An Assessment of the Relationship between Real Wage and Labor Productivity

by Adalmir A. Marquetti*
Assistent Professor, Pontifícia Universidade Católica do Rio Grande do Sul, PUC-RS, Departamento de Economia, Av. Ipiranga 6681, Porto Alegre, RS, 90910-000, Brazil (aam@portoweb.com.br)

Abstract

Most of the Classical-Marxian literature in economic growth assume that causality runs from increase in labor productivity to increase in real wage. In this paper we raise the theoretical possibility that causality goes from real wage to labor productivity. We investigate the long run relationship between real wage and labor productivity through cointegration test in the US economy over the period 1869-1996 and in a panel data for 38 countries in the period 1965-1990. In both cases the series cointegrated indicating that there is a link tying real wage and labor productivity in the long run. Granger-causality tests between real wage and labor productivity were also performed for the US economy in the period 1869-1996. The vector error correction models indicated that there is unidirectional Granger causality from real wage to labor productivity. This result corroborates the conception that increase in real wage drives profit seeking capitalists to increase labor productivity as their main weapon to defend their profitability. Overall our results confirm the constancy of the wage share as a stylized fact of economic growth. However, it is a theoretical puzzle from both the Classical-Marxian and Neoclassical perspectives.

Resumo

A maior parte da literatura Clássico-Marxiana em crescimento econômico assume que aumentos na produtividade do trabalho levam a aumentos no salário real. Neste trabalho levantamos a possibilidade teórica de que a causalidade vai do salário real para a produtividade do trabalho. Investigamos a relação de longo prazo entre o salário real e a produtividade do trabalho utilizando testes de cointegração para os Estados Unidos no período 1869-1996 e para dados de painéis em 38 países no período 1965-1990. Em ambos casos as séries cointegraram indicando que existe uma estreita ligação entre salário real e produtividade do trabalho no longo prazo. Testes de causalidade no sentido de Granger entre o salário real e a produtividade do trabalho também foram realizados para os Estados Unidos no período 1869-1996. Os resultados indicaram que existe causalidade no sentido de Granger somente do salário real para a produtividade do trabalho. Este resultado está de acordo com a concepção de que aumentos nos salários reais induzem os capitalistas a aumentarem a produtividade do trabalho como sua principal arma na defesa de sua lucratividade. Nossos resultados confirmam que a participação constante dos salários no valor adicionado é um fato estilizado do crescimento econômico. Contudo, a participação constante dos salários no valor adicionado não é devidamente explicado tanto na perspectiva Clássico-Marxiana como na Neoclássica.

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The relationship between real wage and labor productivity has received sparse attention in the empirical literature on economic growth. In the theoretical literature the conception that mechanization with its labor displacing effect might hurt wage share was noted by Ricardo (1951). Marx (1977), following similar lines, argued which technical change in the form of mechanization is the main capitalist weapon to increase profits in the confront against labor. The result of this process would be a reduction in the wage share or, in other words, an increase in the rate of surplus value.

In empirical terms the link between real wage and labor productivity was recognized in the 1920's. In 1927 Paul Douglas observing this phenomenon asked for the mathematician Charles Cobb which type of mathematical function dealing with capital and labor inputs and output would provide constant factor share (Douglas, 1967). As is well know the mathematical function capable of showing this result is now the famous Cobb-Douglas production function. Anwar Shaikh (1974) criticized the Cobb-Douglas production function in the terms that the constancy of shares is assumed ex-ante as a result of the laws of algebra and not of the laws of production. Nicholas Kaldor (1961) called the constant labor share a stylized fact of economic growth.

Michl (1997) presented a model of economic growth in the Classical-Marxian tradition in which he obtained a production function that is isomorphic to the Cobb-Douglas. In Michl's (1997) model real wage, w, is linked to labor productivity, x, through the equation $w = a x^{\phi}$, where the real wage elasticity, ϕ, is nonnegative. The real wage elasticity governs the behavior of the wage share. If $\phi = 1$, labor share is constant with real wages and labor productivity expanding at same rates. If $\phi < 1$, labor share declines over time with real wage increasing at lower rates than labor productivity. If $\phi > 1$, labor share increases over time with real wage increasing at higher rates than labor productivity. If $\phi = 0$, labor share declines over time with a constant real wage. The observed constancy of labor share in economic growth implies that $\phi = 1$.

