Very provisional version

PERMANENT SCARS: THE EFFECTS OF WAGES ON PRODUCTIVITY

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Abstract

This paper analyzes how the deterioration in real wages may be detrimental to productivity growth. We focus on two different direct effects of wages on productivity: a dynamic labor-saving effect due to induced technical change; and a more static effect, whereby high wages induce firms to re-organize their processes by making more efficient use of available labor. We first propose a shift-share analysis of the dynamics of both productivity and wages in the USA in recent decades, and we investigate the sectoral contributions to the cumulative growth of the wage-productivity gap. On this basis, we advance the hypothesis that the disappointing growth in productivity is not only due to the growing weight of low-wage and low-productivity sectors, but is also due to the recent trend towards the massive use of cheap labor even in some historically high-productivity sectors. Secondly, we focus our analysis on manufacturing, estimating the effects of wages on productivity through the productivity equation proposed by Paolo Sylos Labini. We also include two indicators that measure labor "weakness" in terms of duration and reasons for unemployment. Our estimates show that both stagnating wages and increasing labor insecurity do indeed contribute to the decline of productivity.

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1. Introduction

The recent decades, particularly the last twenty years, have been characterized in the USA as much as in most advanced economies by a disappointing growth performance and a quite 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, that usually fall back either on pure technological reasons or on some institutional incapability of the economy to exploit the innovation potential (see for example Gordon 2016). Productivity dynamics is also essential, the mainstream account goes, 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 stagnating dynamics of wages, starting however from a demand-led growth perspective, in which aggregate demand, differently from the mainstream account, has a prominent role in determining both output growth and the growth of resources. Reversing the mainstream causation, in such a framework the dynamics of productivity, though also connected in part to exogenous factors, can be seen as heavily affected both by output growth and by the growth of wages.

Recent literature in the demand-led growth approach has proposed especially two – not necessarily contrasting – explanations of the productivity slowdown. The first one (Storm 2017) 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 would imply an aggregate distributional shift against wages, which also adversely reacts on the growth of aggregate demand. The second explanation (see for example Fazzari et al 2020, Deleidi et al 2020) focuses precisely on endogeneity of productivity growth to the growth of aggregate demand. Such endogeneity is primarily analyzed through the so-called 'Kaldor-Verdoorn effect', which postulates 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. On the first count, we review the notion of productivity in the demand-led growth approach showing that, in this theoretical framework, productivity should not be interpreted merely as an indicator of technological knowledge but also as an indicator of the intensity of use of resources, an intensity which is determined endogenously by the conditions in which the economy operates. We use this notion in analyzing the possible endogeneity of productivity growth to the dynamics of wages, which constitutes the main focus of our analysis. We start from a conception of distribution (inspired to 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), who also studied the wages-productivity nexus by drawing on the analysis and insights of the classical political economists. Sylos Labini identifies a double direct effect of wages on productivity, one acting through induced technical progress – labor-saving innovations fostered by high wages – and a second one, of a more static character, 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 played a relevant part of their own as concomitant causes of the productivity slowdown. The dramatic distributional shift against wages that has materialized in recent decades has in our view reduced the incentive to technical innovation, at least in some sectors or sub-sectors of the economy. Moreover, it has constituted a strong incentive for a number of firms in different sectors to build their business strategies by taking advantage of the mass availability of low-wage labor, for example by lengthening the working day or the working week, with a consequent reduction in measured hourly productivity. By analogy with agricultural techniques, we refer to such practice as ‘extensive’ (versus ‘intensive’) use of the labor input induced by low wages. Although such phenomenon cannot have affected in the same measure all sectors, we believe that it 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 organization of production (regarding for example inventory management, the organization of the workspace, and the intra-sectoral redistribution of employment between firms with different work arrangements and different levels of productivity). Especially, we hypothesize that manufacturing, traditionally a high-productivity sector that has lately shown a slowing down of its productivity dynamics, has been somehow affected by such a drift towards a more extensive use of the labor input.

Our second purpose is to test empirically our theoretical hypothesis by using data on the US economy. We assess preliminarily 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 to our main hypothesis about the possible direct effect of wages on productivity, observing the fact that the most relevant drop in productivity growth materializes after the occurrence of a relevant distributional shift against wages that gave rise, especially in the 2000-2008 period, to a widening gap between productivity and wages.

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 to 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 considering 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 the issues of causality and 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 set of data.

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, are significant in affecting 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 and concludes.

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, do not only offer different explanations of the determinants of productivity and its relation 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 produce 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 massively 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. 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 is 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.

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, which need not coincide with the optimal use of resources and especially with full employment of labor,[1] is the result of the 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). Its measurement relies however on a series of very strict hypotheses, among which constant returns to scale and the validity of the marginalist theory of distribution. These allow to interpret the observed income shares of labor and capital as good approximation of the corresponding output elasticities in 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 growth of technological efficiency.[2] 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. Felipe and McCombie (2014) show that, although the indicator may be obtained through simple differentiation of an accounting identity with no particular theoretical assumptions, yet in this case it has simply a tautological meaning and, being defined in value terms, bears no definite relation to the quantity variables, so that its interpretation as an index of technological efficiency is entirely groundless. Due to the controversial and theory-laden nature of the notion, we

[1] 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.

