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Articles

A mathematical contribution to the economic growth theory. Evidence on the relationship between wages and output from the Italian regions

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Abstract:

In this manuscript, the authors empirically assess the impact of an increase in the wage per worker on the GDP per capita of the Italian regions. To achieve this research aim, the authors carry out a panel data regression analysis, relying on an identification strategy based on the standard Neoclassical model of economic growth. The authors' results suggest that, on average, the output effect of an increase in the wage per worker is positive, with a substantial difference between the Northern and Center-Southern regions. The authors' policy implication is that wage moderation does not represent a remedy to the economic stagnation that the Italian regions have been experiencing since the second half of the 1990s.

Keywords: Wage-led economic growth; wage per worker; regional development; Neo-Kaleckian economics; Neoclassical economics.
JEL Classification: C02; C23; O47; P16; R11.

Una contribución matemática a la teoría del crecimiento económico. Evidencia sobre la relación entre salarios y producción de las regiones italianas

Resumen:

En este manuscrito, los autores evalúan empíricamente el impacto de un aumento del salario por trabajador en el PIB per cápita de las regiones italianas. Para lograr este objetivo de investigación, los autores realizan un análisis de regresión de datos de panel, basándose en una estrategia de identificación basada en el modelo neoclásico estándar de crecimiento económico. Los resultados de los autores sugieren que, en promedio, el efecto sobre la producción de un aumento en el salario por trabajador es positivo, con una diferencia sustancial entre las regiones Norte y Centro-Sur. La consecuencia política de los autores es que la moderación salarial no representa un remedio al estancamiento económico que las regiones italianas han experimentado desde la segunda mitad de los años noventa.

Palabras clave: Crecimiento económico impulsado por los salarios; salario por trabajador; Desarrollo regional; economía Neo-Kaleckiana; economía neoclásica.
Clasificación JEL: C02; C23; O47; P16; R11.

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1. Introduction

The relationship between effective wages and economic growth is an important but controversial topic in economics. Some scholars argue that in pre-industrial Europe (XVIII century), wages and GDP per capita did not follow a common pattern, and they try to find the reason for their different evolution (Angeles, 2007). Instead, as far as modern economies are concerned, the possibility that an increase in effective wages has a positive effect on economic growth (wage-led growth) is very debated. This idea was originally developed by Kaleckian and Keynesian macroeconomics (Bhaduri and Marglin, 1990; Rowthorn, 1999), and, over time, it has been discussed and empirically tested mostly (but not only) using Keleckian and Keynesian approaches, finding, net of few partial exceptions like Skott (2016) and King (2019) who downsize it, a general positive relation between wage and economic growth (Barros, 1993; Atesoglu and Smithin, 2006; Stockhammer and Onaran, 2013; Altman, 2015; Onaran and Obst, 2016; Álvarez et al., 2018; Lupu et al., 2022).

The reasons why an increase in wage has a positive impact on the GDP growth rate seem to be related both to the demand and supply sides of the economy (Stockhammer, 2011; Storm and Naastepad, 2013). More precisely, the supply side effects exist because: *i*) wage growth fosters labor effort and productivity and, consequently, also investments; *ii*) real wage growth implies higher productivity growth. As concerns instead the demand side effects: *iii*) wage growth enhances the marginal propensity to consume; *iv*) a higher wage share entails higher capital accumulation.

However, some of the fundamental assumptions of the wage-led economic growth have been criticized by Pariboni (2016), who highlights that capacity utilization is not really the adjusting variable in equilibrating investment and savings as claimed by Bhaduri and Marglin (1990) and that the treatment of investment is also unconvincing.

Furthermore, the wage-led economic growth paradigm must be assessed also in light of the criticalities concerning the Neo-Kaleckian economic growth model, the most important of which is its inability to reconcile actual and normal rates of capacity utilization in equilibrium, implying that any attempt by firms to restore their desired degree of capacity utilization produces instability of the Harrodian type (Skott, 2012; Cesaratto, 2015). Some researchers tried to work out this technical issue by including in the Neo-Kaleckian models appropriate micro foundations ensuring the convergence between the normal rate of utilization (assumed to be an endogenous variable) and the actual utilization rate (Hein et al., 2012), but this solution has raised several critiques because of the restrictive, mutually incompatible assumptions on which it is based (Girardi and Pariboni, 2019).

In addition, the evidence presented by Gahn (2021) shows that the effect of a demand shock on the effective capacity utilization is merely transitory, contradicting the Neo-Kaleckian view, according to which the same effect should be persistent over time.

Considering all these problems, the relationship between average wage and GDP per capita needs to be reconsidered from perspectives other than the Neo-Kaleckian one.

In this paper, the authors address precisely this research topic by adopting the Neoclassical model of economic growth as a reference point to derive a sound identification strategy able to produce an unbiased estimate of the output effect of wage.

The manuscript is organized as follows: Section 1 provides a general overview of the topic of the paper, namely the features and limits of the wage-led growth theory; Section 2 summaries the authors' research aims; Section 3 proposes a graphical analysis of the GDP per capita and wage per worker of the Italian regions and autonomous provinces; Section 4 outlines the theoretical framework (namely, the neoclassical model of economic growth) on which the authors' research work is based; Section 5 describes the authors' research methods; Section 6 presents the authors' baseline results, Section 7 includes a sensitivity analysis of the authors' results; Section 8 draws the concluding remarks and the policy implications of the authors' analysis; the last section contains a detailed bibliography.

2. Research aims

In this Section, the authors describe their research aims and stress both the methodological innovation and contribution made by their study.

In particular, the authors' research goal consists of estimating the impact of an increase in the average wage on the GDP per capita of the Italian regions. It is important to clarify that, in this research study, the authors use the term "wage per worker" (or, equivalently, "average wage") to indicate the average annual gross wage at constant prices per full-time and full-year equivalent employee in the total economy.

In order to obtain a safe and sound identification strategy, the authors adopted, as a reference point, the textbook's Neoclassical model of economic growth. As is well known, under the conventional Neoclassical assumptions, it is possible to prove that firms maximize their profits by hiring new workers as long as marginal productivity of the labor equals the wage. Consequently, output grows until marginal productivity and unitary cost of labor converge on each other. Starting from this baseline result, the authors show that the relationship between GDP per capita and wage can be represented by an increasing, convex function, indicating that a rise in the average wage has a positive effect on output up to the point at which wage and marginal productivity of labor are equal, while beyond this point the same effect becomes negative.

The controversial economic and mathematical meaning of the term 'marginal productivity' represents one of the most important critiques moved from the Post-Keynesian economists to the Neoclassical theory within the so-called 'Cambridge controversy'. In fact, the opponents argue that marginal productivity is a mathematical concept lacking a clear economic meaning because of its strict dependence on the specification of the production function (Moseley, 2012).

