Productivity Growth, Smith Effects and Ricardo Effects in Euro Area's Manufacturing Industries

Emilio Carnevali*, Antoine Godin†, Stefano Lucarelli‡ and Marco Veronese Passarella§

Updated: 1 November 2016 (EAEPE Version No. 2)

Abstract. We analyse the determinants of labour productivity across (a sample of) Euro Area's member-states. We focus on the divergent dynamics of core countries relative to peripheral countries. We ground our empirical analysis in Paolo Sylos-Labini's theoretical framework, particularly on his productivity equations. We test both a Panel 2S-LS model and a Panel VAR model. Our preliminary findings confirm and strengthen Sylos-Labini's main insights. Labour productivity in manufacturing industries is strongly and positively correlated with the market size (Smith effect), the relative cost of labour (Ricardo effect), the absolute cost of labour (organisation effect), and past investment, whereas it is negatively correlated with current investment. This holds true for either group of countries.

Keywords: labour productivity, Sylos-Labini, EA imbalances

1. Introduction

This paper analyses the determinants of labour productivity in some selected Euro Area (EA)'s member-states. We focus on the divergent developments in manufacturing industries of "core" countries relative to "peripheral" countries.[1] Our empirical examination is grounded in Paolo Sylos-Labini's "productivity equations" (Sylos-Labini 1983, 1995). We test a number of simple theoretical models accounting for the endogenous nature of labour productivity. As mentioned, we look at possible differences and divergences across EA's countries, particularly across early member-states. The reason is that the gap in productivity growth rates between the core and the periphery is frequently mentioned (along with the gap in compensation of employees' growth rates) as the main driver of the imbalances in the balance of payments among member-states of the EA (e.g. Draghi 2013). That very gap provides the rationale for structural reforms, which are called for to enhance competiveness of peripheral countries, particularly through the increase of labour market flexibility. While we recognise that labour productivity is determined endogenously, we question its alleged causality with labour market reforms. A thorough examination of a variety of other possible determinants is provided instead.

* University of Leeds, UK

† University of Kingston, UK

‡ University of Bergamo, Italy

§ University of Leeds, UK. Corresponding author: m.passarella@leeds.ac.uk

[1] Following a widely adopted classification, the group of core countries includes four EA's member-states, notably, Austria, France, Germany, and the Netherlands (we do not include Belgium and Luxemburg because of data availability reasons). The group of peripheral countries is made up of four EA's members, notably, Greece, Italy, Portugal, and Spain (we do not include Ireland because of data availability reasons). The distinguishing characteristic between the two groups is the sign of the balance of payments since the launch of the Euro. Core countries are those which have recorded a surplus, whereas peripheral countries are those which have faced a deficit (before the crisis that has been taking place since the end of 2009).

Labour productivity developments in manufacturing industries of some selected EA member-states are portrayed in Figures 1 and 2. As stressed by the President of the ECB Mario Draghi (2013), a slower growth rate in labour productivity of peripheral countries compared to core countries is apparent since the early 2000s, particularly when Ireland is not taken into account. National trends within the group of deficit countries are quite variegated though. From mid-1990s to mid-2000s, Italy and Spain were both marked by a flat trend in labour productivity. Greece and Portugal, in contrast, were characterised by a rapid catching up. After the US financial crisis, labour productivity has increased remarkably in Spain and Portugal, whereas it has remained flat in Italy. Greece has been marked by a collapse in labour productivity over the same period instead. The development of labour productivity rates looks more homogenous across core countries. All of them are marked by an increasing trend before the US financial crisis, followed by a general decrease in 2007-2009, and then a recovery from 2009.

As mentioned, the examination of the factors underpinning recent (different) developments in labour productivities across EA-members manufacturing industries is the main target of this research. For this purpose, the rest of the manuscript is organised as follows. In section 2 the theoretical framework is discussed. Drawing from Sylos-Labini (1983, 1995), we link labour productivity with technological innovation. The latter, in turn, is connected dynamically with the size of the goods market (i.e. demand conditions), the absolute cost of labour, the relative cost of labour (i.e. the trend in compensation of employees relative to the cost of machinery), and the real investment. In section 3 both the data used and the main methodological features of the benchmark model are discussed. In section 4 we present the main findings of our empirical analysis. In section 5 we extend the model developed in previous sessions to investigate the gap between core countries and peripheral countries. Section 6 is devoted to the development of a panel VAR model, aiming to address bicausality issues with the benchmark model. Section 7 provides some final remarks.

2. The theoretical framework: Sylos-Labini's productivity equations

The theoretical starting point of our empirical investigation is the simple model developed by Sylos-Labini (1983, 1995). It is based on the idea that labour productivity growth in manufacturing industries arises from innovation and the latter, in turn, is driven by four factors. The first factor is the size of the market, as pioneeringly emphasised by Adam Smith. This principle echoes the so-called 'Kaldor-Verdoorn law' and postulates that the rate of technical progress is endogenous. More precisely, it states that labour productivity growth is a positive function of the growth rate of the economy or the industries considered (Kaldor 1961, 1978, Verdoorn 1980). This is a key relationship of Keynesian economics (Lavoie 2014) and has been validated by many empirical works (e.g. McCombie et al. 1994, McCombie 2002). The second factor leading firms to innovate is the growth in the absolute cost of labour in real terms. While many different formulations are possible, the absolute cost of labour is simply defined here as the ratio between the wage rate and the price level. An increase in the absolute cost of labour leads the firms to improve the allocation of labour inputs to increase efficiency. The new, more efficient, organisation, triggered by the rise in real wages is expected to lead to an increase in labour productivity. The third factor is the growth in the cost of labour relative to the price of investment goods, say, machines. An increase in the relative cost of labour leads the firms to replace workers with machines. Such a Ricardian effect depends inversely on the monopoly power of the firms. For the higher the competition on the final goods market, the sharper will be the fall in the profit margin of the firms following an increase in the cost of labour. Consequently, the higher will be the incentive to invest in labour-saving technology, thereby enhancing the productivity rate.[2] The fourth factor affecting labour productivity is the real investment

[2] Sylos-Labini recovers and develops an idea originally formulated in chapters I and XXXI of the last edition of Ricardo's *Principles* (Ricardo 1821). Notice that, in spite of the superficial resemblance, the Ricardo effect is at odds with the 'neoclassical' hypothesis of smooth substitutability of inputs (and the claim that there would be a monotonic non-increasing relationship between the capital intensity of production techniques and the rate of profit). The latter expresses a static theory of allocation efficiency and income distribution, whereas the former underpins a dynamic theory of labour productivity growth's determinants.

level. The impact of investment on productivity is twofold: on one hand, a 'disturbance effect' is possible in the short run, as the new machinery takes time to be used effectively; on the other hand, investment is expected to improve labour productivity in the medium to long run.

