral effect, obtained as the interaction between changes in productivity in individual industries and changes in the employment shares. It measures the part of change in aggregate productivity due to reallocation towards sectors with faster (or slower) productivity growth.

3.2.1. A shift-share analysis of the change in productivity

We apply the formula to our data on the economy as a whole, focusing on the above-described three periods and using our sectoral classification.[21] Results are reported in Table 2.

[21] See Table A2 in the Appendix for the full list of 20 sectors.

Table 2. Shift-share analysis of the change in productivity. USA, 1992-2018, total economy						
	8-year percentage change			Percent contribution		
	1992-2000	2000-2008	2010-2018	1992-2000	2000-2008	2010-2018
Within effect	14.0	17.6	4.9	118%	112%	116%
Structural change effect	-2.1	-1.8	-0.7	-18%	-12%	-16%
Static sectoral effect	-0.8	0.5	-0.3	-7%	3%	-7%
Dynamic sectoral effect	-1.3	-2.3	-0.4	-11%	-15%	-9%
Total change	11.9	15.8	4.2	100%	100%	100%

Source: authors' elaboration on BEA and BLS data.

In all the three periods, the within effect is the dominating one, accounting for 112–118 percent of the aggregate change in productivity.[22] The structural change effects overall are negative, showing that indeed there has been re-allocation towards less productive sectors (with the exception of the 2000-2008 phase) or those sectors characterized by slower productivity growth. In this latter regard, it is interesting to note that the (negative) dynamic sectoral effect has been strongest in the high-productivity-growth phase of 2000-2008. However, on the whole the slowdown in productivity in the total economy in the recent decades and especially in the 2010-2018 period is mainly due to lower intra-sectoral productivity growth rather than to structural change, which has a much smaller impact.

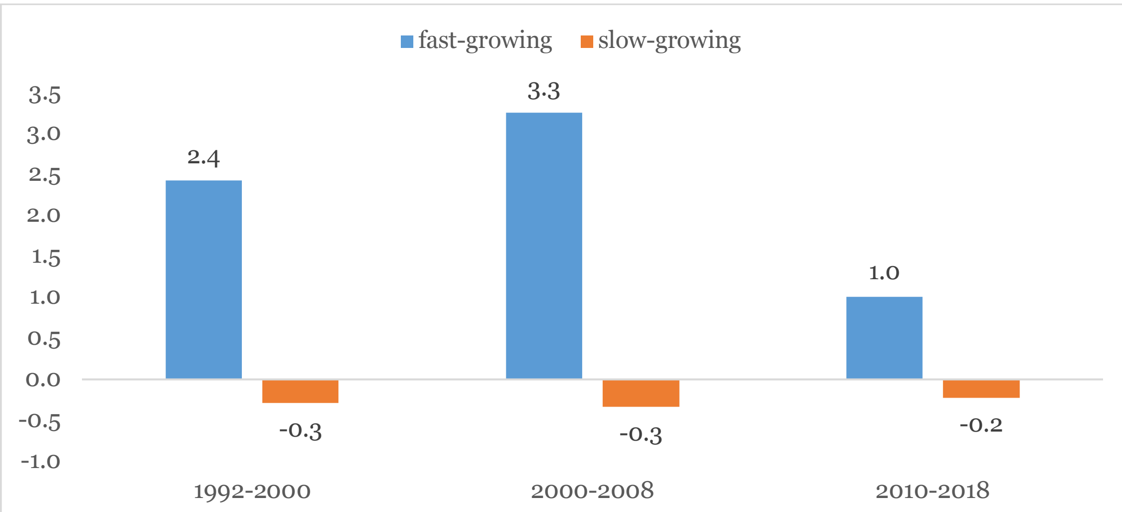
Going into details, in the first phase (1992-2000), the negative structural change effects, both static and dynamic, are mostly due to the reduction in the employment share of sectors with high levels/growth of productivity (such as Manufacturing, Utilities, Mining, Wholesale Trade, Real Estate, Management Activities and Retail Trade). Many workers were reallocated towards sectors with negative productivity growth rates (such as Construction, Health Care and Administrative Activities), but also towards sectors with positive, albeit low, productivity growth (such as Information, Professional Activities, Transportation and Educational Services). Positive contributions to productivity growth come from the growing share of sectors characterized by faster productivity growth, such as Financial Activities and, to a lesser extent, Accommodation and Food. The positive contribution to productivity growth of the Manufacturing sector is crucial: it accounts for 24.6 percent of total productivity change and its contribution to the intra-sectoral effect is equal to 35 percent. (See Table A3 in the Appendix, which reports for each period only the main contributing sectors to total productivity change).

In the second phase (2000-2008), the leading industries in terms of intra-sectoral productivity growth are broadly the same as in the first, i.e. Manufacturing, Wholesale Trade, Retail Trade and Real Estate. However, in this period we observe the rise of the Information sector, characterized by fast productivity growth, and Professional Activities, and the slowing down of the Financial sector. The industry that contributes most to within productivity growth is still Manufacturing (see Table A3). As regards the strong negative dynamic sectoral effect observed in this phase, this is mainly due to the sharp decline of the employment shares of Manufacturing and Information. This effect is partially offset by the

[22] The fact that the within effect and the two structural effects may contribute either positively or negatively to the productivity change, implies that one of the effects may contribute positively for more than 100 percent.

reallocation of workers to industries with high levels of productivity, such as Mining, Real Estate, Government and Health Services. The last two, particularly, show the highest increases in the respective employment shares. Compared to the previous one, the second phase records growing polarization across sectors in terms of productivity performance, i.e. a greater distance between the average growth of productivity of the most dynamic sectors and that of the less dynamic sectors (see Figure 2).

Figure 2. Average intra-sectoral growth of productivity in the five faster-growing industries vs the five slowest-growing industries



Source: authors' elaboration on BEA and BLS data.

In the third phase (2010-2018), the distribution of sectors in terms of productivity growth changes. Among the leading sectors, we count now Mining, Management Activities and Health Services in addition to Wholesale Trade and Retail Trade, while observing the dramatic slowdown of productivity growth in Real Estate and Manufacturing, with a within-effect respectively of -0.3 and 0.1 percent. Indeed, the industry that in this period contributes most to productivity growth is no longer Manufacturing (which contributes negatively) but Information, which contributes positively for 40 percent of total productivity change and 50 percent of within-industry productivity growth (see Table A3). This is also the sector, together with Government, with the highest negative structural effect due to a sharp decline in their employment shares. Employment shifts towards industries with negative productivity growth (such as Real Estate, Construction, Transportation and Accommodation and Food); with an exception being Professional Activities, where both productivity and the employment share grow. On the whole, however, the productivity slowdown in the total economy is not due to a significant increase in the number of low-growing sectors (or an increase in their shares) but rather to a slowdown in the within-sector productivity of the leading industries (see Figure 2). In other terms, the structural change hypothesis may explain only a small part of the productivity slowdown of recent years. The bulk of the explanation lies in intra-sectoral trends and especially in the collapse of productivity growth in Manufacturing, Real Estate and Finance.[23]

[23] Some of the sectors included in our analysis can be problematic when it comes to interpreting what is actually being measured by the productivity indicator. Two well-known examples are real estate and financial activities. The fast productivity

3.2.2. A shift-share analysis of the change in wages

By applying the same technique, we offer in this section a sectoral decomposition of the change in the average hourly wage, in order to assess the role of structural change in accounting for the slowdown of wages. We use again equation (1), substituting the change in average hourly wage (both sectoral and in the aggregate) for the corresponding changes in productivity. Table 3 shows the results.

Table 3. Shift-share analysis of the change in average real wage. USA, 1992-2018, total economy.

	8-year percentage change			Percent contribution		
	1992-2000	2000-2008	2010-2018	1992-2000	2000-2008	2010-2018
Within effect	12.4	10.9	4.8	106%	100.0%	126.1%
Structural change effect	-0.7	0.0	-1.0	-6%	0.0%	-26.1%
Static sectoral effect	0.0	1.4	-0.9	0%	12.6%	-23.4%
Dynamic sectoral effect	-0.7	-1.4	-0.1	-6%	-12.6%	-2.7%
Total change	11.7	10.9	3.8	100%	100%	100%

Source: authors' elaboration on BEA and BLS data.