To address this problem, the authors opt for a specification of the production function of the Italian regions consistent with the literature.

After presenting their theoretically-based identification strategy, the authors empirically assessed the output impact of an increase in the average wage of the Italian regions by employing three different estimators: the Ordinary Least Squares regression model (OLS regression), the fixed-effects linear regression model (FE linear regression), and the two-step system Generalized Method of Moments (Arellano and Bond (1991), Arellano and Bover (1995), Blundell and Bond (1998)) with corrected standard errors (Windmeijer, 2005).

The authors included among the regressors of these three regression models the marginal productivity of labor (for the reasons exposed previously) and also all these variables that, according to the economic research, affect the economic growth of the Italian regions, namely human capital (Ghignoni, 2005; Gagliardi and Percoco, 2011; Vecchione, 2018; Odoardi and Muratore, 2019; Cappelli and Vasta, 2019), migration flows among regions (for their negative impact on the regional economic growth due to the territorial redistribution of human capital) (Fratesi and Percoco, 2014), credit rationing (Faini et al., 1992; Sarno, 2005; Sarno, 2008; di Pietro et al., 2019), integration into the single European market (Paniccià et al., 2011), mafia infiltration (Centorrino and Ofria, 2008; Pinotti, 2015), average firm size (Coppola et al., 2013), technology (Cersosimo and Viesti, 2013), social capital and system of values of individuals (Banfield and Fasano, 1968; Putnam, 1993; Leonardi, 1995; Helliwell and Putnam, 1995; de Blasio and Nuzzo, 2009; Lyon, 2005).

The authors collected the data on the variables listed above from the database of the Italian National Institute of Statistics (ISTAT) and used them to build up a panel dataset ranging between 1995 and 2018.

Finally, with the aim of assessing the robustness of their results, the authors carry out a rich sensitivity analysis by restricting their sample period, using alternative proxies for some of the variables included in their empirical model, and employing some alternative estimators.

They chose to focus on the Italian regions because they believe that these units can represent an interesting case. In fact, the available evidence suggests that the constant increase in wages experienced by the country at both the national and regional level since the second half of the 1990s has led the country

to a loss of competitiveness over time (Torrisi et al., 2015; Vrontis et al., 2018; Kangur, 2018). The reason for this seems to be that wages in Italy are not aligned with marginal productivity of labor because of the nominal rigidities characterizing the Italian labor market, especially the presence of the national-level collective bargaining system (Devincenti et al., 2007; Tronti, 2010).

On the other hand, some researchers argue that the policies of internal devaluation (namely, wage moderation) adopted by Italy and other European countries in the past with the aim of aligning the average wages to the local marginal productivity of labor negatively affected their economic growth (Armingeon and Baccaro, 2012; Stockhammer and Sotiropoulos, 2014).

Hence, in the face of this contrasting evidence, one can expect that the output impact of an increase in the average wage can be either positive or negative.

The authors' contribution is just intended to shed light on the nature of the relationship between average wage and GDP per capita by assessing the validity of the Neoclassical school of thought.

The innovation proposed by the authors in this paper is to prove that, under a few assumptions, the textbook Neoclassical model of economic growth is consistent with the Neo-Kaleckian wage-led growth hypothesis.

3. GDP per capita and wage per worker in Italy: a graphical representation

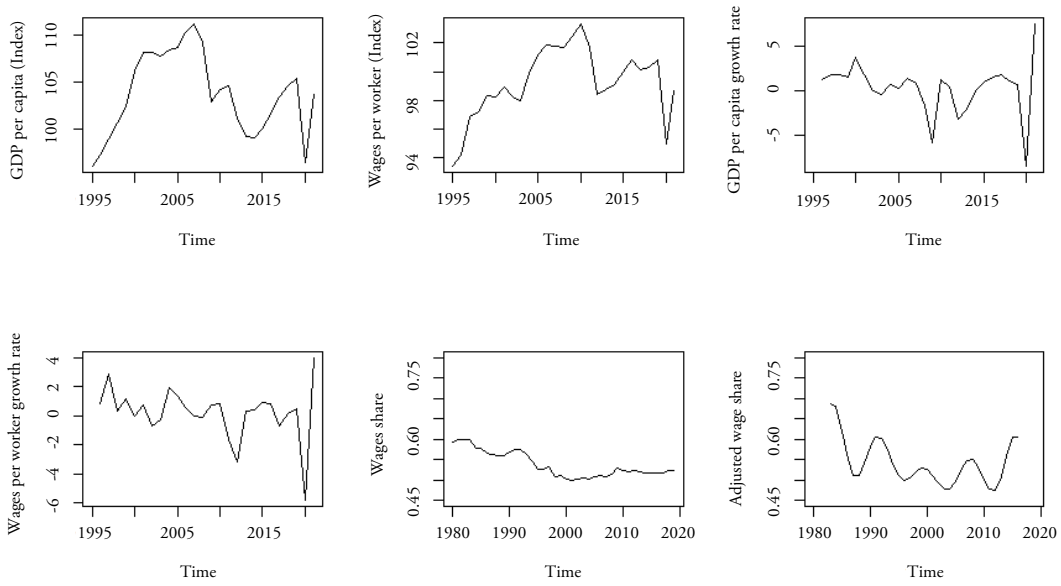
In this Section, the authors, in order to offer the reader a general overview of the territorial gaps in Italy, present a graphical representation of the GDP per capita and of the wage per worker, both at the national and regional level.

Figure 1 below reports the time plots of six key variables to trace out the trends of the national level output and workers' compensation in the sample period considered by the authors (1995-2018), namely, GDP per capita, wage per worker, GDP per capita growth rate, wage per worker growth rate, wage share, and adjusted wage share. These six variables are expressed in 2015 prices, and both GDP per capita and wage per worker have been transformed by the authors into index numbers with a base year of 2015 = 100 with the aim of making comparable two variables having different denominators. As concerns the adjusted wage share, it has been computed by the authors by applying to the wage share time series data provided by the Federal Reserve Bank of Saint Louis (FRED) the band pass filter of Christiano and Fitzgerald (2003), a statistical tool able to decompose non-stationary or trend stationary variables under the hypothesis that their cyclical components lie within a particular band of frequencies. The authors make the realistic assumption that the minimum period of oscillation of the cyclical component of the wage share (pl) is equal to 2, while the maximum period of oscillation (pu) is finite and higher than pl.

The authors prefer the band pass filter to the more traditional Hodrick-Prescott filter because, as is well known, the latter is affected by some relevant drawbacks, such as the detection of spurious dynamic relations that are inconsistent with the data generating process (especially in the presence of exogenous shocks), spurious dynamics of the data filtered at the end of time series (that are also different from those in the middle), and discretion in the values to assign to the smoothing parameters (Hamilton, 2018).