Using a 'dot' to denote growth rates, the average real labour productivity function can be defined by means of the expression below, which is linear in the parameters:

$$\dot{PR} = \alpha + \beta_1 \cdot \left(\dot{V}_{€} - \dot{P}\right) + \beta_2 \cdot \left(\dot{W}_{€} - \dot{P}\right) + \beta_3 \cdot \left(\dot{W}_{€} - \dot{P}_k\right) + \\ + \beta_4 \cdot INV/Y + \beta_5 \cdot (INV_{-\lambda}/Y_{-\lambda}) \quad (1)$$

where $V_{€}$ is the nominal value added of the economy considered, P is the general price level, $W_{€}$ is the nominal wage rate, P_k is the price level of machines, INV stands for new (or current) real investment level, Y is current gross domestic product, and the subscript $-\lambda$ denotes past (or lagged) variables.

Using $V = V_{€}/P$, $U = W_{€}/P$, $W = W_{€}/P_k$, and $I = INV/Y$, in equation (1) we obtain:

$$\dot{PR} = \alpha + \beta_1 \cdot \dot{V} + \beta_2 \cdot \dot{U} + \beta_3 \cdot \dot{W} + \beta_4 \cdot I + \beta_5 \cdot I_{-\lambda} \quad (2)$$

where β_1 captures the Smith effect, β_2 measures the organisation effect, β_3 captures the Ricardo effect, β_4 measures the short-run disturbance effect of newly-undertaken real investment, and β_5 is meant to capture the long-run effect of real investment on labour productivity. Notice that coefficients above are all expected to be positive, except for β_4. On a close inspection, Sylos-Labini's theoretical model may well be regarded as an implementation and extension of the Kaldor-Verdoorn law, where the effect of the size of the market on technical progress is one out of four determinants of labour productivity.

3. Data and methodological issues with the benchmark model

Our dataset covers a subset of current EA member-states from 1996 to 2016 on a quarterly basis at the country level. For the sake of data availability, we focus on eight countries, notably Austria, France, Greece, Germany, Italy, Netherlands, Portugal, and Spain. Definitions and data sources are all provided in Table A1 in the Appendix. Estimates have been obtained by different techniques and by using different clusters of countries. Heteroskedasticy-robust standard errors and covariances have been used unless otherwise stated. Serial correlation was checked and rejected.[3] The hypothesis that there is no time trend in productivity growth rates was checked (by a Wald test) and not rejected. In order to rule out spurious regressions, we checked the stationarity of variables by using a Levin-Lin-Chu test for unit roots in panel datasets[4]. Variables of the model are all stationary except for investment (taken as a ratio to GDP), which is not expressed as a growth rate (see Table A2).

Before we present our main findings, a possible issue is worth discussing here. Labour productivity (PR) is defined as real GDP per person employed (at constant prices of 2010). Since the real value added of the economy (V) is included among the predictors of the model, endogeneity issues may well be raised because of the possible loop of causality between PR and V. As a result, the value of the coefficient β_1 could be biased. This is a well-known recurring problem when trying to estimate the Smith-Kaldor-Verdoorn effect. Many attempts at fixing it have been made in the last three decades. Overall, the existence of a remarkable effect of real value added on labour productivity has been observed whatever the correction method chosen. We addressed the possible endogeneity by using the (average quarterly change in) crude oil price as an instrumental variable. Notice that,

[3] The Durbin-Watson statistic was always close to 2. When we found that error terms could be negatively correlated, a Breusch-Godfrey test was made. A Ljung-Box Q-statistic was used too.

[4] Since this is an adaptation of the Augmented Dickey-Fuller test to panel data, we selected the number of lags by using the AIC criterion (with at most 10 lags).

asymmetric though it is, the effect of oil price shocks on economic growth is widely recognised in the literature (e.g. Jiménez-Rodríguez and Sánchez 2005) and is commonly used in the works on the Smith-Kaldor-Verdoorn law (e.g. Millemaci and Ofria 2014). By contrast, labour productivity is unlikely to be affected by the oil price level directly. Accordingly, a two-stage least square regression was ran. We found that the effect of a change in the real value added of the economy on labour productivity growth is in line with the literature on the Kaldor-Verodoorn effect once the model is amended. Our key findings are discussed in the next section.

4. Productivity determinants in EA8 countries: a simple Panel OLS model

Overall, our findings confirm the soundness of Sylos-Labini (1983, 1995)'s theoretical model. Key variables have all a strong impact on labour productivity growth rates across EA countries. Going in detail, the extended functional form we estimated is:

$$d(\log(PR_{it})) = \alpha_i + \beta_1 \cdot d(\log(V_{it})) + \beta_2 \cdot d(\log(U_{it})) + \beta_3 \cdot d(\log(W_{it})) + \\ + \beta_4 \cdot I_{it} + \beta_5 \cdot I_{it-\lambda} + D_t + LPI_{it} + \epsilon_{it} \quad (3)$$

where subscript i stands for country, t stands for time, $\log(\cdot)$ is natural logarithm, λ is the investment effect time lag, α_i are country fixed effects (if any, where: $\alpha_i = \bar{\alpha}$ if no specific effects are found), and ϵ_{it} are error terms. We used dummies, D_t, to account for the effect of the US financial crisis on the world economy, and the labour protection index, LPI_{it}, to take into consideration the possible impact of labour market conditions on productivity.