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

choose to refrain entirely from reference to TFP in our analysis and refer exclusively to labor productivity.[3] Also the latter indicator, however, although neutral from the point of view of measurement, has different interpretations in the different approaches. Under the same assumptions that allow definition of the 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 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 the composite effect of different parts of the economy undergoing different transformations.[4]

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. Since 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

[3] 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.

[4] 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 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 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.

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 though 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.[5] Falls in output are generally followed by employment reductions only with 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.[6]

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, on the basis of its contribution to production, a tendency of wages is assumed 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 literature, which has explained the phenomenon invoking either structural changes linked to globalization and offshoring (Elsby et al 2013) or the characteristics of technical progress (Autor and Solomon 2018), or the tendency to concentration and the increase in firms' market power (Covarrubias et al 2019).[7]

[5] 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).

[6] See however Gordon (2010, p.15) who challenges this view maintaining 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'.

[7] 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.

If productivity growth may fail in some circumstances to be transmitted to wages, the possibility of a 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 product of market forces, relative scarcity of factors and their productivity. Wages cannot exert, in this context, an independent influence on productivity. Rather, in case imperfections in the market mechanism or the interference of labor market institutions determining excessive workers' power should cause wages to grow faster than productivity, 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 the conflict between workers and profit-earners playing a crucial role. This implies that the growth of wages may be seen as (at least in part) exogenous to productivity, and thus liable to influence the latter. Our reference 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.[8] 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.[9]

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.

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

[9] 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 Sylos Labini,…; 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 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 real wage, which remains constant, but in the value of wage 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.

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,[10] 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.[11] 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'.

The second effect, of a more static character, is instead induced by an increase in wage relative to the price of output, i.e. a relative increase in the cost of the labor input. This implies that firms have an incentive towards its more efficient use, through a re-organization of the production processes that takes place also regardless of technical progress. Sylos labels this effect as the 'organization' effect. While high wages induce a more efficient use of working time, low wages, on the contrary, encourage firms to build their business strategies around masses of low wage labor, for example by lengthening the working day or the working week, with a consequent reduction in measured hourly productivity. 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 'intensive' vs 'extensive' 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).[12]

This may take in practice different forms, also depending on the technical characteristics of the different sectors. Apart changes in working time, it may involve re-organization of inventory management or the workspace or redistribution of employment, within the same sector, between firms with different work arrangements and different levels of productivity thus involving transformations along the various phases of the value-chains.

Also with respect to the organization 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 proportions between factors of production along a production function that supposedly shows a continuum of efficient techniques. In the alternative framework we are describing, no continuum of techniques is postulated, the possibility of choosing among different methods of production need not be generalized (for example it may concern only some sectors), and the coexistence, in the economy, of efficient and less efficient techniques may be contemplated.

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

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

[12] In a partially 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 labour at fairly constant real wages per worker'.

The organization effect 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 in the following, it may provide very useful insights on the recent dynamic of productivity growth.

Summing up, the Post-Keynesian approach offers, if compared with the mainstream approach, a more complex theoretical conception of labor productivity and its determinants. In the first place, it recognizes the impossibility of isolating an indicator of pure technological efficiency, and regards the structure of costs and relative prices as an essential part of the observed changes in productivity. In the second place, it regards productivity growth, both in its purely technological and non-technological dimensions, as far from entirely exogenous but rather subject to multiple influences, among which those of aggregate demand and wages are prominent. In the third place, it also emphasizes those productivity changes generated by re-organization of productive processes and changes in the business models of firms.

Complexity has to do not only with the interpretation of the indicator and the plurality of its determinants but also with the possible existence of multiple interrelations between the relevant variables. Some relations may be highly context-sensitive: for example, not all differences in growth rates of aggregate demand between different historical phases cause parallel differences in productivity growth rates, depending on the structure of the economy and the kind of transformations it is undergoing. At the same time, the demand-led approach admits other interrelations, even with opposite direction of causation. 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. If such complex conception invites much caution in empirical analysis and its interpretation, yet it seems better apt capture the actual nature of the phenomena under scrutiny.

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

We intend now to apply our theoretical framework to the analysis of the productivity slowdown that has materialized in the US economy in recent decades. Actually, a first productivity slowdown occurred in the period between the mid-1970s to the mid-1990s, followed by a phase of sustained productivity growth and a second slowdown in the 2010s. Explanation of these long-run changes in productivity growth has puzzled economists and has been the object of much literature. Based on the mainstream theoretical approach, the slowdowns have mainly been explained in terms of exogenous reduction of 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 authors in this 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), something that contrasts with the standard interpretation of productivity.

Disappointing productivity growth has been also explained through other 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 the Baumol's well-known idea that productivity in the service sector is bound to grow slower than in manufacturing, the growing weight of the service sector has been regarded as a major cause of the first productivity slowdown. 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.[13]

With the prominent role it assigns to the dynamics of aggregate demand and wages as determinants of productivity, the Post-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 referring 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);[14] while the role of wage dynamics has been especially treated in models assuming that low wage growth reacts negatively on the growth of aggregate demand, thus affecting negatively productivity through an indirect channel (Storm, 2017).

We believe however that 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. In particular, a drift towards a more extensive use of labor is widely observable, we think, in such phenomena as the diffusion of low-wage precarious jobs in the economy or the practice of outsourcing some production phases towards firms in which unprotected laborers work for long hours.