In particular, what the authors represent in Figure 1 is the trend component of the wage share time series, namely that unaffected by cyclical fluctuations.

FIGURE 1.
GDP per capita and wage per worker in Italy (1995-2018)



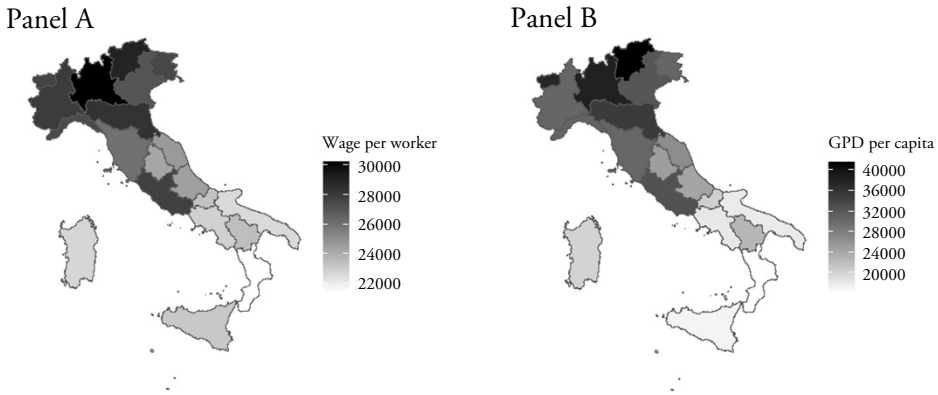
Source: Authors' elaboration on ISTAT and FRED data

Figure 1 shows that GDP per capita and wage per worker index numbers follow common trends during the entire sample period (1995-2018). In fact, they exhibit a positive trend in the years of the Italian convergence to the monetary union (1995-2000) and in the first years following the effective eurozone entry (2001-2006), while the trend becomes negative starting from the economic crisis of 2008 (with a substantial exception for the period after the Covid-19 pandemic). As concerns the wage per worker and GDP per capita growth rates, they constantly declined between 1995 and 2018 (again, with a significant recovery after the pandemic). Finally, raw and adjusted wage shares have a constantly negative trend, and this evidence is consistent with the established economic literature according to which the wage shares of the advanced economies have shrunk since the 1980s (Stockhammer, 2017).

According to some economists, the constant increase in wage per worker highlighted in Figure 1 is, together with the stagnation of Total Factor Productivity (TFP), the reason for the Italian loss of competitiveness compared to the main European countries since the first half of the 2000s (Cottarelli, 2020). However, the data recently released by the Organisation for Economic Cooperation and Development (OECD) and confirmed by the authors' graphical representation of wage per worker growth rate and adjusted wage share in Figure 1, prove that the Italian average annual gross wage at 2020 constant prices was stagnant or declining between 2000 and 2020 (Giangrande, 2022). If aggregate demand is considered a key determinant of economic growth, this trend in the adjusted wage share could represent an important interpretation of the unsatisfactory path of the Italian economy other than that proposed by Cottarelli (2020).

After focusing on the temporal dynamics of output and employee compensations, the authors also carry out a geographical representation of the GDP per capita and the wage per worker (or, better, the averages of both GDP per capita and wage per worker in the sample period 1995-2018). In fact, Figure 2 below divides the twenty Italian regions into different ranges of values based on their wage per worker (Panel A) and GDP per capita (Panel B) in the period 1995-2018 and associates each range with a different colour:

FIGURE 2.
Territorial distribution of the GDP per capita and wage per worker across the Italian regions (average 1995-2018)



Source: Authors' elaboration on ISTAT data

The regions that are conventionally defined as "Mezzogiorno" (Sicily, Sardinia, Calabria, Basilicata, Puglia, Campania, Abruzzo, and Molise), Marche, and Umbria exhibit levels of GDP per capita and wage per worker significantly lower than those of the other regions, a historical gap that, as mentioned by the authors in the previous section, has characterized Italy since the achievement of its political unity in 1861.

The simple overview proposed in this section raises some interesting research question, such as, "What is the relationship between GDP per capita and wage per worker in Italy at regional level?" and "Can a wage support policy encourage the development of the backward South or would it deepen the gap with the North?"

The authors' research study tries to provide an answer to these issues.

4. THEORETICAL FRAMEWORK

In this Section, the authors summarize the textbook Neoclassical model of economic growth, and then they show how this standard theoretical model can be used to obtain a sound identification strategy of the relationship between wage per worker and GDP per capita.

In particular, the authors consider a perfectly competitive economy in which a representative firm maximizes its expected, net profit over an infinite time horizon as below:

$$\max_{\{K_t,N_t,I_t\}} \sum_{t=0}^{\infty} E[\Pi(A_t, K_t, N_t)]$$

Subject to:

1. The conventional, neoclassical specification of the profit function:

$$\Pi(A_t, K_t, N_t) = f(A_t, K_t, N_t) - r_t K_t - w_t N_t$$

where:

- A_t is the technological production factor (that is an exogenous variable);
- K_t is the stock of physical capital;
- N_t represents the stock of labor;

- r_t is the cost of a unit of physical capital (interest rate);
- w_t is the wage;
- $Y_t = f(A_t, K_t, N_t)$ is an increasing and concave production function ($f'(A_t, K_t, N_t) > 0$, $f''(A_t, K_t, N_t) < 0$) taking the Cobb-Douglas form:

$$f(A_t, K_t, N_t) = A_t K_t^{\alpha} N_t^{1-\alpha}$$

with $\alpha \in (0,1)$ being a constant.

This hypothesis is consistent with the literature on the production function of the Italian firms at the subnational level (Cainelli and De Liso, 2005; Cainelli, 2008);

2. The usual low of motion of physical capital:

$$K_t = (1-\delta)K_{t-1}$$

where $\delta \in (0,1)$ is the depreciation rate of physical capital.