Once again, the dominant contribution to overall growth of the average real wage comes in all periods from the within effect (100-126 percent). In the 1992-2000 period, the dynamic sectoral effect is negative (-6 percent) and the static sectoral effect is almost zero, suggesting that the shift of employment between high-wage and low-wage industries is balanced, but sectors with high wage growth (such as Manufacturing, Wholesale and Retail Trade) lose employment. In the 2000-2008 period, 100 percent of the wage change is explained by within effects (while the static and dynamic sectoral effects offset one another). In the 2010-2018 period, the negative effect of structural change on wage dynamics becomes more important, accounting for -26.1 percent of aggregate wage growth, mostly due to an increasing tendency to reallocate labor towards low-wage industries (such as Accommodation and Food, Construction, Administrative Activities) at the expense of high-wage industries (Government, Information, Manufacturing, Finance).

It is interesting to focus on the contribution of Manufacturing to the general trends (see Table 4). In the first phase, Manufacturing accounted for 21 percent of total hourly wage growth and explained 36 percent of within-sectors wage growth. In the years 2000-2008 its contribution to overall change decreases, but its contribution to the total within effect reaches 42 percent. In the 2010-2018 period, the contribution of Manufacturing to overall wage change is negative, and it explains only 3.5 percent of the total within effect. The within-sector growth of wages in this period is led by Information (38.4 percent) and Professional Activities (24 percent).

growth of these sectors in the years 2000-2008, for example, could be related to the asset price bubbles. For the purpose of our analysis, however, it may still be interesting to compare the dynamics of wages and productivity in these sectors: whatever the cause of an inflated value added, we may wonder whether this also benefited wages in the sector. To ensure that the presence of these sectors did not introduce a bias in our analysis, we repeated the analysis by omitting these two sectors (both together and separately) and obtained results that confirm those illustrated in the text.

Table 4. The contribution of Manufacturing to the overall wage change						
	1992-2000		2000-2008		2010-2018	
	Within effect	Total effect	*Within effect*	Total effect	*Within effect*	Total effect
Manufacturing	4.5	2.5	4.6	0.5	0.2	-0.1
Total	12.4	11.7	10.9	10.9	4.8	3.8
% of total	*36.2%*	*21.1%*	*42.3%*	*4.9%*	*3.5%*	*-2.5%*

Source: authors' elaboration on BEA and BLS data.

Comparing the trends of productivity and wages over the whole period, we observe that, while productivity accelerates in the 2000s, wages do not follow but show, on the contrary, a tendency to decelerate which becomes stronger in the third period. A widening gap between productivity and wages materializes in the 2000-2008 period. Table 5 shows that the discrepancy between the within-sectors growth of wages and that of productivity is prominent especially in the fast-growing sectors.[24] In the 2010-2018 period, the gap continues to grow at a much slower pace, but now the discrepancy occurs in the slow-growing industries, where the average wage falls faster than productivity.

Table 5. Average intra-sectoral growth of productivity and wages in the five faster-growing industries vs the five slowest-growing industries						
	1992-2000		2000-2008		2010-2018	
	productivity	wages	productivity	wages	productivity	wages
fast-growing	2.4	2.3	3.3	1.9	1.0	1.0
slow-growing	-0.3	-0.4	-0.3	-0.3	-0.2	-0.4

Source: authors' elaboration on BEA and BLS data.

3.3 Sectoral decomposition of the wage-productivity gap

We now look at the contribution of the various industries to the economy-wide wage-productivity gap. To this end, we follow the methodology proposed by the Conference Board (Erumban and de Vries, 2016), which is based on the definition of the cumulative wage-productivity gap as the difference between the cumulative growth rate of labor productivity and the cumulative growth rate of real compensation:

$$G = \Delta ln\pi - \Delta lnw \qquad (2)$$

[24] It is worth noting that the sectors with the highest productivity growth are not necessarily the same as those with the highest wage growth, as is the case with the Real Estate sector.

where G is the total gap, π is hourly labor productivity, and *w* is the hourly real wage. In order to calculate the contribution of the various industries to the aggregate wage-productivity gap, equation (2) can be rewritten as:[25]

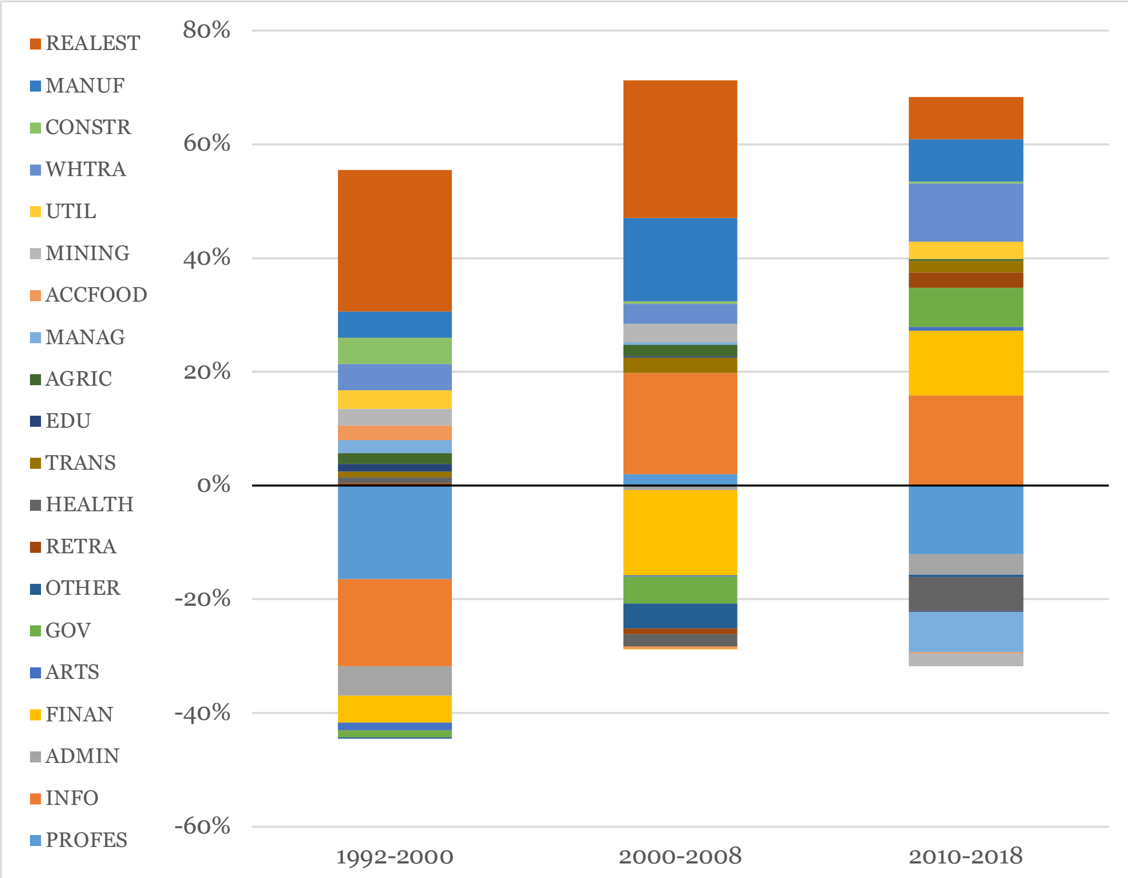
$$G = \sum_{i=1}^{n} [\bar{s}_i \Delta ln\pi_i - \bar{v}_i \Delta lnw_i] \qquad (3)$$

where $\bar{s}_i$ is the share of industry *i* in total nominal GDP and $\bar{v}_i$ is the share of industry *i* in the total wage bill, both averaged over current and previous years. Note that in the above formulation, for simplicity, sectoral reallocation effects are excluded.[26] This sectoral decomposition allows one to identify which sectors contribute more to the cumulated gap between productivity and wages in the overall economy (Erumban and de Vries, 2016). The latter has been, respectively, 0.7 percentage points in 1992-2000, 4.5 in 2000-2008 and 1.9 in 2010-2018. Figure 3 shows the contribution of the various sectors to the aggregate wage-productivity gap.

[25] This is obtained by defining aggregate productivity and real wage growth as the Tornqvist sum of sectoral productivity growth and sectoral wage growth, with the respective weights being the share of each sector in nominal GDP in the case of labor productivity and the share of each sector in the nominal wage bill in the case of aggregate wage growth (see Erumban and de Vries 2016 for details).

[26] If such effects were taken into account, the equation would become $G = \Sigma\ [\bar{s}_i \Delta ln\pi_i - \bar{v}_i \Delta lnw_i] + (RL - Rw)$, where RL is the productivity reallocation effects, and Rw is the real wage reallocation effect across industries.

Figure 3. Industry origins of the cumulated growth of the wage-productivity gap



Source: our calculation on BEA and BLS data. See table A4 in the Appendix for numerical values of contributions.