As mentioned, estimates have been made by using different models and different clusters of countries. Initially, we focused on the whole sample (EA8 hereafter), including both peripheral countries (notably, Greece, Italy, Portugal, and Spain) and core countries (notably, Austria, Germany, France, and the Netherlands). In accordance with Sylos-Labini's theory, estimates are made for the manufacturing industry. Results are reported in Table 1.

Table 1. Estimates of productivity function in EA8 – dependent variable: $\boldsymbol{d(\log(PR_t))}$

	Model 1	Model 2	Model 2bis	Model 3	Model 4	Model 5
$d(\log(V_t))$	0.7322724*	0.7550214*	0.7582034*	0.7592724*	0.7598966*	0.572887*
$d(\log(U_t))$	0.1528584*	0.1423471*	0.1409087 ***	0.1431701*	0.1278014*	0.2170521*
$d(\log(W_t))$	0.299599*	0.3228984*	0.3284804*	0.3217206*	0.3260761*	0.2450983*
I_t		-0.0045496 **	-0.0046588*	-0.0043409**	-0.0055402*	-0.0016923
$I_{t-\lambda}$		0.0033162***	0.0033197*	0.0033599***	0.0036523***	0.0006741
D_{crisis}				0.0013609		
LPI_t					0.0011929	
Adjusted R²	0.68511566	0.694650806	0.692604799	0.694830764	0.718122506	0.6847 (*n-adj.*)

Notes: White cross-section standard errors & covariance (d.f. corrected). Significance: * 1% threshold, ** 5% threshold, *** 10% threshold. Models 1-2 and 3-4 method: pooled OLS, no cross-country fixed effects. Model 2bis method: pooled OLS, cross-country fixed effects. Model 5 method: 2S-LS, no cross-country fixed effects, no robust errors. Investment lag: $\boldsymbol{\lambda = 1}$. $\boldsymbol{D_{crisis}}$: crisis dummy (2008Q3-2016Q1).

The proportion of response variation of productivity growth explained by models' regressors is rather high, as coefficients of determination (i.e. *Adjusted* R^2) are all above 68%. Model 1 is the simplest

model we tested. Coefficients are all statistically significant at the 1% threshold and below. The market size (Smith effect), the relative cost of labour (Ricardo effect), and the organisation effect, have all a positive impact on the real productivity of labour, thereby supporting Sylos-Labini insights. However, model 1 could be affected by misspecification, as some possible productivity drivers identified by Sylos-Labini are not taken into account, the most important one being the investment level. The impact of current and past investment (meaning one-lag investment) is accounted for in model 2.[5] The coefficients are all statistically significant and signs are all consistent with Sylos Labini's theory (meaning a positive sign for the Smith Effect, the organisation effect, the Ricardo Effect, and the long-run effect of real investment, and a negative sign for the short-run disturbance effect of newly-undertaken real investment).

Models 1 and 2 are pooled OLS estimations based on the assumption that there is a common constant term for all countries included in our sample. In principle, it would be possible to introduce some degree of heterogeneity by using a cross-country fixed effects estimator. This is made by model 2bis in the Table 1. The validity of the fixed effects method is assessed through a F-test comparing the fit of model 2 with that of model 2bis. Since it is not possible to reject the null hypothesis that the country specific dummy variables are not jointly statistically different from zero,[6] we stick to the pooled OLS estimator model with a common constant term (model 2).

Another factor that is expected to have impacted on productivity levels across European countries is the so-called "European sovereign debt crisis" following the US financial crisis. Model 3 is augmented with a dummy variable to take into account the outbreak of the economic and financial crisis that has been taking place since the third quarter of 2008. The dummy is not statistically significant at 10%. However, this does not rule out the possibility of a structural break. The latter was also checked by running the same model (model 3) before and after the crisis, respectively. We used a Chow test to check if the difference was statistically significant at 1% threshold,[7] and it turned out that a structural break occurred indeed.[8]

We tested also the impact of labour market conditions on productivity (model 4). Although this effect was not advocated by Sylos-Labini, the implementation of labour market reforms has been frequently said to foster productivity (European Commission 2015). To test the impact of labour market conditions, we used the labour protection index provided by the OECD. Our findings do not support the view that a reduction in labour protection would promote labour productivity. The coefficient is not statistically significant (model 4) and the same result is obtained when the change in labour protection index is employed instead of the absolute level.

Finally, we addressed the possible endogeneity issue with the real value added by using the oil price growth rate and the one-period lagged real value added as instrumental variables within a two-stage least square estimation (model 5). We found that the Smith effect coefficient is statistically significant and the value of the parameter (0.57) is very close to the one estimated by the literature on the Verdoorn-Kaldor's effect (e.g. McCombie et Alii 2002). Organisation effect and Ricardo effect are both positive and statistically significant, although investment variables are no longer statistically significant in the 2S-LS model.[9]

---

[5] We chose the number of lags by comparing different models through the Akaike's information criterion. The best result (AIC = -3779.52) was obtained with one lag. Notice that the sample narrows down as the number lags increases. Consequently, we chose to limit our analysis to 4 lags.

[6] The critical value at 1% threshold (restrictions: 8; sample size: 632) is 2.6682148. This is well above the F statistic, which is 0.46.

[7] The Chow statistic obtained is 4.9448867, which is well beyond the critical value of F-statistic (restrictions: 6, sample size: 632), which is 2.8305354. As a result, we rejected the null hypothesis that the coefficients are not statistically different before and after the crisis.

[8] Notice, however, that the some variables of the two sub-models are no longer significant. See Table A3.