The diffusion of low-wage jobs in the economy has also given rise to a structural hypothesis that accounts for the productivity slowdown in terms of a growing 'dualism', i.e., a growing polarization between low-wage and low-productivity sectors (like food preparation, healthcare and the like) on the one hand, and high-productivity and high-wage sectors (like manufacturing) on the other hand (Storm 2017; Taylor 2020). The expansion of the former at the expense of the latter would explain the parallel stagnation of productivity and wage growth in the aggregate.

[13] "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.

[14] Studying Okun's law, Fontanari et al (2020) show that lower levels of unemployment tend empirically to be associated with faster productivity increases.

Before testing empirically the direct effects of wages on productivity, we thus explore as a preliminary step, in section 3, the structural hypothesis, i.e. the hypothesis that the productivity slowdown has especially taken place in one part of the economy and may be explained through the contraction of high-productivity sectors as manufacturing.

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 previous industry data on compensation of employees and working hours. The level of disaggregation is up to 3 digits for almost all sectors. 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. According to the National Bureau of Economic Research (NBER), during the period covered by our data the US economy went through three cycles. Particularly, the three cycles have been made of comparatively short recessions followed by long expansionary phases. Within those cycles, 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.[15] 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

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

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

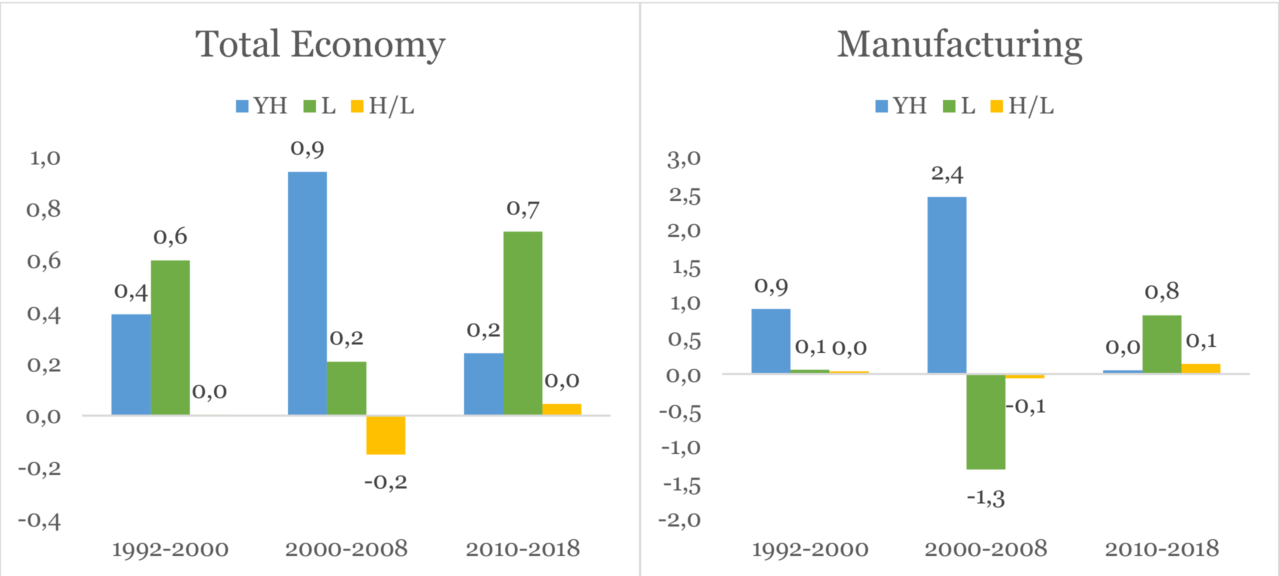
the third phase. Employment growth, on the contrary, slows down almost to zero in the second phase, and then shows a marked acceleration.

Table 2 proposes the same comparison of annual rates of growth but referring to the manufacturing sector only. Here we notice some differences with the trends of the total economy. Output growth slows down continuously over time, hourly wages never grow in line with hourly productivity, and employment in terms of hours worked shows positive growth almost only in the third phase. The intermediate 2000-2008 phase shows the same trends of the total economy but more marked: very high productivity growth and a dramatic decrease in hours worked. Also in the third phase, the same trends that characterize the total economy are more marked in manufacturing: output growth is mirrored almost entirely in an increase in hours worked, while productivity shows zero average growth.

Table 2. Average annual growth rates. Manufacturing			
	1992-2000	2000-2008	2010-2018
Output	2.4	1.9	1.4
Hourly productivity	1.9	5.3	0.0
Hours worked	0.5	-3.2	1.3
Hourly wages	1.2	3.9	0.6

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 between employment growth and output growth. 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.

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



Source: our calculation on BEA and BLS data. Legend: YH= hourly productivity; L=number of employed; H/L= hours per worker.

These ratios measure the growth of the three variables in relative terms and summarize and specify the trends already described. 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 output elasticity of productivity 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.

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) 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:

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

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.[16] Results are reported in Table 3.

Table 3. Shift-share analysis of the change in productivity. USA, 1992-2018, total economy						
	Annual average 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%

In all the three periods, the within effect is the dominating one, accounting for 112–118 percent of the aggregate change in productivity. The structural change effects on the whole 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 have been 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 4, which reports for each period only the main contributing sectors to total productivity change).