The first period shows the lowest cumulative growth of the productivity-wage gap; indeed, positive and negative contributions almost offset each other. The second phase (2000-2008) is the one in which the gap between productivity and wages accumulates the most. This large cumulative growth is driven by the Real Estate sector (57 percent), followed by Information (42.2 percent) and Manufacturing (34.5 percent). In the third period, the cumulative growth of the productivity-wage gap slows down; the main contributors to the growth of the gap are Information (accounting for 43.3 percent) and Financial Services (31.1 percent). Over time, some sectors always contribute positively to the cumulative growth of the gap, even if to a variable extent (these are Agriculture, Construction, Manufacturing, Wholesale Trade, Transportation and Real Estate). By contrast, sectors that always contribute negatively to the growth of the gap are Administrative Activities and Other Services.

We may now briefly summarize the results of these three decomposition analyses. In the first place, we have concluded that the structural change hypothesis may explain only a small part of the changes in productivity of the last three decades, while forces operating within the sectors have had a much more important role in determining the trend of productivity as well as that of wages.[27] This does not amount to excluding, in our opinion, that the US economy has undergone important transformations in recent times, including the growing polarization between high-productivity/high-wage productions and low-productivity/low-wage productions so often underlined in the literature (Storm 2017, Taylor 2020, Lazonick 2015). Rather, our results induce us to suppose that such kinds of changes have happened also through a reallocation of employment and production *within* the sectors themselves, between firms operating with different business models, as envisaged in the theoretical analysis we have illustrated in section 2 (see particularly the 'organization' effect of wages described in section 2.2). That a marked slowdown of productivity has occurred in the last decade also in manufacturing, a traditionally dynamic sector, is a possible confirmation of this hypothesis.[28]

In the second place, we have seen that the third phase (2010-2018) stands out for a particularly slow growth of productivity, which is possibly affected by what happened in the previous (2000-2008) phase, characterized by strong productivity growth and stagnating wages. This is the phase in which the wage-productivity gap has widened the most, thus pointing to a relevant distributional shift against wages. We suspect that such marked distributional shift has had long-lasting effects on the productivity performance, contributing to a switch, for large parts of the economy, towards a regime characterized by slower growth of productivity.

4. Estimating the direct effects of wages on productivity

Using our theoretical framework, we want now to check more carefully the just-mentioned hypothesis that a regime of low wage growth is detrimental to productivity growth, by estimating the empirical relationship between productivity growth and wage growth focusing on the possible effects of the latter on the former. To address this question, it is necessary to take into account the complex nature of the productivity indicator and the intricacy of the possibly bi-directional interrelations between variables that we have described in section 2. We do not believe that such complexity can be fruitfully addressed by modeling all the possible effects at the same time through a system of simultaneous equations, especially given that some of the interrelations between variables have varying intensity and are influenced by contingent circumstances. This could only produce a blurred picture with a cloudy interpretation of results. A more fruitful route, in our opinion, is to estimate a single equation in which productivity growth is regressed on wage growth, controlling however for the effects of other variables, particularly demand, and directly addressing the issue of causality.

We are especially interested in assessing the direct effects of wages on productivity, composed, as we have seen in section 2.2, of the mechanization effect, which captures the incentive for technical

[27] Of course, our result holds for our chosen level of sectoral disaggregation. Data with a finer level of disaggregation might reveal a different picture.
[28] The very different trends of hours worked in the various periods may also be related to the intensified practices of international outsourcing of production phases in the second period (2000-2008) and the reshoring of some activities in the third period (2010-2018).

innovation represented by fast-growing wages, and the organization effect, which captures the incentive to re-organize the productive process efficiently when wages are high or fast-growing or, conversely, to use the labor input extensively when wages are low or slow-growing.

To perform our estimates, we use the productivity equation that Sylos Labini (1984, 1993) proposed as an integral part of his analysis of productivity. In the following section we begin by illustrating Sylos's equation and review the issues raised in the empirical literature devoted to the estimation of the equation.

4.1. Sylos Labini's productivity equation

Sylos Labini (1984, 1993) attempts to summarize in one 'productivity equation' all the main determinants of productivity identified in his theoretical analysis. Briefly, this analysis, which as noted above is deeply influenced by classical political economy, rests on an identification of three categories of factors that exert the main influences on productivity growth: the extension of the market, changes in labor costs, and investments. As regards the first factor, Sylos derives directly from Smith's analysis the idea that the growth of the market induces greater division of labor, thus giving rise to productivity growth associated with both static and dynamic increasing returns (see section 2.1 above). He labels the effect of extent of the market (measured with output) on productivity as the 'Smith effect'. The second factor includes the two different effects that changes in wages may exert on productivity described in section 2.2 above: the mechanization effect (or Ricardo effect, in Sylos's terms), associated with changes in the average wage relative to the price of machinery, and the organization effect, associated with changes in the ratio between wages and output prices.

Sylos considers the mechanization effect as acting with a lag of several periods, while the organization effect as acting with no lag. As regards the third factor, i.e. the impact of investments on productivity, Sylos identifies two different and contrasting effects: on the one hand, a "disturbance effect" which occurs in the short run, since new equipment takes time to be used effectively and may temporarily have a negative influence on productivity growth; on the other hand, however, investment is introduced to improve labor productivity in the medium-long run and thus has a positive effect after a number of periods. It is worth noting that Sylos distinguishes between labor-saving investment and capacity-increasing investment, thus emphasizing that the incentive to invest may be associated not only with an increase in wages but also with entirely different causes. Accordingly, in the first formulation of the productivity equation he introduces investment as a distinct factor among the determinants of labor productivity. Indeed, Sylos extracts two different versions of the productivity equation from his theoretical analysis. In the first, proposed in Sylos Labini (1984), he assumes that changes in the price of machinery (P_m) and in the general price level (P) are almost equivalent ($\Delta P \cong \Delta P_m$). Thus productivity growth is expressed as depending on output growth ΔY_t (representing the extent-of-the-market effect, or 'Smith effect'), growth in the relative labor cost $\Delta(W/P_m)_{t-n}$, encompassing the different direct effects of wages on productivity, and the level of past and contemporary investment I_{t-n} and I_t:[29]

[29] Sylos maintains that the increase in labor costs does not affect the level of investment (which depends primarily on demand pressure), but rather its composition. As it is not, however, possible to determine exactly to what extent labor-saving

$$\Delta\pi = a + b\Delta Y_t + c\Delta(W/P_m)_{t-n} + dI_{t-n} - eI_t$$

In a second formulation, however, which he regards as equivalent, Sylos (1993) expresses productivity growth as a function of output growth ΔY_t, labor cost growth relative to changes in the general price level $\Delta(W/P)_t$, and labor cost growth relative to machine prices $\Delta(W/P_m)_{t-n}$. The terms relating to investment are omitted, on the assumption that the mechanization effect takes care of the part of investment embodying technical change.[30]

$$\Delta\pi = \alpha + a\Delta Y_t + b\Delta(W/P)_t + c\Delta(W/P_m)_{t-n}$$

This second version models separately the organization effect and the mechanization effect. Notice that the difference between the two independent variables is given not only by the different price index in the denominator but also by the fact that the ratio between the wage and machine prices is lagged (usually 3 or 4 years) while the organization effect is supposed to be contemporaneous.[31] Over the years, the author developed several estimates of these two versions of the productivity equation, never estimating an equation containing at the same time all the determinants described above. This can instead be found in subsequent authors (Guarini, 2007; Carnevali et al., 2020).

The empirical literature stemming from Sylos's analysis of productivity (see for example Lucidi and Kleinknecht, 2009; Lucarelli and Romano, 2016; Vergeer and Kleinknecht, 2011; Lucarelli and Perone, 2020; Corsi & D'Ippoliti, 2013; Guarini, 2007; Carnevali et al., 2020), which finds general empirical confirmation of Sylos's insights, also raises several relevant issues related to estimation of the productivity equation. A first issue regards the fact that measured productivity growth is far from representing a correct measure of pure technical improvements. We have seen however in section 2 how the effects on productivity both of demand and of wages also include changes in the intensity of use of labor which cannot be ascribed merely to technical progress. Due to the lack of a different indicator, we will use in our own estimates the standard definition of labor productivity, being however aware of the complexity of its interpretation.

A second issue concerns the use of lagged values for the wage variables as a tool to control for reverse causation, i.e. the possible endogeneity of wages to productivity. Some authors (Vergeer and

investment is stimulated by an increase in wages relative to machine prices and to what extent it is independent, he initially includes both variables in the analysis (Sylos Labini, 1984).

[30] Sylos (1989, p.150; 1993, p. 258) states that the two versions of the productivity equation are not contradictory, since the temporal sequence revealed by the estimates is justified theoretically. The idea is 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, is thus implicitly represented by the mechanization effect, at least for the part of investment embodying technical innovations.