The solutions to the optimization problem proposed above are the equilibrium values of the endogenous variables K_t, N_t and I_t, namely those maximizing the firm's expected profit under constraints 1) and 2) and they have been found and listed below by the authors:

I. The marginal productivity of physical capital ($MPK_t = \frac{\partial f(A_t,K_t,N_t)}{\partial K_t} = \alpha K_t^{\alpha-1} N_t^{1-\alpha}$) is equal to the interest rate:

$$MPK_t = r_t$$

implying that the representative firm accumulates physical capital to maximize its expected, net profit as long as the marginal productivity of physical capital becomes equal to its unitary cost (interest rate);

II. The marginal productivity of labor factor ($MPN_t = \frac{\partial f(A_t,K_t,N_t)}{\partial N_t} = (1-\alpha) K_t^{\alpha} N_t^{-\alpha}$) is equal to the wage:

$$MPN_t = w_t$$

entailing that the representative firm hires workers to maximize its expected, net profit as long as the marginal productivity of labor factor becomes equal to its unitary cost (wage);

III. The firm's investment between $t-1$ and t is equal to the share of physical capital depreciating between $t-1$ and t:

$$\Delta K_t = \delta K_t$$

where $\Delta K_t = K_t - K_{t-1}$ is the firm's investment;

IV. The expected value of the interest rate at time $t+1$ is equal to the expected value of the marginal productivity of physical capital at time $t+1$:

$$E[MPK_{t+1}] = E[r_{t+1}]$$

namely, the representative firm forms adaptive expectations on the interest rate.

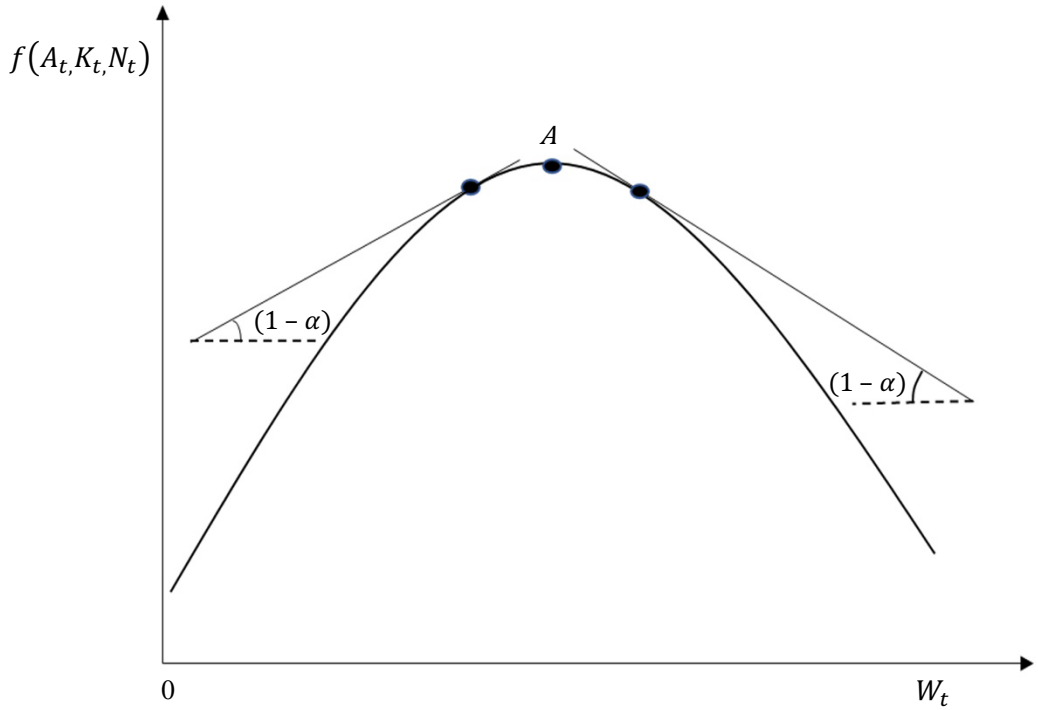
The solutions reported above are well-known in literature and, taken together, grants the existence of a unique, stable, macroeconomic equilibrium. The innovative authors' contribution consists of showing that, using the assumption 2), the solution ii) can be rearranged as follows:

$$y_t = \frac{w_t}{(1-\alpha)} = \frac{MPN_t}{(1-\alpha)} \tag{1}$$

where $y_t = A_t \left(\frac{K_t}{N_t}\right)^{\alpha}$ is the GDP per capita. Equation (1) establishes a clear nexus between GDP per capita, wage, and marginal productivity of the labor factor. More in particular, equation (1) points out that an increase in wage (corresponding to an equivalent increase in marginal productivity of labor) involves a growth of national income per capita equal to $\frac{1}{1-\alpha}$. However, the marginal effect of an increase in wage on GDP per capita is decreasing in w_t, because the marginal productivity of labor is a concave function ($MPN_t'' < 0$).

The relationship between GDP per capita and wage found by the authors have been represented in Figure 3 below:

FIGURE 3.
Graphical representation of the relationship between GDP per capita and wage established by equation (1)



Source: Authors' elaboration

Figure 3 shows that the GDP per capita is increasing in wage up to point A, while beyond this point the national income per capita is decreasing in wage. In Figure 3, the function $f(A_t, K_t, N_t)$ has a positive vertical intercept because the cost of the labor factor (wage) is never equal to zero. The reason for the shape of the function represented in Figure 3 is that, up to point A, wage is less than or equal to the marginal productivity of labor, making it profitable for firms to increase their output by hiring new workers. Beyond point A, any additional increase in wage instead induces firms to reduce output by reducing their labor stock, because wage exceeds the marginal productivity of labor.

In the next sections, the authors try to estimate the impact of an increase in wage on the GDP per capita of the Italian regions described by equation (1) by exploiting appropriate quantitative techniques.

5. Research method

In this Section, the authors estimate the impact of the average wage on the GDP per capita of the Italian regions by using the following linear regression model proposed by Sala-i-Martin (1996) to assess the beta convergence (namely, the convergence towards the steady-state equilibrium) among regions:

$$\ln(y_{i,t}) = \beta_0 + \beta_1 \ln(y_{i,t-1}) + \beta_2 \ln(w_t) + \underline{z_{i,t}}' \underline{\delta} + u_{i,t} \quad (2)$$

where:

- $y_{i,t}$ is the GDP per capita of the Italian regions;
- β_0 is a constant accounting for the common growth path of the regions;
- β_1 represents beta convergence of the regions to their steady-state equilibrium (the lower the value of the estimated coefficient, the faster the convergence);
- β_2 accounts for the effect of an increase in average wage per worker on GDP per capita;
- $\underline{z_{i,t}}$ is 1 x K vector of independent variables;
- $\underline{\delta}$ is a K x 1 vector of parameters to be estimated;
- $u_{i,t}$ is a zero mean and $\sigma^2_{u_{i,t}}$variance error term.

The authors chose this empirical model just because of its ability to account for business cycle fluctuations (captured by the coefficient β_1). Moreover, model (2) is perfectly consistent with the assumptions of the Neoclassical model of economic growth.

The model (2) was estimated using three different statistical techniques: a multivariate Ordinary Least Squares regression model (OLS), a fixed effects regression model (FE) and a two-step system Generalized Method of Moments estimator (the GMM-SYS proposed by Arellano and Bond (1991), Arellano and Bover (1995), Blundell and Bond (1998)) with corrected standard errors (Windmeijer, 2005). For each estimator, standard errors were clustered at regional levels to deal with the presence of group-wise heteroskedasticity.