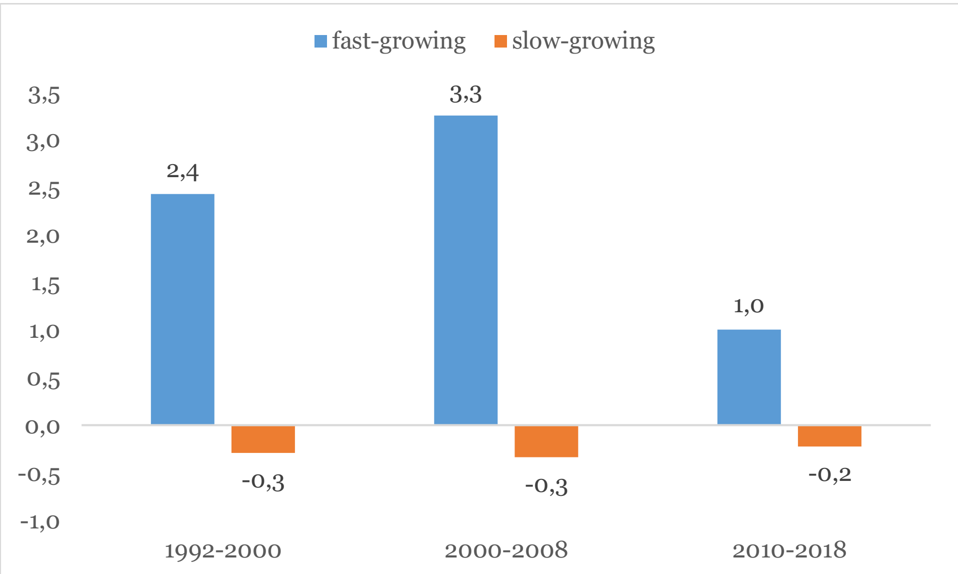
Table 4. Main contributors to total productivity change				
1992-2000				
	Within effect	*Static sectoral effect*	*Dynamic sectoral effect*	Total change
Manufacturing	4.9	-1.4	-0.6	2.9
Total	14.0	-0.8	-1.3	11.9

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

% 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%*
% of total *Man*	*1.4%*	*98.1%*	*0.4%*	*-5.3%*

In the second expansionary 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 4). 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 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 phase, the second one 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



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 slowing down 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 4). 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); the exception being Professional Activities, where both productivity and the employment share grow. On the whole, however, the productivity slowdown of 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 explains 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.

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. Also in this case, the aim of the analysis is 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.

The within effect measures the contribution of intra-sectoral wage growth to the overall wage change. The static sectoral effect will be negative when the share of low-wage industries in total employment increases at the expense of high-wages industries; while the dynamic sectoral effect will be negative if the sectors characterized by slow growth of wages increase their employment shares. Table 5 shows the results.

Table 5. Shift-share analysis of the change in average real wage. USA, 1992-2018, total economy.

	Annual average 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%

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 (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 6). 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).

Table 6. 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%*

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 7 shows that the discrepancy between the within-sectors growth of wages and that of productivity is prominent especially in the fast-growing sectors.[17]

Table 7. 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

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.

3.3 Sectoral decomposition of the wage-productivity gap

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

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 starts from 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:

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

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:[18]

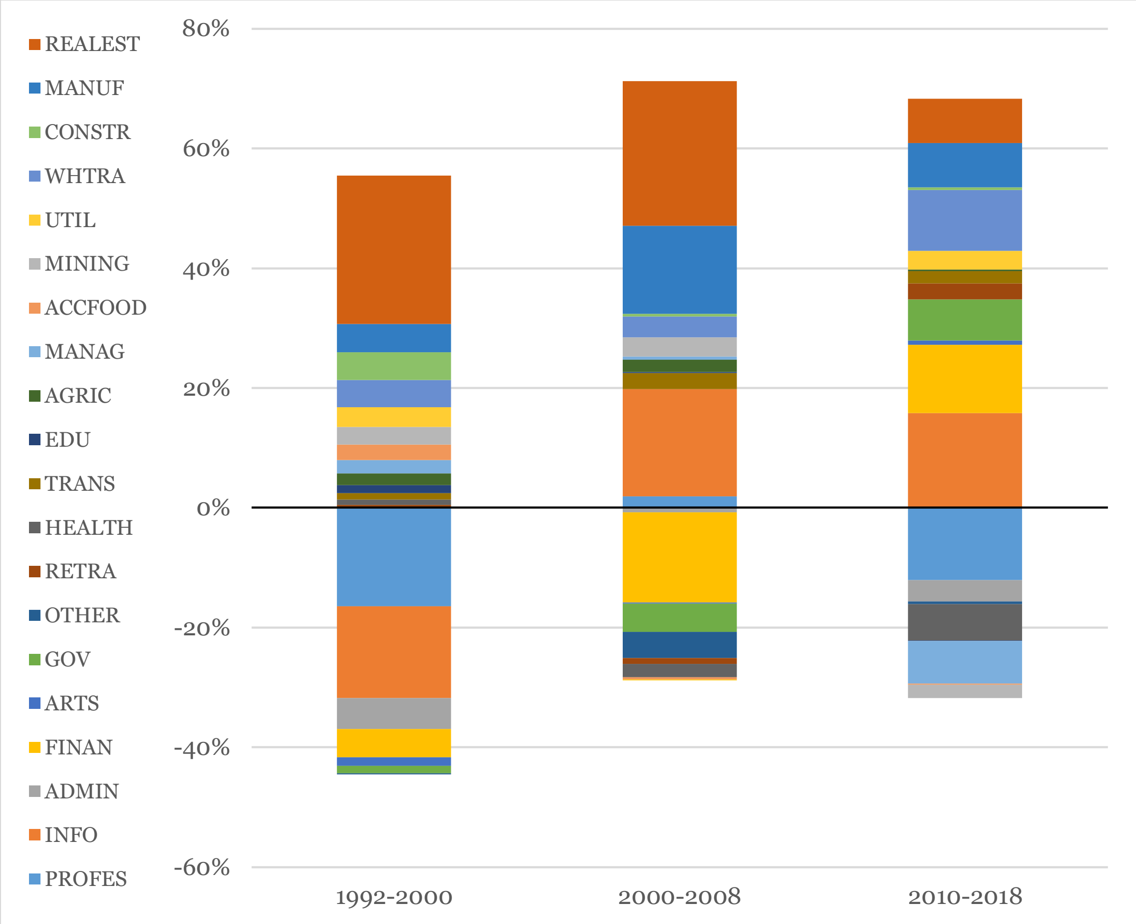
$$G = \sum_{i=1}^{n} [\bar{s}_i \Delta ln\pi_i - \bar{v}_i \Delta lnw_i] \qquad (3)$$