[31] When working in aggregate, a correlation normally appears between the two price indices; however, in our set of data they show different trends especially after 1995 and the correlation is much weaker when moving from index levels to growth rates of the deflated labor cost variables. In addition, when working with subsectors, we use a single aggregate CPI index at the manufacturing level for all sectors, whereas the investment deflator is diversified for each sector, leading to measures of the mechanization effect that vary widely across sectors (see section 4.2 for details on variables).

Kleinknecht, 2011; Lucarelli and Perone, 2020 among others) introduce multiple lags for each independent variable, while others (Guarini, 2007; Carnevali et al., 2020) choose a specific lag for each variable in line with Sylos's original analysis, following the time sequence he proposed and detected empirically. A third crucial issue concerns the possible endogeneity between productivity and output growth. This is a well-known issue in the literature estimating the Kaldor-Verdoorn law that can be addressed with many different techniques (see McCombie et al. 2002 for a survey). One of the most effective techniques to overcome the problem is the use of instrumental variables (McCombie and DeRidder, 1984; Carnevali et al., 2020; Corsi & D'Ippoliti, 2013), which we will use in our own estimation.

4.2 Data and methodology

For our estimates, we make use of the Conference Board International Labor Comparisons database, which contains data both for Manufacturing as a whole and its subsectors on value added, employment, total hours worked, average hours worked and total labor cost. Data on investment in private fixed assets come from the Bureau of Economic Analysis (BEA). On this basis we build a dataset that contains annual data on the above-defined variables over the period 1950-2018 for 19 manufacturing subsectors. Following the standard use, we define productivity as real GDP per hour worked (in chained 2012 values). Detailed definitions and data sources for all variables are provided in Table A2 in the Appendix.

Focusing on Manufacturing alone and its subsectors allows us both to benefit from the availability of long time series and to concentrate attention on a sector whose dynamics have been crucial in the aggregate outcome, as shown by our analysis in section 3. The use of annual instead of quarterly data allows us to smooth out, at least in part, the cyclical effect of demand on productivity, if any should appear indeed in the data.[32]

We begin by checking the stationarity of our variables using the Levin–Lin–Chu test for unit roots and find that their stationarity is confirmed, except for the level of investment (see Table A5 in the Appendix). We estimate different models using different techniques. Particularly, our first and second model replicate Sylos Labini's two versions of the productivity equation:

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

$$\Delta\pi_{i,t} = \alpha + a\Delta Y_{i,t} + b\Delta(W/P)_{i,t} + c\Delta(W/P_m)_{i,t-n} \qquad (model\ 2)$$

where $\Delta\pi_{i,t}$ is the growth of productivity, $Y_{i,t}$ real value added, W/P the hourly labor cost deflated with the consumer price index (CPI), W/P_m the hourly labor cost deflated with the price index of investment in private equipment by sector, I_t the level of real investment in private non-residential fixed assets. Our

[32] We do not enter here the above-mentioned debate raised by Gordon (2010).

third model contains all determinants in a single equation:[33]

$$\Delta\pi_{i,t} = \alpha + a\Delta(W/P)_{i,t} + b\Delta Y_{i,t} + c\Delta(W/P_m)_{i,t-n} + dI_{i,t-n} - eI_{i,t} \qquad (model\ 3)$$

Coefficient a captures the organization effect; coefficient b the extent-of-the-market effect which, in our interpretation, encompasses the different effects that aggregate demand exerts on productivity (both the Kaldor-Verdoorn effect and changes in efficiency not linked to technical progress); 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.

To deal with possible reverse causation between wages and productivity and to identify the lag structure, we use both approaches proposed in the literature. We first include up to 9 lags for each of the two measures of wages (while for output growth and investment only significant lags are included). We also estimate a model in which a unique lagged term is introduced for each independent variable, according to the time sequence originally proposed by Sylos (contemporaneous term for the organization effect, 3 or 4 period lagged term for the mechanization effect). To deal with the possible endogeneity of output growth, we use the method of instrumental variables.

4.3 Estimates

As a first step, we perform pooled OLS estimates of our models, either with 9 lags of the wage indicators and all significant lags of the other independent variables, or with a specific lag structure. The 9 lags are added both simultaneously and sequentially (starting from the 1-year lag and then gradually adding up the others). The different timing of the effect of the two measures of labor cost, the mechanization effect and the organization effect, emerges clearly from the procedure of gradual addition of lags. In fact, the organization effect has its strongest effect at times *t* and *t-1* and then gradually fades out, while the mechanization effect is initially very small, not always significant and sometimes even negative, and only after a few years it becomes a strong positive effect. This result helps to reveal, together with a comparison of models through the Akaike information criterion, the optimal lag structure, which is no-lags for the organization effect and the extent-of-the-market effect, only the fourth lag for the mechanization effect and first lag for investment.[34]

[33] Following part of the literature, we have also experimented with the ratio between investment and output as a regressor. However, since the results are not significantly different, we prefer to follow more closely Sylos Labini's original estimations by including the level of investment.

[34] The 4-year lag may seem like a long time for wages to affect productivity, but the timing covers both the reaction to an increase in relative labor costs before introducing an innovation and the effect of that innovation on productivity. About the latter, innovating firms may introduce innovation quickly, but at the same time there are declining firms which are stagnating or disappearing. When the increase in aggregate productivity becomes visible, this implies that many firms have adopted innovative techniques and the latter have become so relevant in the whole sector that their effect shows in aggregate data.

Table 6. Pooled OLS estimates						
	Single-lag model			Multiple-lags model		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
$\Delta(W/P)_{i,t}$		0.33*** (.0155)	0.31*** (.0152)		0.30*** (.0156)	0,30*** (.0154)
$\Delta(W/P)_{i,t-1}$					0.12*** (.0156)	0,11*** (.0156)
$\Delta(W/P)_{i,t-2}$					0.06*** (.0140)	0,06*** (.0138)
$\Delta(W/P)_{i,t-3}$					0.02 (.0140)	0,02 (.0139)
$\Delta(W/P)_{i,t-4\ to\ 9}$					0.11**	0,11**
$\Delta Y_{i,t}$	0.73*** (.0131)	0.59*** (.0128)	0.61*** (.0127)	0.76*** (.0130)	0.60*** (.0123)	0,61*** (.0125)
$\Delta Y_{i,t-1}$				-0.08*** (.0126)	-0.17*** (.0120)	-0,15*** (.0121)
$\Delta(W/P_m)_t$				0.10** (.0413)	-0.08** (.0360)	-0,09** (.0355)
$\Delta(W/P_m)_{t-1}$				0.04 (.0413)	-0.09** (.0382)	-0,06 (.0380)
$\Delta(W/P_m)_{t-2}$				0.12** (.0442)	0.03 (.0384)	0,03 (.0380)
$\Delta(W/P_m)_{t-3}$				0.05 (.0439)	0.02 (.0382)	0,02 (.0378)
$\Delta(W/P_m)_{t-4\ to\ 9}$	0.24*** (.0384)	0.21*** (.0338)	0.21*** (.0331)	0.49***	0.34***	0,32***
I_t	-0.5*** (.0585)		-0.4*** (.0506)	-0.44*** (.0556)		-0,26*** (.0469)
I_{t-1}	0.53*** (.0599)		0.42*** (.0519)	0.45*** (.0569)		0,26*** (.0481)
Constant	0.003 (.0018)	0.000 (.0338)	0.00 (.0015)	-0.01*** (.0023)	-0.002 (.0019)	-0.002 (.0019)
Adj-R^2	0.73	0.79	0.80	0.77	0.84	0.84

Authors' elaboration. Note. W/P= *organization effect;* Y= *Smith effect;* W/P_m= *mechanization effect;* I= *effect of investment.*

Table 6 shows the results of estimation of the various models. All variables are significant in explaining productivity growth and all coefficients have the expected signs. Sylos's equation appears to explain around 80 percent of the variability of labor productivity in the US manufacturing sectors. In the multiple-lags regression, the cumulated coefficient of the organization effect is about 0.6; the extent-of-the-market effect ranges between 0.4 and 0.6; the mechanization effect is about 0.2 (except for model 2 where it reaches 0.7); while the cumulated effect of investment is very small due to the opposite signs of their contemporaneous and lagged effects. In the single-lag model, the effect of investment and the mechanization effect remain almost the same size, while the extent-of-the-market effect increases to around 0.6-0.7 and the organization effect is reduced to about 0.3.[35] Overall, the inclusion of 9 lags does not seem to improve the estimates significantly, while it reassures us that the two labor cost measures have positive and significant effects on productivity growth over time.