Unlike OLS and FE estimators, which could generate inconsistent estimates due to some econometric problems, the GMM-SYS allows for the elimination of the unobserved area-specific effect in the dynamic panel specification of the model. Furthermore, in order to deal with the suspected endogeneity issue between economic growth and wages (for instance, that one discussed in Section 1 but also others such as changes in the economic conditions of the labor market could lead to an increase in the job demand or supply), the variable *wage per worker* was instrumented including lagged levels and differences. As usual, the correctness of the model was checked through the Sargan test of over-identifying restrictions for the validity of the instruments. The Arellano-Bond test was used, instead, for testing the zero autocorrelation in the first-differenced errors at order one - AR(1) – and the autocorrelation between the errors' terms over time - AR(2).

As concerns the FE estimator, it was used because it accounts for geographical differences and all those meso variables such as social norms and system of values that, as emphasized by Tabellini (2008) and Guiso, Sapienza and Zingales (2008), show a long-term persistence that go beyond a 23-years period.

The authors estimate model (2) by employing annual panel data ranging between 1995 and 2018. More in particular, the authors use the GDP per capita as a measure of the Italian regions' output, while the set of regressors comprises variables such as the firms' investment and R&D expenditure, resident population, stock of human capital, variation in the labor force, household consumption per capita, exports towards the European Single Market, size of the companies, and different proxies of social capital, institutional quality, and Total Factor Productivity (TFP). A detailed list and description of all the authors' variables are provided in Table 1 (Cfr. Section II of the Appendix).

6. Empirical Evidence

In this Section, the authors present their estimates of the regression model (2). Further, in order to strengthen their empirical analysis and better identify the relationship under scrutiny, the authors conduct a battery of preliminary statistical tests, namely the Granger test, the Variance Inflation Factor (VIF), the Chow test, the unit root test and (Im et al., 2003), the Wald test[1] (Cfr. Section I of the Appendix). The outcome of the estimation of model (2) for the twenty Italian regions and the two autonomous provinces of Trento and Bolzano is reported in Table 2 below:

Table 2.
Estimation of the model (2)

	(1)	(2)	(3)
y=ln(GDP per capita)	**OLS**	**FE**	**GMM**
ln(GDP per capita) (t-1)	0.9199***	0.7094***	0.9194***
	(0.0124)	(0.0372)	(0.0182)
ln(Wage per worker)	0.0947***	0.0923*	0.0938***
	(0.0186)	(0.0476)	(0.0204)
ln(Investments)	0.0090	0.0214	0.0096
	(0.0060)	(0.0138)	(0.0064)
ln(Population)	-0.0099*	-0.0394	-0.0104*
	(0.0057)	(0.0776)	(0.0057)
ln(Education)	-0.0011	-0.0008	-0.0010*
	(0.0007)	(0.0011)	(0.0005)
Emergency	-0.0001**	0.0000	-0.0001**
	(0.0000)	(0.0000)	(0.0000)
Labor growth	0.0052***	0.0051***	0.0051***
	(0.0006)	(0.0007)	(0.0008)
Number of Crimes	0.0000**	-0.0000	0.0000**
	(0.0000)	(0.0000)	(0.0000)
ln(R&D Expenditures)	0.0014	0.0010	0.0015
	(0.0011)	(0.0019)	(0.0010)
ln(Exports)	0.0029*	0.0115**	0.0028
	(0.0015)	(0.0053)	(0.0019)
ln(Social Capital 1)	0.0011	0.0009	0.0010
	(0.0014)	(0.0016)	(0.0012)
ln(Consumption per capita)	0.0252**	0.1537***	0.0256*
	(0.0125)	(0.0467)	(0.0140)
Firm size	-1.0747	-0.0762	-1.0050
	(1.7054)	(5.0927)	(1.4931)

[1] The Granger test provides evince that wage per worker causes unidirectionally GDP per capita; the VIF indicates absence of any multicollinearity issue for the model (2); The Chow test does not find any structural breaks in all the time series reported in Table 1; the unit roos test does not detect non-stationarity of the time series reported in Table 1; the Wald test rejects the null hypothesis of exogeneity of wage per worker once GDP per capita is the left-hand-side variable (Cfr. Section I of the Appendix).

TABLE 2. CONT.
Estimation of the model (2)

	(1)	(2)	(3)
y=ln(GDP per capita)	**OLS**	**FE**	**GMM**
Industry	0.0003***	0.0005**	0.0003***
	(0.0001)	(0.0002)	(0.0001)
Services	0.0000	0.0004***	0.0000
Observations	492	492	492
R-squared	0.9983	0.9516	0.9884
Macro Fixed Effect	YES	YES	YES
Time Fixed Effects	YES	YES	YES
Period	1995-2018	1995-2018	1995-2018

Robust standard errors in parentheses
Standard errors in brackets; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The estimated coefficient associated with $\ln(y_{i,t-1})$ is positive and less than 1.00, indicating that the convergence process towards steady-state (beta convergence) of the Italian regions between 1995 and 2018 was slow but very significant.

As concerns the output impact, the estimated coefficient associated with the average wage (positive, very significant, and similar in size among the three estimators) provides strong evidence that, keeping constant labor factor productivity and the other independent variables, an increase of 1.00% in this variable prompts a growth in the regional GDP per capita that, on average, is slightly less than 0.10%.

The estimated coefficients associated with gross fixed capital formation, exports to the single European market, and consumption per capita are positive but small and little significant, suggesting that it is improbable that between 1995 and 2018 the economic growth of Italian regions was barely due to demand factors (namely consumption, investment, and exports).

The mild evidence according to which an increase in resident population causes a decrease in GDP per capita is coherent with the neoclassical theory.

The estimated coefficient associated with the changes in the labor force (positive and very significant) implies that the economic growth of the Italian regions is little affected by their ability to attract workers from other Italian regions and abroad (namely the migration flows of the workers).

From the estimated coefficient related to the number of crimes (positive, very small, and significant only in the GMM-SYS) is deduced that the activities of the Italian police and legal authorities to combat organized crime are either not very important or too poor to boost regional economic growth.

All the other independent variables included in the estimated model do not appear to impact (or slightly impact) the regional economic growth.

Finally, it is important to note that the coefficients estimated by the FE regression have dimensions and significance levels similar to those estimated using OLS regression and the GMM-SYS method[2]. This indicates that all variables that are specific to the local context but that do not vary over time (such as geographical characteristics) or that in any case do not vary over a period of only 23 years (such as social norms and the system of values of individuals) play a marginal role.