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.[19] This sectoral decomposition allows 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.

[18] 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).

[19] 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 wage-productivity gap



The first period presents 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). On the contrary, 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 our 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).[20] 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

[20] Of course, our result holds for our chosen level of sectoral disaggregation. Data with a finer level of disaggregation might reveal a different picture.

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.

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 and faster employment growth.

4. Estimating the direct effects of wages on productivity

Using our theoretical framework, we want now to check particularly 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 such an analysis, it is necessary to take into account the complex meaning 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 due to the consideration that some of the interrelations between variables have varying intensity and are influenced by contingent circumstances. This would imply a blurred picture with difficult interpretation of results. A more fruitful route, we believe, 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 addressing the issue of causality.

We are especially interested in assessing the relevance of the direct effects of wages on productivity, composed, as we have seen in section 2.2, of the mechanization effect, which captures the incentive to technical innovation represented by high of fast-growing wages, and the organization effect, which captures the incentive to re-organize the productive process efficiently with high wages 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 (see section 2.2 above). We first of all illustrate Sylos's equation and review the issues raised in the empirical literature devoted to the estimation of the equation. We then describe our data and methodology in section 4.2 and present the results of our own estimates in section 4.3.

4.1. Sylos Labini's productivity equation

Sylos Labini (1984, 1993) summarizes in a 'productivity equation' all the main determinants of productivity identified in his theoretical analysis. Briefly, such analysis, which as noted above is deeply influenced by classical political economy, consists in identifying three categories of factors as exerting 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). The second factor includes the two different effects that changes in wages may exert on productivity and that have been 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, he believes that investment has to be introduced as a distinct factor among the determinants of labor productivity.[21]

From such theoretical analysis Sylos extracts different versions of his productivity equation. In Sylos Labini (1984) we find the first formulation, based on the assumption that changes in the price of machinery (P_m) and in the general price level 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' in Sylos's terms), 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:

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

A different version is proposed in Sylos Labini (1993), where productivity growth is expressed as 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 $\Delta(W/P_m)_{t-n}$, with the omission of the

[21] 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 investment is stimulated by an increase in wages relative to machine prices and to what extent it is independent, then, the author states, it is worthwhile to include both variables in the analysis (Sylos Labini, 1993).

terms relating to investment:[22]

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

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 of the wage over machine prices is lagged (usually 3 or 4 years) while the organization effect is supposed to be contemporaneous. 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 other authors (Guarini, 2007; Carnevali et al., 2020).

The empirical literature stemming from Sylos's analysis of productivity (see for example Lucidi and Kleincknecht, 2009; Lucarelli and Romano, 2016; Vergeer and Kleincknecht, 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 Kleincknecht, 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,

[22] Sylos (1989, p.150; 1993, p. 258) states that the two versions of the productivity equation are not contradictory, if the temporal sequence revealed by the estimates is explained 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 taken at least for the part of investment embodying technical innovations
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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 on 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.[23]

We begin by checking the stationarity of our variables using Levin–Lin–Chu test for unit roots and find that their stationarity is confirmed, except for the level of investment (see Table A3 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:

$$\Delta\pi_{i,t} = \alpha + a\Delta Y_{i,t} + b\Delta(W/P)_{i,t} + c\Delta(W/P_m)_{i,t-n} \qquad (model\ 1)$$
$$\Delta\pi_{i,t} = a + b\Delta Y_{i,t} + c\Delta(W/P_m)_{i,t-n} + dI_{i,t-n} - eI_{i,t} \qquad (model\ 2)$$

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 third model contains all determinants in a single equation: [24]

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

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.