The model with the optimal lag structure includes only the contemporaneous term for the ratio between wage and the general price level, i.e. the term that allows measuring the organization effect. This raises the question of possible reverse causality between productivity and this wage indicator. We thus proceed to further robustness checks. In the first place, we run the single-lag model by replacing the contemporaneous $\Delta(W/P)$ term with its one-period lagged value. Both the significance of the regressor and the sign of the coefficient are confirmed. In the second place, we perform estimates of the multiple-lags model in which we control for possible reverse causality by including up to 9 lags of productivity among the regressors (see Table A6 in the Appendix).[36] Again, significance and signs of all coefficients are confirmed. Finally, we run the Granger causality test that suggests that the $\Delta(W/P)$ term positively affects productivity growth (see Table A7 in the Appendix).

Our second step is to perform a set of estimates that better account for the panel nature of the data through a two-way fixed-effects model. By eliminating time-varying sector-specific effects, the panel estimator allows us to estimate the net effect of predictors within each sub-sector (i.e., considering only time-varying effects). We also introduce time-fixed effects to control for unexpected changes or special events that may affect the outcome variable. Due to the presence of within autocorrelation and cross-panel correlation, we run a Prais-Winsten regression, which calculates panel-corrected standard error (PCSE) estimates for linear cross-sectional time-series models that are assumed to follow a panel-specific first-order autoregressive process. Estimates are based on the optimal lag structure previously detected. Table 7 reports the results.

[35] It is worth noting that our estimated coefficients for the labor cost variables are in line with the results of other empirical literature (see for example Verger and Kleinknecht, 2011 and 2014).

[36] When we include the lagged levels of the dependent variable among the regressors, we check for the absence of autocorrelation in the residuals. This also ensures a condition of weak exogeneity of wages with respect to productivity (see Vergeer and Kleinknecht, 2011).

Table 7. Two-way fixed effect Prais-Winsten regressions			
Variable	Model 1	Model 2	Model 3
$\Delta(W/P)_{i,t}$		0.21*** (.0182)	0.21*** (.0178)
$\Delta Y_{i,t}$	0.86*** (.0138)	0.76*** (.0157)	0.77*** (.0154)
$\Delta(W/P_m)_{t-4}$	0.14** (.0543)	0.18*** (.0484)	0.19*** (.0475)
I_t	-0.21*** (.04185)		-0.19*** (.0396)
I_{t-1}	0.21*** (.04267)		0.19*** (.0403)
Constant	-0.033*** (.0052)	-0.025*** (.0039)	-0.026*** (.0039)
R^2	0.88	0.90	0.91
legend: * p<.1; ** p<.05; *** p<.001			

Authors' elaboration. Note. W/P= *organization effect;* Y= *Smith effect;* W/P_m= *mechanization effect;* I= *effect of investment.*

Our previous results are confirmed, both as regards the significance of the regressors and the signs of the coefficients. The size of the coefficients is broadly the same for the mechanization effect, slightly smaller for the organization effect and greater for the aggregate demand effect. As in the previous estimates, the contemporaneous and lagged effect of investments tend to offset each other, resulting in an almost zero cumulative effect. As a further robustness check, we have also performed estimates of the same models by using 5-year moving averages both of the endogenous and the exogenous variables. The procedure allows to smooth away entirely any cyclical behavior of productivity that could still affect annual data and to focus on the long-run nature of the effects of both demand and wages on productivity. All results regarding significance of the regressors and sign of the coefficients are confirmed.[37]

We then proceed to a third step in our estimates. In order to address the question of the possible endogeneity of output growth to productivity growth, we run a 2SLS instrumental variable estimation, widely used in the empirical literature on the Kaldor-Verdoorn Law (see for example McCombie and DeRidder, 1984; Corsi and D'Ippoliti, 2013; Ofria, 2009; Marconi et al., 2016). We estimate two different specifications of our models. The first specification uses as excluded instruments the one-period lagged growth of value added, the growth of export at times *t* and *t-1* and the growth of current public expenditure.[38] The second specification does not include the lagged value of output growth. Exports and public expenditure are quite commonly used as an instrument for output growth in the literature that addresses the same question (Deleidi et al. 2020, Millemaci and Ofria, 2012). All the estimates we run are based on 2-way cluster-robust SEs and statistics, which are robust to arbitrary within-panel

[37] Results are available from authors on request.

[38] Current government expenditures have been calculated as the sum of primary public expenditure (including public consumption, current and capital transfers except interest payments, and gross capital formation). Data on both total exports and government expenditure come from the Bureau of Economic Statistics and are converted into chained 2012 values by applying the corresponding GDP quantity indexes.

autocorrelation (clustering on panel id) and to arbitrary contemporaneous cross-panel correlation (clustering on time). We estimate the three models by means of a fixed effects 2SLS estimator for panel data.

Apart from testing the validity of the selected instruments through the Sargan-Hansen-J test, we rely on the Kleibergen-Paap Wald rk F statistic, which is the counterpart of the Cragg-Donald Wald statistic for the case of non i.i.d errors, to check for the possible weakness of the instruments. Finally, to test their relevance, i.e. their correlation with the endogenous regressor, we refer to the Kleibergen-Paap rk LM statistic. The results obtained for our two different specifications of the instruments are reported in Table 8.

Table 8. Instrumental Variables estimates						
	Specification 1			Specification 2		
Variable	Model 1	Model 2	Model3	Model 1	Model 2	Model3
$\Delta(W/P)_{i,t}$		0.52*** (.0847)	0.51*** (.0579)		0.55*** (.0534)	0.55*** (.0530)
$\Delta Y_{i,t}$	0.22** (.1031)	0.19** (.0574)	0.22** (.0875)	0.19* (.1006)	0.14* (.0750)	0.15* (.0785)
$\Delta(W/P_m)_{t-4}$	0.29** (.1146)	0.24* (.1234)	0.23* (.1189)	0.29** (.1180)	0.24* (.1314)	0.24* (.1290)
I_t	-0.10 (.1546)		-0.09 (.0786)	-0.08 (.1561)		-0.03 (.0976)
I_{t-1}	0.12 (.1393)		0.10 (.0811)	0.10 (.0999)		0.04 (.1017)
Adj-R^2	0.37	0.59	0.62	0.33	0.54	0.55
Hansen-J test p-value	.0881	.0507	.0516	.0755	.1170	.1014
rk F-statistic	16.56	18.67	16.31	20.04	22.63	21.04
rk LM p-value	.0629	.0815	.0646	.0316	.0405	.0322
legend: * p<.1; ** p<.05; *** p<.001						

Authors' elaboration. Note. W/P = *organization effect;* Y = *Smith effect;* W/P_m = *mechanization effect;* I = *effect of investment.*

The results once again confirm the validity of Sylos Labini's productivity equation. The coefficients are significant and have the expected signs with the sole exception of investment, which are no longer significant in the IV estimation. As the values of the Kleibergen-Paap Wald rk F statistic for all specifications are higher than the rule-of-thumb value of 10 proposed by Staiger and Stock (1997), our estimates are not harmed by the problem of weak instruments. In all specification, we also accept the null hypothesis of the Hansen-J test that the overidentifying instruments are valid, which means that our instruments are not correlated with the error. However, only in the second specification, which does not include lagged growth of output among the instruments, are we able to reject the null hypothesis of the LM under-identification test, i.e. our model is identified. Therefore, if we include past output growth among the instruments, the model is only weakly identified; whereas when we use as instruments exports and government spending alone, the model is identified.

The results show that the extent-of-the-market effect on productivity growth is still relevant, although the coefficient is now lower than in the previous estimates (0.2 versus 0.6-0.7). We may argue that in the IV estimation some of the explanatory power of output growth is lost because export growth and government spending explain only part of the variation in output growth. Our estimates thus capture the effect of these components of demand rather than market expansion as such, and this would also explain the lower impact on labor productivity growth (for a similar consideration see Deleidi et al. 2022). We can therefore conclude that, even when instrumented, output growth is still a statistically significant determinant of labor productivity growth. As regards the two indicators of relative wages, they are always significant in explaining changes in productivity, although the size of the respective coefficients is now different, especially as regards the organization effect (which appears greater). In brief, except for investments, our key qualitative findings are generally confirmed, even though the sizes of the coefficients are different.