[2] In the case of two step system GMM, both the Sargan and the Arellano-Bond AR(2) tests do not reject H_0, suggesting validity for the over-identifying restrictions and the absence of second-order serial correlation. These tests were not reported but are available upon request.

7. Sensitivity Analysis

In order to make their empirical findings more robust, also in terms of theoretical prediction, the authors perform a battery of sensitivity analyses. In particular, they carry out 15 additional estimates of model (2) by reducing the sample period, changing the dependent variable and some regressors, and using two alternative estimators. All these alternative estimates represent robustness exercises, namely, they need to verify that the results contained in Table 2 are valid also after modifying the basic model (Cfr. Section III of the Appendix). Since all of them confirm the results obtained in Table 2, only the three most interesting among them are exposed here. The first one consists of re-estimating equation (2) after grouping the twenty Italian regions into two macro areas, namely, North (Aosta Valley, Piedmont, Lombardy, Friuli Venezia Giulia, Veneto, Trentino Alto Adige, Liguria and Emilia Romagna) and Centre & South (Tuscany, Marche, Lazio, Abruzzo, Molise, Campania, Basilicata, Puglia, Calabria, Sardinia and Sicily), in order to account for the significant difference in the wage-labor productivity gap between North and Centre & South (Daniele, 2021).

The results are reported in Table 3 on the next page.

The positive, less than 1, and very significant estimated coefficient associated with the variable $\ln(y_{i,t})$ indicates that both macro areas converge to their respective steady-state, but the North does it faster than the Centre-South. This is not surprising considering that many contributions prove that convergence is quicker in economies with higher income per capita, better capital markets, a higher human capital stock, and a favourable geographical position (Gennaioli et al., 2014).

The estimated coefficient related to the average wage (positive and very significant) shows that in both macro areas a rise in wage per worker stimulates regional output, but a huge difference in size exists between the Northern and Center-Southern regions. In fact, an increase of 1.00% in wage per worker in the Northern regions prompts an average growth in GDP per capita of 0.16%, namely 2.6 times more than the regions of the Center-South (0.06%).

The estimated coefficients related to consumption expenditure, gross fixed investment, and exports to the EU single market (positive, small, and barely significant) provide weak evidence that the Center-South economy is partially led by domestic and foreign demand (namely investment, consumption per capita, and exports). In this regard, it is also impressive that exports to the single European market are an economic growth driver for Centre-Southern regions, that are located far from the main industrial European areas, and not for the Northern ones, which are more integrated into the German production chains. The lack of statistical significance of the estimated coefficients associated with firms' investment (except the FE coefficient of the North) supports the claim of Deleidi et al. (2021) about the necessity of fostering public investment to boost the economic growth of the Italian regions (in particular in the poorer South).

The estimated coefficient associated with the resident population (negative but significant only for Center-South in the FE estimator) suggests that the demographic factor has no predictive power for the North and a low one for Centre-South that complies with neoclassical theory.

From the estimated coefficients associated with the year-on-year change in the labor force (little significant) and human capital (positive and very significant), it is deduced that both North and Centre-South economic growth are little dependent on their ability to attract workers, including skilled ones.

There is weak evidence (the estimated coefficient related to this variable is negative and significant in the FE estimator for this area) that small firms mainly contribute to the economic growth of Northern regions.

All other variables included in the model play either a marginal or no role. The evidence that the two macro areas do not benefit from the accumulation of human capital (a factor generally regarded as fundamental for economic growth) is in line with previous research (Di Liberto, 2008; Odoardi and Muratore, 2019).

TABLE 3.
Estimation of the model (2) for macro area

	(1)	(2)	(3)	(4)	(5)	(6)
y=ln(GDP per capita)	OLS - North	OLS - Centre & South	FE - North	FE - Centre & South	GMM - North	GMM - Centre & South
ln(GDP per capita) (t-1)	0.8695***	0.9270***	0.6071***	0.6483***	0.8695***	0.9270***
	(0.0324)	(0.0138)	(0.0400)	(0.0591)	(0.0437)	(0.0191)
ln(Wage per worker)	0.1639***	0.0626***	0.1708*	0.0661**	0.1639***	0.0626**
	(0.0526)	(0.0209)	(0.0835)	(0.0261)	(0.0471)	(0.0270)
ln(Investments)	0.0132	0.0045	0.0507**	0.0177	0.0132	0.0045
	(0.0180)	(0.0079)	(0.0191)	(0.0116)	(0.0129)	(0.0083)
ln(Population)	-0.0090	-0.0061	0.0736	-0.3491***	-0.0090	-0.0061
	(0.0139)	(0.0074)	(0.0569)	(0.0695)	(0.0071)	(0.0080)
ln(Education)	0.0034	-0.0025**	-0.0011	0.0009	0.0034	-0.0025**
	(0.0058)	(0.0010)	(0.0074)	(0.0017)	(0.0063)	(0.0011)
Emergency	-0.0001	0.0001	-0.0001	-0.0000	-0.0001	0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Labor growth	0.0052***	0.0055***	0.0054***	0.0045***	0.0052***	0.0055***
	(0.0011)	(0.0007)	(0.0009)	(0.0008)	(0.0007)	(0.0011)
Number of Crimes	-0.0003	0.0000***	-0.0003**	-0.0000	-0.0003	0.0000***
	(0.0002)	(0.0000)	(0.0001)	(0.0000)	(0.0002)	(0.0000)
ln(R&D Expenditures)	-0.0026	0.0021	0.0011	-0.0029	-0.0026	0.0021
	(0.0032)	(0.0013)	(0.0036)	(0.0017)	(0.0036)	(0.0015)
ln(Exports)	-0.0028	0.0037**	-0.0161*	0.0135**	-0.0028	0.0037
	(0.0052)	(0.0016)	(0.0077)	(0.0049)	(0.0048)	(0.0022)
ln(Social Capital 1)	-0.0002	-0.0007	0.0007	0.0014	-0.0002	-0.0007
	(0.0023)	(0.0024)	(0.0033)	(0.0032)	(0.0018)	(0.0024)
ln(Consumption per capita)	0.0718	0.0537***	0.2129**	0.0240	0.0718	0.0537**
	(0.0437)	(0.0172)	(0.0828)	(0.0516)	(0.0453)	(0.0242)

TABLE 3. CONT.
Estimation of the model (2) for macro area

	(1)	(2)	(3)	(4)	(5)	(6)
y=ln(GDP per capita)	**OLS - North**	**OLS - Centre & South**	**FE - North**	**FE - Centre & South**	**GMM - North**	**GMM - Centre & South**
Firm size	-0.0527	-1.4645	-8.3697	22.8880***	-0.0527	-1.4645
	(3.1187)	(2.3081)	(14.8030)	(4.9487)	(2.5561)	(3.0298)
Industry	0.0001	0.0003***	0.0002	0.0008***	0.0001	0.0003***
	(0.0002)	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0001)
Services	0.0001	0.0000	0.0002	0.0008***	0.0001	0.0000
	(0.0002)	(0.0001)	(0.0003)	(0.0002)	(0.0001)	(0.0001)
Observations	219	273	219	273	219	273
R-squared	0.9913	0.9979	0.9336	0.9759	0.9964	0.9977
Time Fixed Effects	YES	YES	YES	YES	YES	YES
Period	1995-2018	1995-2018	1995-2018	1995-2018	1995-2018	1995-2018

Robust standard errors in parentheses
Standard errors in brackets; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Moreover, cultural factors (namely, the system of values and the social capital) explain little of the economic growth of both Northern and Center-Southern regions (the reasons being, again, that the coefficients of the OLS and the GMM-SYS estimators have dimensions and significance levels like those of the FE estimator and that the coefficients associated with the social capital turn out to be null).