As concerns the issue of possible reverse causation between wages and productivity and 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); subsequently, we 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). For what

[23] We do not enter here the debate raised by Gordon (2010).

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

concerns 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 time 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 Akaike information criteria, 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. Table 8 shows the results of estimation of the various models.

Table 8. 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**
$\Delta Y_{i,t}$	0.59*** (.0128)	0.73*** (.0131)	0.61*** (.0127)	0.60*** (.0123)	0.76*** (.0130)	0,61*** (.0125)
$\Delta Y_{i,t-1}$				-0.17*** (.0120)	-0.08*** (.0126)	-0,15*** (.0121)
$\Delta(W/P_m)_t$				-0.08** (.0360)	0.10** (.0413)	-0,09** (.0355)
$\Delta(W/P_m)_{t-1}$				-0.09** (.0382)	0.04 (.0413)	-0,06 (.0380)
$\Delta(W/P_m)_{t-2}$				0.03 (.0384)	0.12** (.0442)	0,03 (.0380)
$\Delta(W/P_m)_{t-3}$				0.02 (.0382)	0.05 (.0439)	0,02 (.0378)
$\Delta(W/P_m)_{t-4\ to\ 9}$	0.21*** (.0338)	0.24*** (.0384)	0.21*** (.0331)	0.34***	0.49***	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	0.000 (.0338)	0.003 (.0018)	0.00 (.0015)	-0.002 (.0019)	-0.01*** (.0023)	-0.002 (.0019)
Adj-R^2	0.79	0.73	0.80	0.84	0.77	0.84

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 (with the exception of 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 effect. When passing to 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. 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 significance of the regressor and 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 A4 in the Appendix).[25] 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 A5 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 correlated-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 9 reports the results.

Table 9. 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)
$\Delta Y_{i,t}$	0.76*** (.0157)	0.86*** (.0138)	0.77*** (.0154)
$\Delta(W/P_m)_{t-4}$	0.18*** (.0484)	0.14** (.0543)	0.19*** (.0475)
I_t		-0.21*** (.04185)	-0.19*** (.0396)
I_{t-1}		0.21*** (.04267)	0.19*** (.0403)
Constant	-0.025*** (.0039)	-0.033*** (.0052)	-0.026*** (.0039)
R^2	0.90	0.88	0.91
legend: * p<.1; ** p<.05; *** p<.001			

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.

[25] 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).

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 model (3). The first specification uses as excluded instruments the one-period lagged growth of value added, the growth of export at time *t* and *t-1* and the growth of current public expenditure.[26] 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 autocorrelation (clustering on panel id) and to arbitrary contemporaneous cross-panel correlation (clustering on time). We estimate equation (3) 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 Crag-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 10.

Table 10. 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)
$\Delta Y_{i,t}$	0.19** (.0574)	0.22** (.1031)	0.22** (.0875)	0.14* (.0750)	0.19* (.1006)	0.15* (.0785)
$\Delta(W/P_m)_{t-4}$	0.24* (.1234)	0.29** (.1146)	0.23* (.1189)	0.24* (.1314)	0.29** (.1180)	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	0.59	0.37	0.62	0.54	0.33	0.55
Hansen-J test p-value	.0507	.0881	.0516	.1170	.0755	.1014
rk F-statistic	18.67	16.56	16.31	22.63	20.04	21.04
rk LM p-value	.0815	.0629	.0646	.0405	.0316	.0322
legend: * p<.1; ** p<.05; *** p<.001						

The results once again confirm the validity of Sylos Labini's productivity equation. The coefficients are significant and with the expected signs with the only 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

[26] 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.

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, we are able to reject the null hypothesis of the LM underidentification 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.

Overall, the results show that the extent-of-the-market effect on productivity growth is always relevant, although the coefficient is now lower than in the previous estimates (0.2 versus 0.6-0.7). We may conclude that simple OLS models tend to overestimate the coefficients of value added, thus emphasizing the importance of using instruments when estimating the impact of value added on labor productivity. 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, with the exception of investments, our key qualitative findings are generally confirmed, even though the sizes of the coefficients are different.