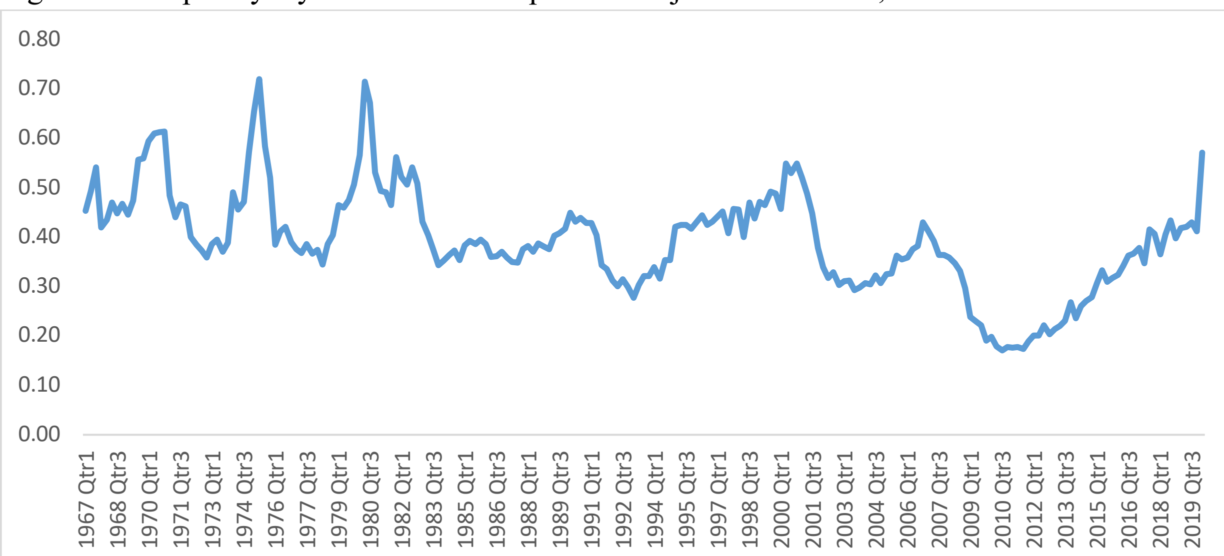
Although we regard our IV model as the most convincing one due to the fact that it allows controlling for endogeneity, yet, given the intricacy of possible interrelations between the variables and the estimation issues involved, we believe that the fact that all our models confirm the same qualitative results is very relevant. While the effect of aggregate demand on productivity is undisputable, and confirmed when checking for endogeneity, what especially concerns us here is that in the US manufacturing sectors wages do indeed exert direct powerful effects on productivity. Both the organization effect and the mechanization effect are consistently significant across all our different estimations, and our checks and tests confirm that this cannot be attributed to reverse causation. This proves that the persistent deterioration in real wages and the wage share does not only raise the social question of the living standards of a great part of the population, but may also produce permanent macroeconomic scars, in terms of long-term negative effects on the growth prospects of the economy.

4.4 The role of labor market institutions: productivity and indicators of labor weakness

Based on these results, it can be affirmed that a situation of prolonged workers' weakness which induces reduction of labor costs relative to the price of output and other inputs can produce persistent negative effects on productivity growth. Faced with the choice of increasing production through investment and innovation, with its costs and risks, or through employing more workers, firms are likely driven, due to the availability of low-cost and unprotected labor, to a more extensive use of work rather than innovation. Starting from a Schumpeterian perspective, some authors argue that both wage growth and labor market rigidity would instead foster the process of 'creative destruction' by incentivizing innovations as firms aim to be more competitive in a high-cost environment (Kleinknecht et al., 2006; Pieroni and Pompei, 2008). In addition, easier firing and a higher labor turnover can harm innovative activity by negatively affecting training and high-quality human resource management practices within firms. More secure and long-lasting labor relations, on the contrary, create in the firm an environment of trust, fostering knowledge accumulation and workers' cooperation in innovative activity (for a detailed analysis see Kleinknecht, 2020).

In this section we intend to test empirically the idea that labor 'weakness' has adverse effects on productivity by augmenting the productivity equation with suitable indicators. As a measure of labor weakness, we use two different indicators. The first one, proposed by Perry et al. (1993), is the ratio of temporary layoffs to permanent job losses among the unemployed, which may be interpreted as an index of the 'ease of dismissal'.[39] Recessions typically cause a rise in both temporary layoffs and permanent job terminations. Until the mid-1980s, the increase in temporary layoffs during contractions exceeded the increase in permanent job losses, causing an increase in their ratio. However, from that time on, the trend has changed, as permanent job losses have started to become more relevant than in the past. According to Perry et al. (1993), this has to do, at least in part, with job restructuring by many prominent firms.[40] In the 2008-2009 crisis, the increase in permanent job losses was significantly greater than the increase in temporary layoffs, causing a sharp reduction of the indicator; the opposite of what happened, for example, in the deep recession of 1975 (see Figure 4).[41]

Figure 4. Temporary layoffs as a ratio of permanent job losses. USA, 1967-2020



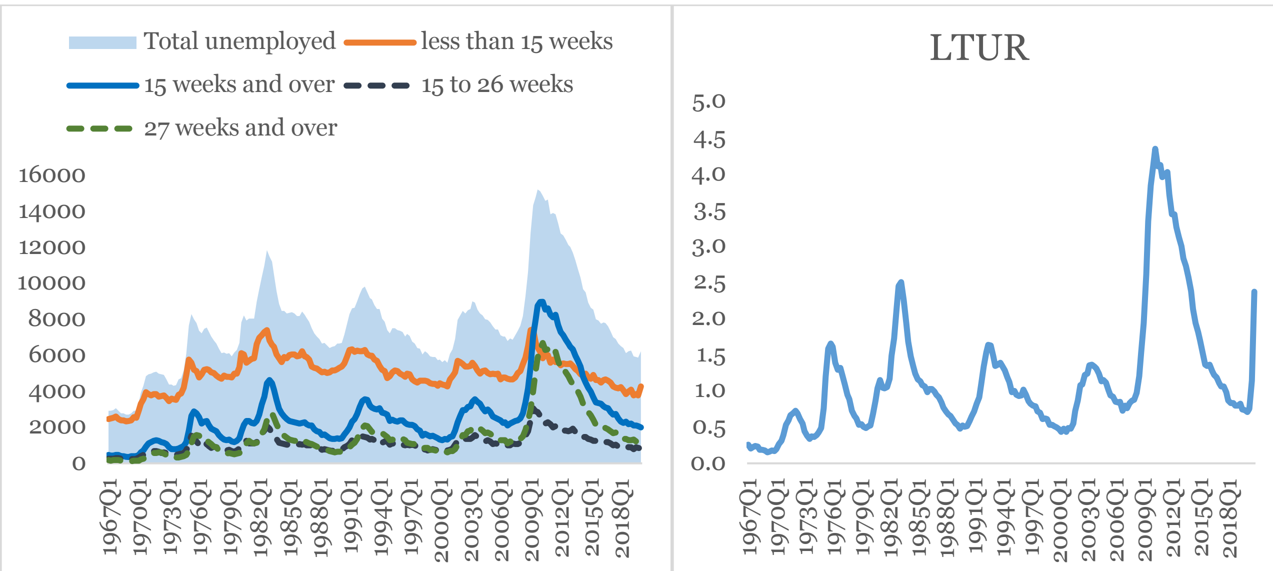
Source: authors' elaboration on BLS data.

As our second indicator of labor weakness, we take the cumulated growth of the long-term unemployment rate, defined as the ratio between the number of people unemployed for 27 weeks or more and the labor force (for the advantages of using this indicator instead of the *incidence* of long-term unemployment see Paternesi Meloni et al., 2021). Looking at the number of unemployed by duration, we see that once again the 2009 crisis differs from the past in that the increase in the number of unemployed seems to involve mainly an increase in long-term unemployment (see Figure 5). The average duration of

[39] The BLS breaks down data on the unemployed by reason for unemployment. We refer to the split between those who are on temporary layoffs and those who have lost their jobs permanently (either because their contract ended, or they were fired).
[40] As recalled in section 2.1. above, Gordon (2010) describes the change in labor relations and organization that has taken place since the 1980s in terms of a drastic reduction in the quasi-fixed nature of the labor input, entailing a much greater tendency to easily terminate labor relations.
[41] In 2020 we observe an increase of the indicator. It is not clear yet whether this is a temporary phenomenon due to the peculiarity of the pandemic crisis, or instead the signal of a structural change in the labor market. The year 2020 is however outside our dataset.

unemployment has been increasing over time, but whereas in the past both short-term and long-term unemployment increased in recessions, in the recent period the increase in long-term unemployment seems to be more pronounced. Taken together, the two indicators seem to show that in recent decades, until the recession induced by the covid crisis, the ease of dismissal has increased, and the time needed to re-enter the labor market has lengthened.[42] Supposing these changes reflect indeed increased labor weakness, we want to test whether they affect labor productivity growth.

Figure 5. Unemployment by duration. USA 1967-2020



Source: authors' elaboration on BLS data. LTUR= long-term unemployment rate (unemployed for 27 weeks or more divided by the labor force).