To verify whether the relationship between output and average wage is well fitted by a quadratic specification as postulated by equation (1) or not, the authors estimate the regression model (1) including the squared average wage as a regressor (Cfr. Section III of the Appendix) for macro areas. As can be seen, the estimated coefficients associated with the squared average wage take value -0.000000159 for all the Italian regions, -0.000000179 for the North, and -0.000000101 for the Center & South. This output confirms that the function established in equation (1) is increasing and concave, as graphically represented in Figure 3. In fact, this result suggests that the output impact of an increase in the average wage becomes negative for values of the average wage equal to or higher than 352.515,72 euros. Similarly, the threshold value of the average wage beyond which the output impact of an increase in the average wage becomes negative is equal to 432.960,89 euros in the North and 297.524,75 euros in the Centre & South.

The second robustness exercise that the authors decided to put in this Section is the result of the quantile regression with fixed effects by Canay (2011) (more precisely, that reported below is the second estimation step).

Table 4.
Estimation of the model (2) using the quantile regression with fixed effects by Canay

	(1)	(2)	(3)	(4)	(5)
y=ln(GDP per capita)	**Q-25**	**Q-50**	**Q-75**	**Q-90**	**Q-95**
ln(Wage per worker)	0.5971***	0.5005***	0.4835***	0.5597***	0.6134***
	(0.0707)	(0.0578)	(0.0546)	(0.0671)	(0.0469)
ln(Investments)	0.1411***	0.1957***	0.1545***	0.1366***	0.1779***
	(0.0241)	(0.0197)	(0.0186)	(0.0229)	(0.0160)
ln(Population)	-0.1307***	-0.1891***	-0.1586***	-0.1405***	-0.1741***
	(0.0231)	(0.0188)	(0.0178)	(0.0219)	(0.0153)
ln(Education)	-0.0091***	-0.0054**	0.0031	0.0019	0.0013
	(0.0027)	(0.0022)	(0.0021)	(0.0026)	(0.0018)
Emergency	0.0001	0.0002	0.0001	0.0002*	0.0002***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Labor growth	0.0073***	0.0072***	0.0064***	0.0052**	0.0046***
	(0.0024)	(0.0019)	(0.0018)	(0.0023)	(0.0016)
Number of Crimes	-0.0001	-0.0001**	-0.0003***	-0.0003***	-0.0003***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0000)
ln(R&D Expenditures)	0.0131***	0.0096***	0.0049	0.0036	0.0027
	(0.0043)	(0.0035)	(0.0034)	(0.0041)	(0.0029)
ln(Exports)	0.0149***	0.0245***	0.0340***	0.0385***	0.0300***
	(0.0056)	(0.0045)	(0.0043)	(0.0053)	(0.0037)
ln(Social Capital 1)	0.0161***	0.0082*	0.0035	0.0053	0.0063*
	(0.0057)	(0.0046)	(0.0044)	(0.0054)	(0.0038)
ln(Consumption per capita)	0.5316***	0.5624***	0.6856***	0.7272***	0.6818***
	(0.0409)	(0.0335)	(0.0317)	(0.0388)	(0.0271)
Firm size	-3.0927	-2.8946	-7.7309	-10.1264*	-16.4597***

Table 4. CONT.
Estimation of the model (2) using the quantile regression with fixed effects by Canay

	(1)	(2)	(3)	(4)	(5)
y=ln(GDP per capita)	Q-25	Q-50	Q-75	Q-90	Q-95
	(6.0746)	(4.9641)	(4.6958)	(5.7637)	(4.0268)
Industry	0.0013***	0.0010***	0.0011***	0.0010***	0.0008***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Services	0.0006**	0.0003	0.0003	0.0002	0.0000
	(0.0003)	(0.0002)	(0.0002)	(0.0003)	(0.0002)
Observations	492	492	492	492	492
R_squared	0.9726	0.9830	0.9716	0.9593	0.9477
Macro Fixed Effect	YES	YES	YES	YES	YES
Time Fixed Effects	YES	YES	YES	YES	YES
Period	1995-2018	1995-2018	1995-2018	1995-2018	1995-2018

Robust standard errors in parentheses
Standard errors in brackets; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

This estimation output is particularly interesting in the authors' opinion because it shows the effect of the variable *wage per worker* on economic growth corresponding to the different quantiles of the distribution of the GDP per capita of the regions and autonomous provinces (Q-25, Q-50, Q-75 and Q-95) and because it provides results that are partially different from the mean estimations reported above. In fact, it can be seen that a rise in wage per worker of 1.00% causes an increase in GDP per capita near or higher than 0.5% for each quantile. This positive effect is far greater than the mean of 0.10% estimated in Table 3. Other important discrepancies compared to the mean estimations are that the positive return of investment in physical capital, the negative effect of population density, and the positive impact of consumption per capita on the GDP per capita of the regions and autonomous provinces are more pronounced. All the other coefficients are similar both in size and in significance levels to those present in the rest of the robustness exercises.

Finally, the third and last robustness exercise proposed in this Section by the authors consists of the Generalized Moments (GM) estimation of a spatial panel data model (SPGM) of Kapoor et al. (2007), which can account for spatial correlation both in the dependent variable (GDP per capita) and errors. The authors provide a summary of this particular model and its computation technique in the Appendix (Cfr. Section IV of the Appedix). Here, it is sufficient to stress that the authors use an inverse distance matrix based on the centroid distances among regions as a weight matrix, as in Di Vita (2018). The estimation output of the panel data regression model with spatially correlated error components divided for macro areas (North and Center & South) is reported in Table 5 below.