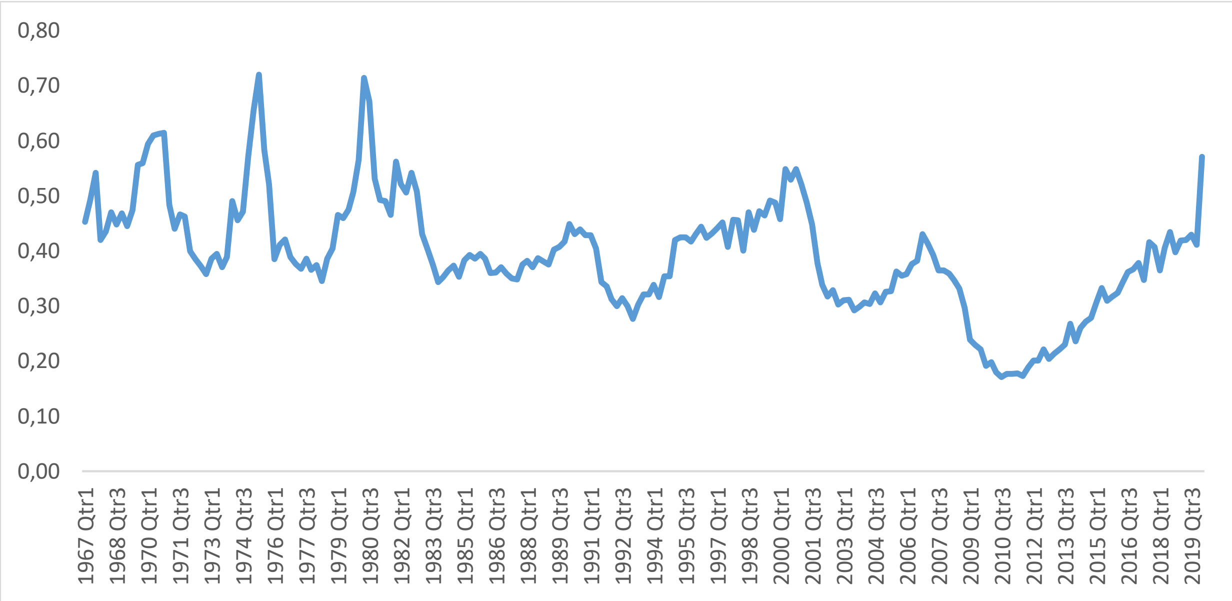
Given the intricacy of possible interrelations between the variables and the estimation issues involved, we believe that the fact that all our models confirm the same qualitative results is very relevant. While the effect of aggregate demand on productivity is undisputable, and confirmed when checking for endogeneity, what especially concerns us here is that in the US manufacturing sector 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.

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 can produce persistent negative effects on productivity growth. Reducing labor costs relative to prices reduces the incentive to save labor per unit of output through the implementation of organizational innovations and encourages business models based on extensive use of cheap labor. The availability of low-paid labor also reduces the incentive for firms to make labor-saving investments and, more in general, to innovate. Faced with the choice of increasing production through investment, with its costs and risks, or through employing more workers (or employing them for longer hours), the availability of low-cost, unprotected labor could likely drive to a more extensive use of work rather than innovation.

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'. 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 changed, as permanent job losses 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. 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).[27]

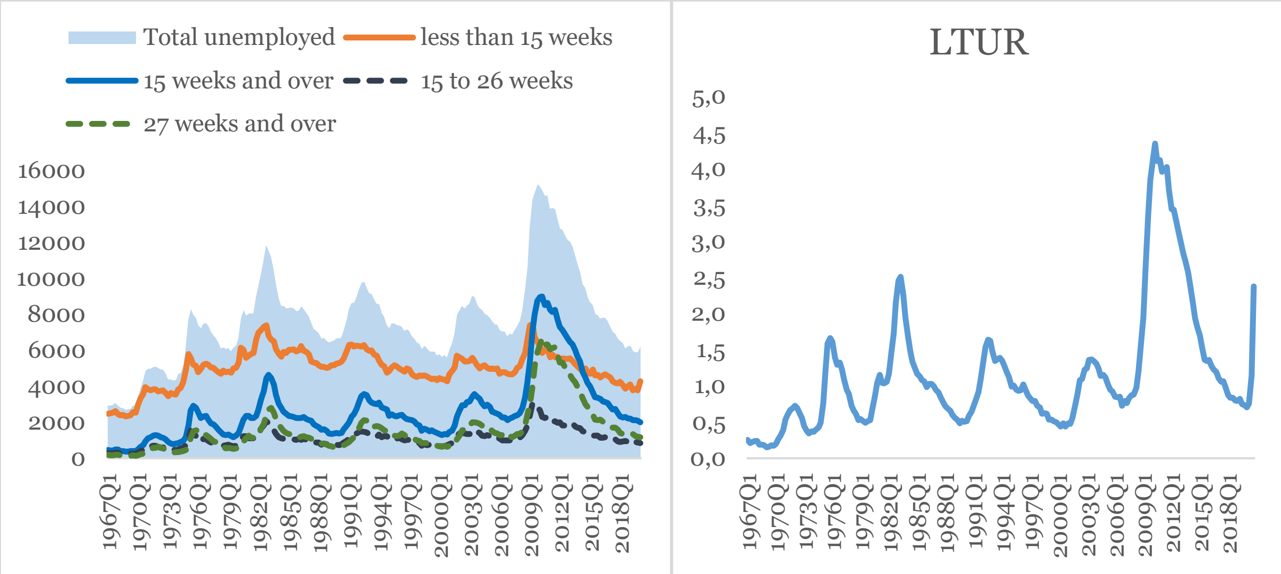
Figure 4. Temporary layoffs as a ratio of permanent job losses. USA, 1967-2020



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 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 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 the ease of dismissal has increased and the time needed to re-enter the labor market has lengthened. Supposing these changes reflect indeed increased labor weakness, we want to test whether they affect labor productivity growth.

[27] In 2020 we observe an increase of the indicator, which, however, may not be due to underlying structural changes but rather to the peculiarity of the pandemic crisis.

Figure 5. Unemployment by duration. USA 1967-2020



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:

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

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 AR(1) model and we also perform a 2SLS estimate with kernel-based autocorrelation-consistent standard errors. Results are shown in Table 11.