Given the fact that investments are not significant in some of our estimates, we include the labor weakness indicators in the version of Sylos Labini's productivity equation without investments. The extended functional form we estimate is:

$$\Delta\pi_t = \alpha + a\Delta Y_t + b(W/P)_t + c\Delta(W/P_m)_{t-3} + d\Delta weak_{t-1} \qquad (4)$$

where $\Delta weak_t$ stands alternatively for the ratio of temporary layoffs to permanent job losses or for the cumulated growth of the long-term unemployment rate. Estimates have been performed for total manufacturing for the period 1966-2018 using annual data from the Conference Board International Labor Comparisons database and BLS data on the unemployed. The optimal lag structure has been derived by applying the procedure of gradual addition of lags as used in section 4.3 and relying on Akaike's information criteria. Due to the presence of autocorrelation in the residuals, we use an autoregressive model of the first order AR(1) and we also perform a 2SLS estimate with kernel-based autocorrelation-consistent standard errors. Results are shown in Table 9.

[42] This result, it is worth noting, is at odds with policy prescriptions supporting labor market deregulation, according to which greater labor flexibility in the form of easier firing should supposedly lead to easier hiring, reducing the average duration of unemployment.

Table 9. The impact of labor weakness – total manufacturing				
	Temporary vs permanent job loss		Long term unemployment rate	
Variable	AR (1)	2SLS	AR (1)	2SLS
$\Delta(W/P)_{i,t}$	0.48*** (.1334)	0.46*** (.1439)	0.45*** (.1224)	0.43*** (.0496)
$\Delta Y_{i,t}$	0.30*** (.0836)	0.21*** (.0414)	0.30*** (.0870)	0.22*** (.0496)
$\Delta(W/P_m)_{t-3}$	0.23** (.1005)	0.37*** (.1395)	0.26*** (.0856)	0.34*** (.0861)
$\Delta weak_{t-1}$	0.09* (.0466)	0.06* (.0344)	-1.3*** (.4596)	-1.1*** (.2387)
$\Delta\pi_{t-1}$	0.44*** (.1584)		0.35* (.1903)	
Constant	-0.02 (.0189)	0.01 (.0119)	0.02*** (.0053)	0.02*** (.0062)
Adj-R^2	0.59	0.49	0.61	0.59
rk F statistic		240.14		94.8
legend: * p<.1; ** p<.05; *** p<.001				

Authors' elaboration. Note. W/P= *organization effect;* Y= *Smith effect;* W/P_m= *mechanization effect;* $weak$= *effect of alternative indicators of labor weakness.*

The coefficients of both indicators have the expected signs: positive for the ratio between temporary and permanent job losses (which decreases for increases in labor weakness); negative for the cumulative growth of the long-term unemployment rate (which increases for increases in labor weakness). Table 9 also reports the results of the instrumental variable estimate, which confirm the effects of both indicators on productivity. As excluded instruments for the growth of output, we use the growth of total exports at times *t* and *t-1* and the growth of public expenditure. Equation (4) has been estimated by means of an autocorrelation-consistent 2SLS estimator (based on Newey-West standard errors). A high Kleibergen-Paap Wald rk F statistic in both specifications reassures us that our estimates are not harmed by the problem of weak instruments. In addition, we are able to accept the null hypothesis of the Hansen-J test that the overidentifying instruments are valid. However, we are not able to reject the null hypothesis of the Kleibergen-Paap rk LM test statistic, suggesting that the model is only weakly identified. All the qualitative results are once again confirmed.

Summing up our results, if there is reason to regard the indicators we have selected as good proxies for labor weakness and insecurity, we may maintain that both increasing labor insecurity and stagnating wages can indeed contribute to the productivity decline. Notwithstanding the different indicators and reference to different institutional contexts, we may surmise that our results go in the same direction of the literature which has found, especially with reference to European countries, a negative effect of the increases in labor flexibility and the reduction of employment protection on labor productivity (see Bassanini & Ernst, 2002; Lucidi & Kleinknecht, 2009; Storm and Naastepad, 2009; Vergeer & Kleinknecht, 2011, 2014; Hoffman et al., 2021).

5. Conclusions

Our paper contributes to the debate on the causes of the anemic growth of productivity in the USA in recent decades, by taking as its standpoint the classical-Keynesian approach, which, if compared with the mainstream approach, offers a more complex theoretical conception of labor productivity and its determinants. Consistent with the principle that growth is demand-constrained and no automatic tendency exists in the system to full and efficient use of all available resources, the classical-Keynesian approach states the impossibility of isolating an indicator of pure technological efficiency, and regards changes in the structure of costs and relative prices as an essential part of the observed changes in productivity. Productivity growth, both in its purely technological and non-technological dimensions, is considered to be far from entirely exogenous but rather subject to multiple influences, among which those of aggregate demand are prominent.

Within this theoretical framework, we have particularly focused on the possible independent effects that the growth of wages may exert on productivity growth. Based on literature (particularly taking advantage of the contributions of Sylos Labini), we have identified two possible direct effects, the mechanization effect and the organization effect, occurring through the stimulus that high and fast-growing wages represent towards respectively technical innovations and organizational innovations, i.e., more efficient organization of the production process. We especially regard the wage stagnation of the last decades as one possible concomitant cause of the disappointing dynamics of productivity that has lately characterized the US economy, since it may have constituted an incentive towards an 'extensive' use of labor – i.e., a business strategy that takes advantage of the mass availability of cheap labor.

Our empirical analyses show, in the first place, that much of the dynamics of U.S. productivity over the years 1992-2018 is explained by within-sectors changes rather than by big changes in the structure of the economy. The sharp slowdown in productivity from 2010 to 2018, in particular, can be attributed to the slowdown of productivity in sectors that showed a comparatively high productivity growth in previous years, such as Manufacturing, Real estate, and Finance. A polarization between high-productivity/high-wage productions and low-productivity/low-wage productions took place especially in the years 2000-2008. Based on our results, we believe that these types of changes have occurred not only through a reallocation of employment and production *between* sectors, but also *within* sectors, among firms operating under different business models. Our sectoral decomposition of the growth in wages and, through a different technique, of the change in the wage-productivity gap, show that the increase in the wage-productivity gap is mainly concentrated in a single period, 2000-2008, which stands out as the period of the highest growth of productivity in which, however, wages did not benefit from that growth and the change in distribution against wages was most marked. Notably, it is after that change in distribution against wages that some historically high-productivity sectors switched towards a slower growth of productivity while showing employment gains. This constitutes, in our view, a first empirical confirmation of our hypothesis regarding the existence of an incentive towards an extensive use of labor.

In the second place, we have tested the hypothesis that wage growth directly affects productivity growth, by estimating the Sylos Labini productivity equation at the sectoral level for a panel of 19 sub manufacturing sectors over the period 1950-2018. Our results confirm the existence of such effects as well as the relevance of both effects (mechanization and organization). We also find evidence of a potential negative effect of labor 'weakness' on productivity, by augmenting the equation with two alternative indicators: the ratio between temporary and permanent job losses and the cumulative growth of the long-term unemployment rate. If we take the indicators we have proposed as indicators for labor weakness and job insecurity, we can thus conclude that increasing job insecurity and stagnant wages have indeed contributed to the decline in US productivity.

To state the existence of such 'supply-side' effects of wages on productivity does not amount to maintaining that increases in productivity might by themselves induce higher growth of output in the system. Consistent with our theoretical structure, we believe that growth is primarily induced by the dynamics of aggregate demand (which also exerts its own influence on productivity growth, as our estimates show). By positively affecting productivity, high wages may have however a double (if indirect) effect: on the one hand, the growth of productivity may produce a greater capability for firms (or the national productive system as a whole) to attract more international demand, thus contributing to the growth of aggregate demand and output; on the other hand, it may enlarge the space for non-inflationary growth under the pressure of high demand.

All the above implies that a strategy of growth based on labor weakness and wage stagnation, as the one that has dominated the recent decades, however favorable to profits in the short run, is short-sighted both from the point of view of the whole system and, from a long-term perspective, also of the firms that populate it. High wages, on the contrary, not only are likely to boost demand but constitute a powerful incentive for firms to look for innovative and efficient strategies of growth. This implies that any policy aimed at bringing the economy towards a high-employment target through sustaining aggregate demand would be far more effective in enhancing the long-term growth prospects if accompanied by policies that directly address distribution.