[9] As for the consistency of the 2S-LS estimation, we checked the possible weakness of instrumental variables through a F-test. The latter assesses the overall model significance of a regression of the endogenous variable on the instrumental variables. As we obtained a p-value = 0.0000, we rejected the null hypothesis of weak instruments. We also checked the possible correlation of instrumental variables with the residuals of the model (endogeneity). A Sargan instrument validity

5. Productivity determinants in peripheral countries vs. core countries

We then focused on the different productivity developments in deficit and surplus countries, respectively. The first group includes those countries which have been the most hit by recent crises, and have been pushed to adopt structural reforms, particularly in the labour market.[10] The second group includes the two dominant European nations (Germany and France) and other countries which are the most economically and politically akin to them. Surplus countries have been characterised, on average, by a quicker recovery compared to deficit countries. The key divide between the two groups is the different trend in current (and financial) accounts of the balance of payments. That divide is expected to be mirrored by the parameters of productivity equations. Estimates about deficit countries are reported in Table 2.

Table 2. Estimates of productivity function in peripheral countries – dependent variable: $\boldsymbol{d}(\mathbf{log}(\boldsymbol{PR_t}))$

	Model 1	Model 2	Model 3	Model 4	Model 5
$d(\log(V_t))$	0.6024748*	0.6364563*	0.6497951*	0.6529111*	0.499133*
$d(\log(U_t))$	0.1858531*	0.1801424*	0.1744017*	0.1685258*	0.22862*
$d(\log(W_t))$	0.2687922*	0.2878414*	0.2906792*	0.2932799*	0.231357*
I_t		-0.0041905	-0.0035691	-0.0058853**	-0.0021383
$I_{t-\lambda}$		0.0029152	0.0030893	0.0032663	0.0011025
D_t			0.0032512		
LPI_t				0.0010435	
Adjusted R²	0.5321597	0.5389713	0.540254313	0.5819139	0.5383 (*n-adj.*)

Notes: White cross-section standard errors & covariance (d.f. corrected). Significance: * 1% threshold, ** 5% threshold, *** 10% threshold. Models 1-2 and 3-4 method: pooled OLS, no cross-country fixed effects. Model 2bis method: pooled OLS, cross-country fixed effects. Model 5 method: 2S-LS, no cross-country fixed effects, no robust errors. Investment lag: $\boldsymbol{\lambda = 1}$. $\boldsymbol{D_{crisis}}$: crisis dummy (2008Q3-2016Q1).

It is worth noticing that coefficients of determination have decreased, as they are now all between 53% and 54%. Regressors' values are highly significant for Sylos-Labini's effects all, the only exceptions being current and lagged investments which are never significant.

Turning to core countries, estimates are reported in Table 3.

Table 3. Estimates of productivity function in core countries – dependent variable: $\boldsymbol{d}(\mathbf{log}(\boldsymbol{PR_t}))$

	Model 1	Model 2	Model 3	Model 4	Model 5
$d(\log(V_t))$	0 .8320443*	0.8444334*	0.8436645*	0.8431201*	0.6480371*

test was conducted. The null hypothesis of non-correlation was not rejected, thereby confirming the validity of instruments chosen.

[10] For the sake of institutional homogeneity and data availability, Ireland was excluded from estimations shown in Tables 1 and 2. Consequently, the definition of deficit or peripheral countries matches the label of Mediterranean countries. Notice *inter alia* that France and Italy could be regarded as somewhat 'spurios' cases. The French economy shares some of the issues faced by peripheral countries, think of the deterioration of the balance of trade since the launch of Euro. The Italian economy has never performed as bad as other peripheral countries when looking at the balance of trade. At the same time, labour productivity has been stagnating in the last two decades.

$d(\log(U_t))$	0.1297303*	0.1162122*	0.1146351*	0.103079**	0.210841*
$d(\log(W_t))$	0.3144876*	0.3280044*	0.3295726*	0.3374841*	0.2456501*
I_t		-0.0034004**	-0.0034337**	-0.0034743***	0.0002152
$I_{t-\lambda}$		-0.0006404	0.0023001	0.0022832	-0.0010901
D_t			-0.0003882		
LPI_t				0.0012096	
Adjusted R²	0.85257607	0.855349551	0.860235711	0.85897149	0.8511 (*n-adj.*)

Notes: White cross-section standard errors & covariance (d.f. corrected). Significance: * 1% threshold, ** 5% threshold, *** 10% threshold. Models 1-2 and 3-4 method: pooled OLS, no cross-country fixed effects. Model 2bis method: pooled OLS, cross-country fixed effects. Model 5 method: 2S-LS, no cross-country fixed effects, no robust errors. Investment lag: $\boldsymbol{\lambda = 1}$. $\boldsymbol{D_{crisis}}$: crisis dummy (2008Q3-2016Q1).

Coefficients of determination have increased significantly. They are all above 85%. Regressors' values associated with Sylos-Labini's effects are almost all highly significant, including current investment. The only exception is lagged investment, which is never significant. Interestingly, both the Smith and the Ricardo effects seem to be stronger when focusing on core countries. By contrast, the organisation effect looks stronger for peripheral countries. In other words, core countries seem to be more sensitive to changes in the size of market and the relative cost of labour (meaning the wage to machine price ratio). Peripheral countries, in turn, seem to be more sensitive to changes in the absolute cost of labour. Finally, current investment affects labour productivity of core countries but it does not seem to affect productivity of peripheral countries' manufacturing industries. However, the null hypothesis that parameters are identical across the two groups cannot be rejected.[11] We discuss these findings in the last section.

An alternative way to test the difference between core and peripheral countries is to use dummy variables. Using model 2 as the benchmark one, we used a dummy variable (1 for core countries; 0 for periphery countries) to assess unobserved heterogeneity between deficit and surplus countries (Model A). We also assessed each individual coefficient (Model B), to cope with the degree of freedom issues which could arise from the Chow test. Our findings are shown in Table 4.

Table 4. Estimates of productivity functions in EA8

	Model A	Model B
$d(log(V_t))$	0.7550404*	0.7202433*
$d(log(U_t))$	0.14114*	0.1078035
$d(log(W_t))$	0.3243579*	0.3167399*
	-0.0045006**	-0.0082297*
I_{t-1}	0.0033641***	0.0068762*
D_t	0.0008289	-0.0014681
$D_t \cdot d(log(V_t))$		0.0593097
$D_t \cdot d(log(U_t))$		0.04177

[11] We used a Chow test in model 3 to assess whether the distinction between peripheral and core countries is significant and it turned out that it was not. The F-statistic of the Chow test was 1.2034559, while the critical value (restrictions: 6; observation: 332) at the 1% threshold is 2.8310911 (or 2.1131859 at 5%).