Table 5.
Estimation of the panel data regression model with spatially correlated error components by Kapoor et al. (2007)

y=ln(GDP per capita)	(1) SPGM – All regions	(2) SPGM – North	(3) SPGM – Centre&South
ln(GDP per capita) (t-1)	0.9524***	0.8478***	0.9589***
	(0.0013)	(0.0215)	(0.0019)
ln(Wage per worker)	0.1101***	0.1790***	0.0579***
	(0.0192)	(0.0112)	(0.0121)
ln(Investments)	0.5430	0.2367	0.1537

TABLE 5. CONT.
Estimation of the panel data regression model with spatially correlated error components by Kapoor et al. (2007)

y=ln(GDP per capita)	(1) SPGM – All regions	(2) SPGM – North	(3) SPGM – Centre&South
	(0.5578)	(0.4594)	(0.1126)
ln(Population)	0.2356	0.7556*	-0.0575*
	(0.4568)	(0.3278)	(0.0201)
ln(Education)	-0.0357	0.1689	0.0126**
	(0.3468)	(0.2357)	(0.0027)
Emergency	-0.0005**	-0.0045	0.0000
	(0.0000)	(0.0256)	(0.0001)
Labor growth	0.0012***	0.0059***	0.0049***
	(0.0008)	(0.0009)	(0.0012)
Number of Crimes	0.0000**	0.0045	0.0000
	(0.0000)	(0.0033)	(0.0001)
ln(R&D Expenditures)	0.0017*	-0.0012	0.0019
	(0.0011)	(0.0038)	(0.0018)
ln(Exports)	0.1367**	0.5487***	0.1287
	(0.0124)	(0.0001)	(0.5673)
ln(Social Capital 1)	0.0000	0.7857	0.0873
	(0.0000)	(0.9856)	(0.3585)
ln(Consumption per capita)	0.0236**	0.1243*	0.0489**
	(0.0112)	(0.0346)	(0.0212)
Firm size	-1.2539	0.0879	-0.9863
	(1.6022)	(1.5646)	(1.4567)
Industry	0.0022*	0.0000	0.0002
	(0.0011)	(0.0000)	(0.0009)
Services	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0001)
Spatial correlation coefficient	0.5799	0.6302	0.2353
Variance of the error components	0.0022	0.0145	0.0017
Variance of the unit specific error components	0.0065	0.0563	0.0009
Observations	492	219	273
Period	1995-2018	1995-2018	1995-2018

Robust standard errors in parentheses
Standard errors in brackets; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The results reported in Table 5 are very similar to the GMM output in Table 3, indicating that the authors' previous estimations are not biased by spatial correlation in both GDP per capita and error components. The only remarkable changes compared to the GMM output in Table 3 are related to the variables *Population* and *Exports*. In fact, the estimated coefficients associated with the first (*Population*)

unravel that the immigration in the North from both the Centre-South and abroad positively contribute to the economic growth of this macro area, while the estimated coefficients associated with the second (*Exports*) point out that the economies of the Northern regions substantially benefit from the access to the European Single Market. Of course, these results are perfectly consistent with the established literature according to which the migration movements from the poorer to the richer Italian regions are due to spatially dependent factors (Biagi et al., 2011) and the geographical proximity to the main EU economies explains the concentration of the Italian industry in the North (McDonald and Vertova, 2001). In fact, not surprisingly, the spatial correlation coefficient is higher in the North than in the Centre-South, even if, as highlighted by the variance of the unit specific error components, the contribution of the spatially dependent factors differs more within the Northern regions than the Southern ones (namely, the Northern regions present a higher heterogeneity than the Central-Southern ones).

8. Concluding remarks

In this manuscript, the authors studied the wage-led economic growth in the Italian regions. Their estimates were carried out considering the endogeneity concerns coming mainly (but not only) from the simultaneous causality between wage and marginal labor productivity. From the estimation outcomes, two interesting conclusions can be deduced.

The first conclusion is that strong evidence exists that the Italian regions represent a case of wage-led economic growth. However, the average impact of an increase of 1.00% in wage per worker on the regional GDP per capita is quite small (less than 0.10%). Then, wage per worker positively affect the regional GDP per capita but cannot be considered the main driver of the economic growth of the Italian regions. Moreover, it is important to underline that a significant difference exists between the Northern and Center-Southern regions. In fact, the impact of an increase in wage per worker of 1.00% on the GDP per capita of the Northern regions is more than 2.5 times higher compared to the Southern ones.

The second conclusion, instead, is that the constant rise in wage per worker between 1995 and 2018 has not negatively affected the economies of the Italian regions in the same period. Indeed (as can be deduced from the authors' sensitivity analysis), it has played a positive role in mitigating the decline in GDP per capita of the Italian regions during the Great Recession of 2008. It is important to stress that this outcome has been obtained by the authors controlling for labor productivity and other relevant variables affecting the GDP per capita growth rate of the Italian regions.

A minor finding coming from the estimation output exposed here is that factors generally regarded as important for the economic development of the Italian regions (such as human capital, migration flows among regions, integration into the single European market, mafia infiltration, average firm size, technology, social capital and system of values of individuals) appear to play a marginal role.

The policy implication of the authors' analysis is that the policies of internal devaluation (namely, wage moderation) adopted by Italy and other European countries in the recent past do not represent a good strategy to boost Italian economic growth at the local level. Overall, the interpretation of the stagnant path of the Italian economy according to which this phenomenon is due to the constant, positive trend of the average wage in the last decades (Cottarelli, 2020) is refuted by the authors' results.

In more general terms, the contribution of the authors' manuscript consists of proving that the wage-led economic growth paradigm proposed by the Neo-Kaleckian and Post-Keynesian schools is, under a few weak assumptions, also consistent with the Neoclassical theory.

In other words, the innovative contribution of the authors' paper is to demonstrate that, with appropriate hypotheses, the Neoclassical and Neo-Kaleckian/Post-Keynesian views on the relationship between output and wage can be reconciled, namely, these schools of economic thought can reach similar results by adopting different methodologies.

In any case, this result should be considered neither an endorsement to the Neoclassical theory nor a critique of the Neo-Kaleckian economics but, on the contrary, as a proof of the convergence of two apparently opposite conceptions of the complex economic growth phenomenon

Indeed, this manuscript paves the way to some future developments about the relation between wage per worker and GDP per capita in the Italian regions. For instance, consistently with the previous contribution of Paternesi Meloni (2018) on the Italian price competitiveness, it would be interesting to assess the alternative research hypothesis that the Real Effective Exchange Rate (REER) represents a valid transmission channel of the internal devaluation. Given the previous study by Royuela et al. (2016) on the negative impact of income inequality on economic growth in the OECD regions, another case study deserving consideration could be the relationship between wage per worker inequality and output in the Italian regions. Finally, in the wake of the previous analysis by Girardi and Pariboni (2015) on the US, France, Germany, Italy, and Spain, it would be important to search for evidence of demand-led growth.

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