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APPENDIX

Table A1. The 20 sectors of the total economy

Agriculture, forestry, fishing, and hunting	AGRIC
Mining	MINING
Utilities	UTIL
Construction	CONSTR
Manufacturing	MANUF
Wholesale trade	WHTRA
Retail trade	RETRA
Transportation and warehousing	TRANS
Information	INFO
Finance and insurance	FINAN
Real estate and rental and leasing	REALEST
Professional, scientific, and technical services	PROFES
Management of companies and enterprises	MANAG
Administrative and waste management services	ADMIN
Educational services	EDU
Health care and social assistance	HEALTH
Arts, entertainment, and recreation	ARTS
Accommodation and food services	ACCFOOD
Other services, except government	OTHER
Government	GOV

Table A2. Data description

Variable	Name	Frequency	Unit/measure	Source
$\boldsymbol{Y_{i,t}}$	Real Value Added	Annual	Millions of $	Conference Board
$\boldsymbol{W_{i,t}}$	Total Labor cost	Annual	Millions of $	Conference Board
$\boldsymbol{H_{i,t}}$	Total Hours	Annual	Millions of hr	Conference Board
$\boldsymbol{I_{i,t}}$	Real Investment In Private Fixed Assets	Annual	Billions of $	Bureau of Economic Analysis
$\boldsymbol{P_{t}}$	Consumer Price index	Annual	Index	Conference Board
$\boldsymbol{Pm_{i,t}}$	Implicit Deflator Investment in Equipment	Annual	Index	Bureau of Economic Analysis
$\boldsymbol{\pi_{i,t}}$	Labor productivity	Annual	Real value added per hour worked	Conference Board
$\boldsymbol{(W/P)_{i,t}}$	Organization effect	Annual	Real labor cost per hour worked	Conference Board
$\boldsymbol{(W/P_m)_{i,t-n}}$	Mechanization effect	Annual	Real relative labor cost per hour worked	Conference Board
$\boldsymbol{Y_{i,t}}$	Smith effect	Annual	Real value added	Conference Board
$\boldsymbol{I_{i,t}}$	Investment	Annual	Real investment	Bureau of Economic Analysis
$\boldsymbol{EXP_{t}}$	Real Total Exports	Annual	Billions of $	Bureau of Economic Analysis
$\boldsymbol{G_{t}}$	Real Primary Public expenditure	Annual	Billions of $	Bureau of Economic Analysis

Table A3. Main contributors to total productivity change

1992-2000					
		Within effect	*Static sectoral effect*	*Dynamic sectoral effect*	Total change
Manufacturing		4.9	-1.4	-0.6	2.9
Total		14.0	-0.8	-1.3	11.9
% of total		*35.0%*	*169.1%*	*46.0%*	*24.6%*
2000-2008					
Manufacturing		7.0	-2.9	-1.6	2.4
Total		17.6	0.5	-2.3	15.8
% of total		*39.7%*	*-561.0%*	*70.3%*	*15.2%*
2010-2018					
		Within effect	*Static sectoral effect*	*Dynamic sectoral effect*	Total change
Information		2.4	-0.5	-0.3	1.7
Manufacturing		0.1	-0.3	-0.0	-0.2
Total		4.9	-0.3	-0.4	4.2
% of total	*Info*	*49.7%*	*167.3%*	*66.0%*	*40.0%*
	Man	*1.4%*	*98.1%*	*0.4%*	*-5.3%*

Table A4. Industry origins of the cumulated growth of the wage-productivity gap (percentage contributions)

	1992-2000	2000-2008	2010-2018
PROFES	-149,3%	4,6%	-33,0%
INFO	-139,6%	42,2%	43,3%
ADMIN	-46,7%	-1,8%	-9,9%
FINAN	-43,1%	-35,5%	31,1%
ARTS	-12,5%	-0,5%	1,9%
GOV	-11,3%	-11,0%	18,8%
OTHER	-1,8%	-10,3%	-1,1%
RETRA	4,2%	-2,4%	7,2%
HEALTH	8,5%	-5,2%	-16,6%
TRANS	9,3%	6,2%	5,6%
EDU	12,1%	0,6%	-0,2%
AGRIC	18,1%	4,7%	0,8%
MANAG	20,3%	1,2%	-19,5%
ACCFOOD	23,3%	-0,9%	-0,5%
MINING	26,8%	7,6%	-6,1%
UTIL	29,9%	-0,3%	8,5%
WHTRA	41,5%	8,2%	27,9%
CONSTR	41,8%	1,2%	1,0%
MANUF	42,7%	34,5%	20,3%
REALEST	225,8%	57,0%	20,2%
TOT	100,0%	100,0%	100,0%

Table A5. Levin-Lin-Chu unit-root test

Ho: Panels contain unit roots **Ha: Panels are stationary**		
	Adjusted t* statistic	p-value
$\Delta\boldsymbol{\pi}_{i,t}$	-19.36	0.0000
$\Delta(\boldsymbol{W}/\boldsymbol{P})_{i,t}$	-16.80	0.0000
$\Delta(\boldsymbol{W}/\boldsymbol{P}_{m})_{i,t}$	-12.14	0.0000
$\Delta\boldsymbol{Y}_{i,t}$	-18.76	0.0000
$\boldsymbol{I}_{i,t}$	0.69	0.7561

Table A6. Robustness check. Pooled OLS estimates of different model specifications

	Single-lag model			Multiple-lags model		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
$\Delta\boldsymbol{\pi}_{i,t-1}$				0.06** (.0283)	0.19*** (.0277)	0.06** (.0280)
$\Delta\boldsymbol{\pi}_{i,t-2}$				-0.06*** (.0173)	0.01 (.0146)	-0.05** (.0171)
$\Delta\boldsymbol{\pi}_{i,t-3}$				-0.001 (.0171)	0.02 (.0145)	0.00 (.0170)
$\Delta\boldsymbol{\pi}_{i,t-4\ to\ 9}$				-0.01**	0.14**	-0.01**
$\Delta(\boldsymbol{W}/\boldsymbol{P})_{i,t}$				0.31*** (.0156)		0.30*** (.0155)
$\Delta(\boldsymbol{W}/\boldsymbol{P})_{i,t-1}$	0.08*** (.0246)		0.07** (.0242)	0.11*** (.0181)		0.09*** (.0180)
$\Delta(\boldsymbol{W}/\boldsymbol{P})_{i,t-2}$				0.10*** (.0183)		0.09*** (.0182)
$\Delta(\boldsymbol{W}/\boldsymbol{P})_{i,t-3}$				0.02 (.0186)		0,01 (.0185)
$\Delta(\boldsymbol{W}/\boldsymbol{P})_{i,t-4\ to\ 9}$				0.11***		0,11***
$\Delta\boldsymbol{Y}_{i,t}$	0.70*** (.0239)	0.73*** (.0131)	0.72*** (.0234)	0.60*** (.0122)	0.75*** (.0128)	0.61*** (.0124)
$\Delta\boldsymbol{Y}_{i,t-1}$				-0.20*** (.0204)	-0.22*** (.0235)	-0.19*** (.0204)
$\Delta(\boldsymbol{W}/\boldsymbol{P_m})_{t}$				-0.09** (.0361)	0.11** (.0403)	-0.09** (.0357)
$\Delta(\boldsymbol{W}/\boldsymbol{P_m})_{t-1}$				-0.09** (.0383)	0.01 (.0435)	-0.06 (.0383)
$\Delta(\boldsymbol{W}/\boldsymbol{P_m})_{t-2}$				0.03 (.0388)	0.12** (.0435)	0.04 (.0384)
$\Delta(\boldsymbol{W}/\boldsymbol{P_m})_{t-3}$				0.01 (.0385)	0.04 (.0433)	0,01 (.0382)
$\Delta(\boldsymbol{W}/\boldsymbol{P_m})_{t-4\ to\ 9}$	0.23*** (.04121)	0.24*** (.0384)	0.22*** (.0387)	0.39***	0.27***	0.31***
$\boldsymbol{I_t}$		-0.5*** (.0585)	-0.48*** (.0833)		-0.37*** (.0545)	-0,23*** (.0471)
$\boldsymbol{I_{t-1}}$		0.53*** (.0599)	0.51*** (.0837)		0.38*** (.0558)	0,24*** (.0482)
Constant	0.003* (.0017)	0.003 (.0018)	0.002 (.0018)	-0.001 (.0020)	-0.01*** (.0023)	-0.002 (.0020)
Adj-R²	0.71	0.73	0.73	0.84	0.78	0.84

Table A7. Granger causality test

H0: $\Delta(W/P)_{i,t}$ does not Granger-cause $\Delta\pi_{i,t}$ **H1: $\Delta(W/P)_{i,t}$ does Granger-cause $\Delta\pi_{i,t}$ for at least one sector**		
	Statistic	p-value
Z-bar	2.7284	0.0064
Z-bar tilde	2.4855	0.0129
*Optimal number of lags: 1 (tested 1 to 20)		