$D_t \cdot d(log(W_t))$	0.0062069
$D_t \cdot I_t$	0.0045082
$D_t \cdot I_{t-1}$	-0.0042305

None of the coefficients above are significant. This result is consistent with the Chow test, meaning that the two groups of countries do not feature significant differences in the way labour productivity is affected by the variables chosen.

6. A preliminary Panel VAR model

As mentioned, Sylos Labini's theory is based on a single equation that explains productivity as the result of five basic determinants. Clearly, the assumed causality is from the five independent variables (value added, absolute cost of labour, relative cost of labour, and investment level) to labour productivity. However, "reverse causality" effects cannot be ruled out. For instance, productivity is expected to affect competitiveness and therefore export, aggregate demand, and the value added of the economy. In fact, one of the possible issues with the Smith-Kaldor-Verdoorn effect is that a cumulative causation between aggregate demand and supply conditions is likely to occur. This means that labour productivity both affects and is affected by the value added. Similarly, labour productivity changes may well affect real wage rates bargained by workers with their employers. Real wages and the growth in GDP, in turn, can affect investment plans of firms. This highlights a possible problem of "endogeneity" when using an OLS estimation.

In sections 4 and 5 we addressed endogeneity by using oil price and the lagged value added of the economy as instrumental variables. Yet reverse causality is not necessarily at odds with Sylos-Labini's approach. In fact, Sylos-Labini himself pointed out that "productivity increases as cause and effect of the increase of real wages: *cause*, since the increase in productivity induces trade unions to demand higher wages and, at the same time, allows the firms to pay them (...); *effect*, since firms try to offset wage increases by saving labour either in absolute terms by rationalizing the productive process, or in relative terms by introducing machines capable of increasing productivity" (Sylos Labini 1984, p. 169). He also observed that the "level of investment depends primarily on demand pressure" (Sylos Labini 1984, p. 172), meaning the size of the market (captured the value added value in our model). Building upon these preliminary insights, it seems licit to test other bi-directional causality relations. For instance, since the average real wage rate mirrors the bargaining power of the labour force, an increase in real wages could lead firms to replace workers with machines. In other words, investment plans are likely to be affected by the wage level, as firms undertake them also to ensure "discipline" and "political stability" in the workplace (e.g. Kalecki 1943). We can name this mechanism the "Marx-Kalecki effect".

The point is that causalities are multiple and (both dominant and reverse) effects can take time to show up, as variables operate with a certain number of lags. In order to address this cumulative causation issue, some authors have suggested to use vector autoregression (VAR) models (Coad *et al*. 2011), in which all variables are treated as endogenous and interdependent. We chose a VAR model with 8 lags (two years).[12] This allowed us to take into account time lags without narrowing down too much our sample. Results of the preliminary Granger causality test are reported in Table A4. It turns out that the "other" lagged variables are jointly statistically significant for each and every equation.[13] Therefore, the idea of a net of intertwined causal relationships between variables seems to be verified in general terms. Impulse response functions are shown in Figure 3. Focusing on each individual variable, labour productivity is affected by lagged value added, while value added value is affected by lagged productivity. Overall, both effects are positive and therefore consistent with Sylos-

[12] Notice that the 8-lag model is the one with the highest coefficient of determination (0.9784) for $\lambda \leq 8$.

[13] Notice that the test entails a series of F-tests comparing the original model with amended models where either one "provisional independent" variable or all the other "independent" variables altogether are excluded.

Labini's theoretical framework. In addition, lagged investment positively affects productivity. This is also coherent with Sylos-Labini's equation. Investment, in turn, is affected by demand pressure. By contrast, our estimates do not support the hypothesis of a reverse causality between labour productivity and the absolute cost of labour. Likewise, the absolute cost of labour seems not to affect the real level of investment.

7. Conclusions

We examined the determinants of labour productivity within a sample of selected P is the general price level, EA's member-states. We focused on the divergent dynamics of core countries relative to peripheral countries. Our empirical analysis was grounded in Paolo Sylos-Labini's endogenous theory of labour productivity. We tested a number of Panel OLS models. A Panel VAR model was tested as well. Overall, our findings confirm Sylos-Labini's main results. Labour productivity in manufacturing industries is strongly and positively correlated with the market size (Smith effect), the relative cost of labour (Ricardo effect), the absolute cost of labour (organisation effect), and past investment, whereas it is negatively correlated with current investment. No correlation with the labour protection index was found instead. This holds true for either group of countries. In fact, we found no significant differences in factors affecting productivity trends in peripheral countries compared with core countries. The lower productivity of peripheral countries (with respect to the core) seems to be explained by other variables. Further analysis is therefore necessary to shed light on this point.

References

Coad A., Rao, R. and Tamagni, F., 2011. Growth Processes of Italian Manufacturing Firms, *Structural Change and Economic Dynamics*, 22(1): 54-70.

Draghi, M., 2013. Euro area economic situation and the foundations for growth, *presentation at the Euro Summit Brussels*, 14 March 2013.

Jiménez-Rodríguez, R. and Sánchez, M., 2005. Oil price shocks and real GDP growth: empirical evidence for some OECD countries. *Applied economics*, 37(2), pp. 201-228.

Kaldor, N., 1961. *Capital accumulation and economic growth* (pp. 177-222). Macmillan.

Kaldor, N., 1978. *Further essays on applied economics*. London: Duckworth.

Kalecki, M., 1943. Political Aspects of Full Employment. *The Political Quarterly*, 14(4), pp. 322-330.

Lavoie, M., 2014. *Post-Keynesian* Economics*: New Foundations*, Cheltenham: Edward Elgar.

Millemaci, E., and Ofria, F., 2014. Kaldor-Verdoorn's law and increasing returns to scale: A comparison across developed countries, *Journal of Economic Studies*, 41(1): 140-62.