Table 11. 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				

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 11 also reports the results of the instrumental variable estimate, which confirm the effects of both indicators on productivity. We use as excluded instruments for the growth of output the growth of total exports at time *t* and *t-1* and the growth of public expenditure. Equation (4) has been estimated by means of AC 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 indicators for labor weakness and insecurity, we may maintain that 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 Vergeer & Kleinknecht, 2011, 2014; Lucidi & Kleinknecht, 2009; Naastepad & Storm, 2006; Bassanini & Ernst, 2002).

5. Conclusions

The paper takes as its starting point the anemic productivity growth in the US in recent decades and finds evidences of the role of wage stagnation in producing this outcome.

By means of a shift-share analysis we find 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 in productivity in sectors that showed a comparatively high growth in previous years, such as manufacturing, real estate, and financial sectors. Our analysis also shows that a growing polarization between high-productivity/high-wage productions and low-productivity/low-wage productions takes place especially starting from the 2000-2008 period. However, these types of changes have also occurred – perhaps especially – through a reallocation of employment and production *within* sectors, among firms operating under different business models, with low and stagnating wages favoring regimes characterized by slower growth of productivity and faster employment growth.

We have proposed a sectoral decomposition not only of the growth in productivity, but also of the growth in wages and, through a different technique, of the change in the wage-productivity gap. Through these techniques we have found evidence that the increase in the wage-productivity gap in mainly concentrated in a single period, 2000-2008, which stands out as the period of comparatively highest growth of productivity in which, however, wages have not benefited by that growth so that the change in distribution against wages is most marked. Notably, it is after this change that some historically high-productivity sectors have switched towards a regime of slower productivity growth 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 represented by low and stagnating wages.

To test more directly our hypothesis, we have estimated the Sylos Labini productivity equation at the sectoral level for a panel of 19 manufacturing subsectors. This allows both isolating the direct effects of wages from the effects of the growth in demand, and separating the mechanization effect from the organization effect. Our results confirm the direct effects of wages on productivity as well as the relevance of the two different effects (mechanization and organization). We also find evidence of a potential negative effect of labor ‘weakness’ on productivity, by augmenting the Sylos Labini equation with two alternative indicators: the ratio between temporary and permanent job losses and the cumulative growth of the long-term unemployment rate. We can thus conclude that increasing job insecurity and stagnant wages have indeed contributed significantly to the decline in US productivity.

The policy implications of our analysis are straightforward. A strategy of growth based on low wages, if favorable to profits in the short period, is however 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, constitute a powerful incentive for firms to look for innovative and efficient strategies of growth. Which implies that any policy aimed at boosting demand to bring the economy towards a high-employment target would be far more effective in enhancing the long-term growth prospects if accompanied by policies that directly address the distributional problem.

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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. 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
$\Delta(\boldsymbol{W/P})_{i,t}$	-16.80	0.0000
$\Delta(\boldsymbol{W/P_m})_{i,t}$	-12.14	0.0000
$\Delta\boldsymbol{Y_{i,t}}$	-18.76	0.0000
$\boldsymbol{I_{i,t}}$	0.69	0.7561

Table A4. 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
$\Delta\pi_{i,t-1}$				0.06** (.0283)	0.19*** (.0277)	0.06** (.0280)
$\Delta\pi_{i,t-2}$				-0.06*** (.0173)	0.01 (.0146)	-0.05** (.0171)
$\Delta\pi_{i,t-3}$				-0.001 (.0171)	0.02 (.0145)	0.00 (.0170)
$\Delta\pi_{i,t-4\ to\ 9}$				-0.01**	0.14**	-0.01**
$\Delta(W/P)_{i,t}$				0.31*** (.0156)		0.30*** (.0155)
$\Delta(W/P)_{i,t-1}$	0.08*** (.0246)		0.07** (.0242)	0.11*** (.0181)		0.09*** (.0180)
$\Delta(W/P)_{i,t-2}$				0.10*** (.0183)		0.09*** (.0182)
$\Delta(W/P)_{i,t-3}$				0.02 (.0186)		0,01 (.0185)
$\Delta(W/P)_{i,t-4\ to\ 9}$				0.11***		0,11***
$\Delta Y_{i,t}$	0.70*** (.0239)	0.73*** (.0131)	0.72*** (.0234)	0.60*** (.0122)	0.75*** (.0128)	0.61*** (.0124)
$\Delta Y_{i,t-1}$				-0.20*** (.0204)	-0.22*** (.0235)	-0.19*** (.0204)
$\Delta(W/P_m)_t$				-0.09** (.0361)	0.11** (.0403)	-0.09** (.0357)
$\Delta(W/P_m)_{t-1}$				-0.09** (.0383)	0.01 (.0435)	-0.06 (.0383)
$\Delta(W/P_m)_{t-2}$				0.03 (.0388)	0.12** (.0435)	0.04 (.0384)
$\Delta(W/P_m)_{t-3}$				0.01 (.0385)	0.04 (.0433)	0,01 (.0382)
$\Delta(W/P_m)_{t-4\ to\ 9}$	0.23*** (.04121)	0.24*** (.0384)	0.22*** (.0387)	0.39***	0.27***	0.31***
I_t		-0.5*** (.0585)	-0.48*** (.0833)		-0.37*** (.0545)	-0,23*** (.0471)
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-R^2	0.71	0.73	0.73	0.84	0.78	0.84

Table A5. 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)