Ricardo, D., 1821[1971]. *The principles of taxation and political economy*. London: Penguin.

Sylos-Labini, P. (1983) Factors affecting changes in productivity, *Journal of Post Keynesian Economics*, 6(2): 161-179.

Sylos-Labini, P., 1995. Why the interpretation of the Cobb-Douglas production function must be radically changed, *Structural Change and Economic Dynamics*, 6(4): 485-504.

McCombie, J., 2002. Increasing returns and the Verdoorn Law from a Kaldorian perspective. In *Productivity growth and economic performance* (pp. 64-114). Palgrave Macmillan UK.

McCombie, J.S., Thirlwall, A.P. and Thompson, P., 1994. *Economic growth and the balance-of-payments constraint*. New York: St. Martin's press.

Verdoorn, P.J., 1980. Verdoorn's law in retrospect: A comment. *The Economic Journal*, pp. 382-385.

Additional bibliography

Forges-Davanzati, F., Patalano, R. and Traficante, G., 2016. The Italian Economic Decline in a Kaldorian Theoretical Perspective, *Post Keynesian Economics Study Group*, Working Paper 1606.

Guarini, G., 2007. La funzione di produttività di Sylos Labini tra mercato e territorio: un'analisi econometrica per le regioni italiane. *Moneta e Credito*, 60(238), pp. 173-198.

Guarini, G., 2009. 11. Labour productivity and technological capability: an econometric analysis on the Italian regions. *Geography, Structural Change and Economic Development: Theory and Empirics*, p. 280.

Jimenez-Rodriguez, R., 2008. The impact of oil price shocks: evidence from the industries of six OECD countries. *Energy Economics*, 30(6), pp. 3095-3108.

Jiménez-Rodríguez, R. and Sanchez, M., 2009. Oil shocks and the macro-economy: a comparison across high oil price periods. *Applied Economics Letters*, 16(16), pp. 1633-1638.

Thirlwall, A.P., 2011. Balance of payments constrained growth models: history and overview. *PSL Quarterly Review*, 64(259), pp. 307-351.

Thirlwall, A.P., 2011. The balance of payments constraint as an explanation of international growth rate differences. *PSL Quarterly Review*, 64(259), pp. 429-438.

Appendix

Table A1. Data definitions and sources

Variable	Full name	Frequency	Unit / Measure	Source
H	Hours worked, manufacturing	Quarterly	1000 hours	Eurostat
INV	Machinery and equipment, gross value	Quarterly	Percentage of GDP, s.a.	Eurostat
P	Price index, implicit deflator	Quarterly	Index (2010=100), s.a.	Eurostat
P_k	Domestic price of capital goods	Quarterly	Index (2010=100)	Eurostat
$V_€$	Gross value added, manufacturing	Quarterly	Current prices, million €, s.a.	Eurostat
$\widehat{W}_€$	Wages and salaries, manufacturing	Quarterly	Current prices, million €, s.a.	Eurostat
$PR = V \cdot 1000/H$	Gross value added per person employed	Quarterly	Real product per hour	Our calculations
$U = W_€/P$	Wages and salaries, manufacturing	Quarterly	Real wages	Our calculations
$V = V_€/P$	Gross value added, manufacturing	Quarterly	Real gross value added	Our calculations
$W = W_€/P_k$	Relative wages and salaries, manufacturing	Quarterly	Relative labour cost	Our calculations
$W_€ = \widehat{W}_€ \cdot 1000/H$	Wages and salaries, manufacturing	Quarterly	Hourly wages	Our calculations
COP	Crude oil price (WTI)	Quarterly	Average, USD per barrel	US Energy Information Administration
LPI	Strictness of employment protection – individual and collective dismissals (regular contracts)	Quarterly	Index	OECD

Table A2. Levin-Lin-Chu test for unit roots

	Adjusted t statistic	p-value
$d(log(PR_t))$	-18.7305	0.0000
$d(log(V_t))$	-12.7818	0.0000
$d(log(U_t))$	-17.0619	0.0000
$d(log(W_t))$	-18.7446	0.0000
I_t	-0.8066	0.2100

Table A3. Chow test for structural breaks

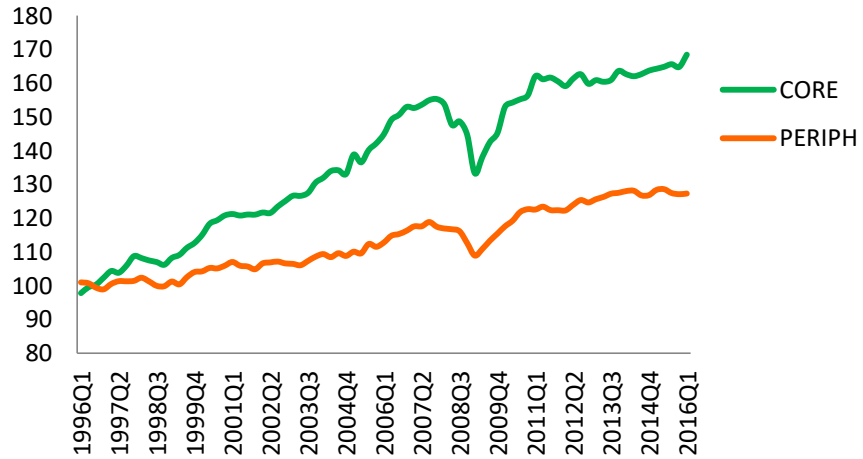
	Before the crisis	After the crisis
$d(log(V_t))$	0.8769042*	0.7252588*
$d(log(U_t))$	0.1716455*	0.0704691
$d(log(W_t))$	0.2519336*	0.4747626*
I_t	-0.0034317***	-0.0058785***
I_{t-1}	0.0023487	0.0047082
Adjusted Rsquare	0.70289906	0.700093887

Table A4. Granger causality test

Equation	Excluded	p-value	Reject null hypothesis with *% significance
$d(log(PR_t))$			
	$d(log(V_t))$	0.069	***
	$d(log(U_t))$	0.495	
	$d(log(W_t))$	0.796	
	I_t	0.004	*
	All	0.000	*
$d(log(V_t))$			
	$d(log(PR_t))$	0.026	**
	$d(log(U_t))$	0.023	**
	$d(log(W_t))$	0.365	
	I_t	0.102	
	All	0.001	*
$d(log(U_t))$			
	$d(log(PR_t))$	0.039	**
	$d(log(V_t))$	0.168	
	$d(log(W_t))$	0.026	**
	I_t	0.007	*
	All	0.000	*
$d(log(V_t))$			
	$d(log(PR_t))$	0.088	***
	$d(log(V_t))$	0.307	
	$d(log(U_t))$	0.087	
	I_t	0.297	
	All	0.092	***
I_t			

$d(log(PR_t))$	0.010	**
$d(log(V_t))$	0.000	*
$d(log(U_t))$	0.955	
$d(log(W_t))$	0.021	**
All	0.000	*

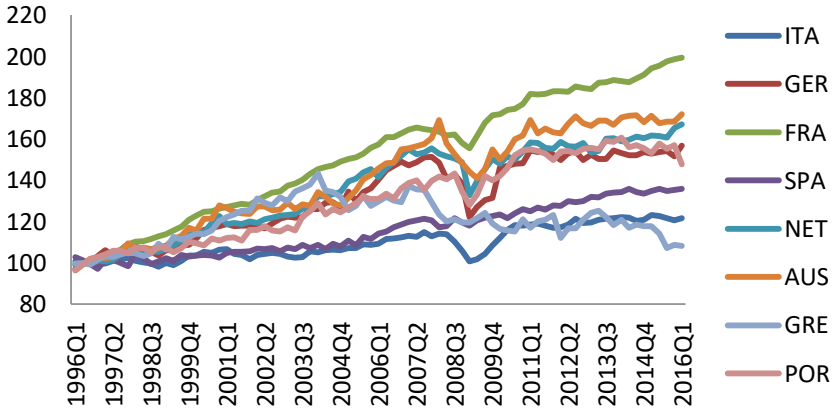
Figure 1. Productivity development in deficit vs. surplus areas



Notes: 1996 = 100. Manufacturing industry. Real value added per employee at 2010 reference level (real GDP-weighted average by country group). Quarterly data.

Source: our elaboration on Eurostat data 2016.

Figure 2. Productivity development in selected EA countries

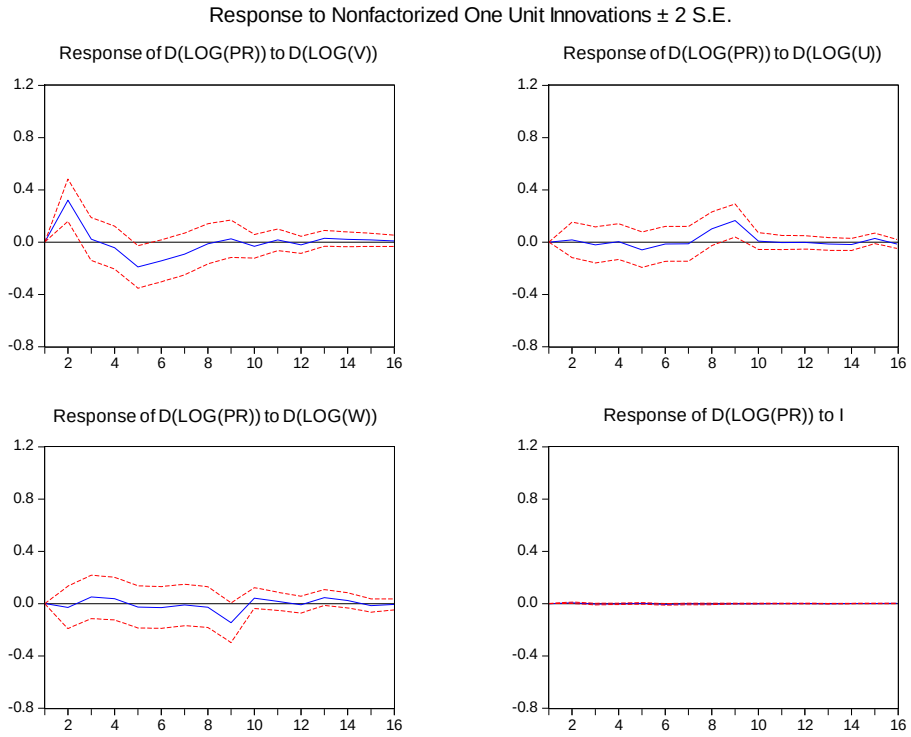


Notes: 1996 = 100. Manufacturing industry. Value added per employee at 2010 reference level. Quarterly data.

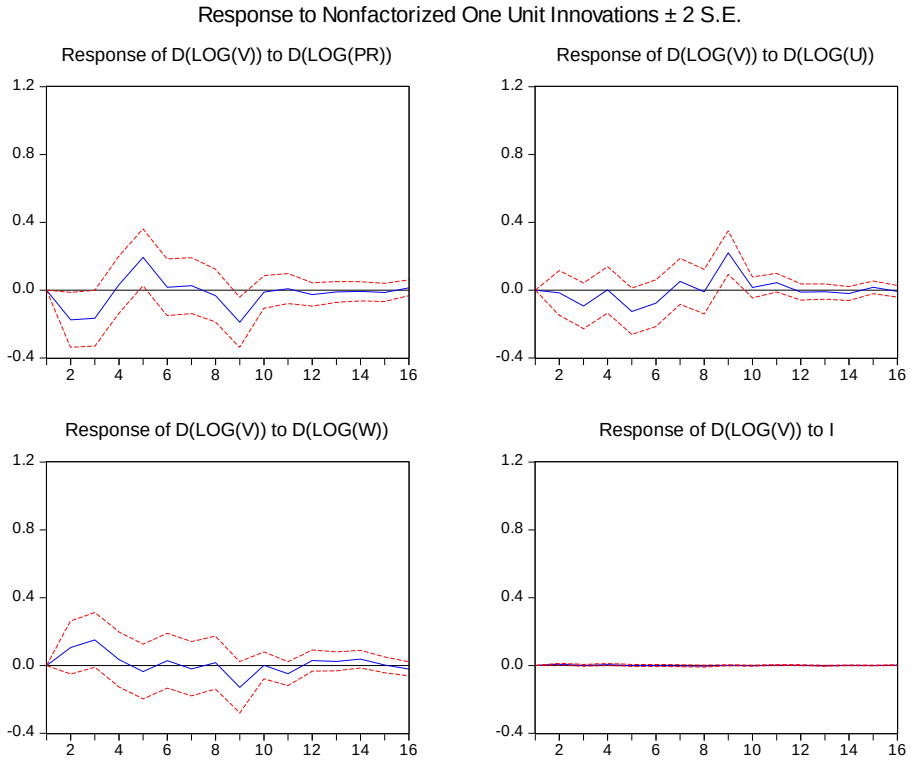
Source: our elaboration on Eurostat data 2016.

Figure 3. Impulse response functions of Panel VAR for EA8 (16 steps head)

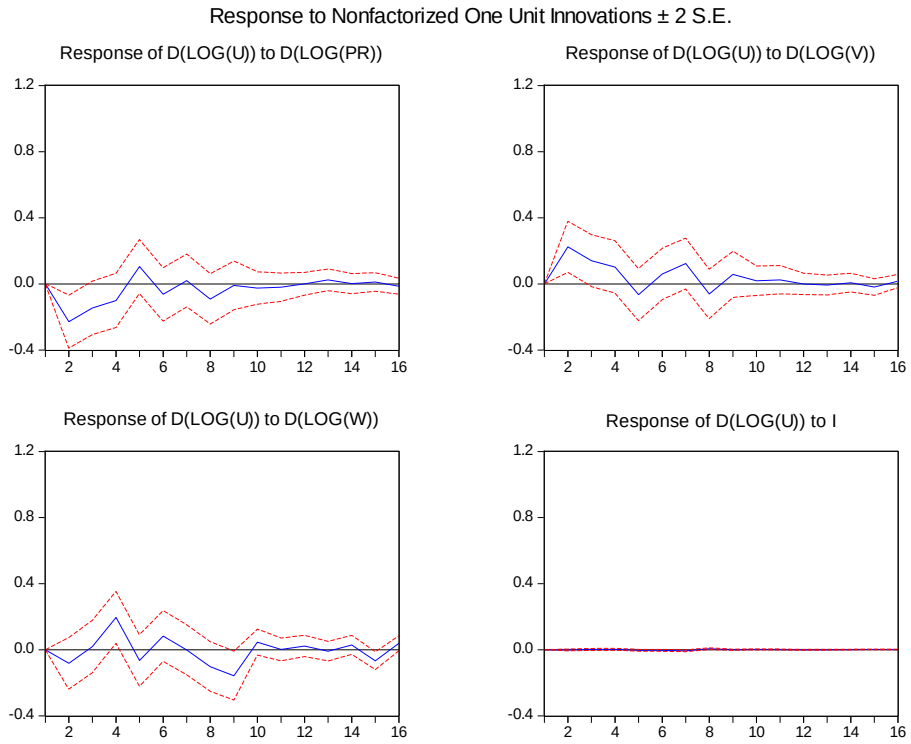
Response of productivity (PR) to a unit shock in value added (V), absolute cost of labour (U), relative cost of labour (W), and investment (I)



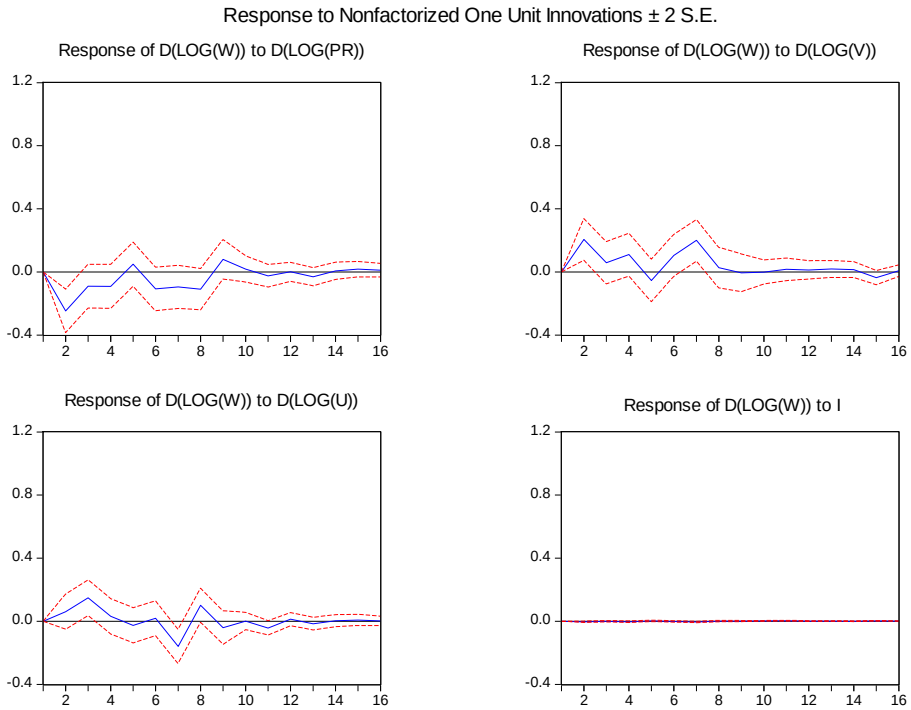
Response of value added (V) to a unit shock in productivity (PR), absolute cost of labour (U), relative cost of labour (W), and investment (I)



Response of absolute cost of labour (U) to a unit shock in productivity (PR), value added (V), relative cost of labour (W), and investment (I)



Response of relative cost of labour (W) to a unit shock in productivity (PR), value added (V), absolute cost of labour (U), and investment (I)



Response of investment (I) to a unit shock in productivity (PR), value added (V), absolute cost of labour (U), and relative cost of labour (W)