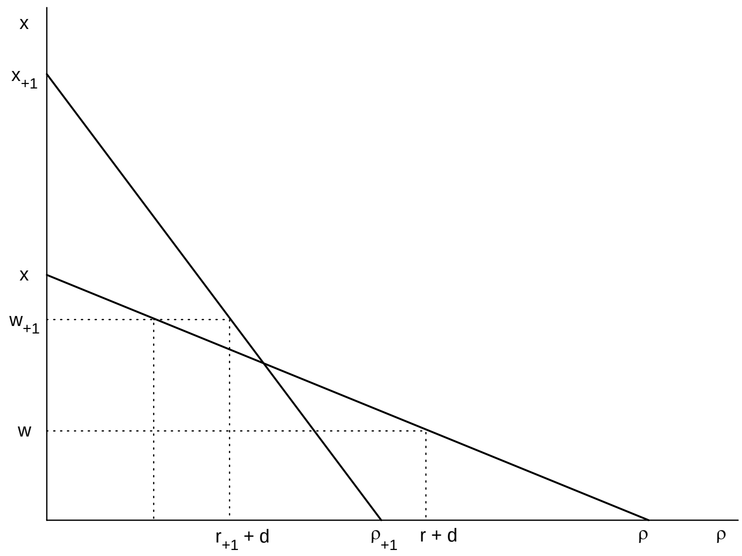
Causality in the model runs from increase in labor productivity to increase in real wage. However, as Michl (1997) called attention to there is nothing in the Classical-Marxian tradition that requires this causal ordering. In fact, increase in real wage might have an effect in the growth of labor productivity.

The question of causality between real wage and labor productivity can be better understood when one looks at the real wage-profit rate schedule movements in the case of labor-saving and capital-using technical change. This form of technical change corresponds to an increase in labor productivity and a decrease in capital productivity. The real wage-profit rate schedule, a line having in its vertical intercept labor productivity and for its horizontal intercept capital productivity, represents a technique of production and shows the distribution of income between real wage and gross profit. A technique of production is described by three parameters, labor productivity, x, the ratio between gross output and labor inputs, capital productivity, ρ, the ratio between gross output and capital stock, and depreciation rate, d, the ratio between depreciation and capital stock. The gross profit rate, r + d, divides the labor productivity into real wage per worker and gross profits per worker.

Figure 1 presents the real wage-profit rate schedule movements for a labor-saving and capital-using technical change and the associated real wage and gross profit rate. Labor-saving technical change might be seen as endogenously induced by the real wage. If the real wage is above the switchpoint, the point of intersection of the new and old real wage-profit rate schedule, profit seeking capitalists will have the incentive to move to a technique with higher labor productivity in order to expand their profitability. An increased real wage might induce profit seeking capitalist to invest in the adoption or in the discovery of new techniques. In fact, higher the real wage, higher is the recompense and the pressure over the capitalists to move into a new technique with greater labor productivity. Labor-saving technical change is the main capitalist weapon to defend profitability. However, in a large part of the Classical-Marxian literature it is assumed that causality runs from labor productivity to real wage (Duménil and Lévy, 1993, and Michl, 1997). The question of constant wage share that implies a long run relationship between real wage and labor productivity is not explained in this framework. It is a puzzle from both Classical-Marxian and Neoclassical perspectives.

In fact, most of the literature in economic growth assume which causality runs from labor productivity to real wage. This line of thought is in contrast with the conception expressed in Figure 1 in which real wage above the switchpoint induces labor-saving technical change. This conception is according to the efficiency wage literature. However, the efficiency wage theory concerns productivity gains from increased labor effort, which is a different point from technical change. Furthermore, the efficiency wage literature looks at a different period of time than the economic growth literature. The former should explain the short term, the general level of activity and its fluctuation, while the latter should explain the long term, the accumulation process and technical change.

Figure 1. The real wage-profit rate schedule for two techniques. Real wage above the switchpoint might induce labor-saving technical change.



The purpose of this essay is to investigate the empirical relationship between wages and labor productivity for the US economy over the period 1869-1996 and for a panel data for 38 countries in the period 1965-1990. If the constancy of the wage share corresponds to a stylized fact of economic growth, then real wage and labor productivity might be cointegrated in the sense of Robert Engle and Clive Granger (1987).

We test for cointegration between real wage and labor productivity looking at a time series for the US economy assembled by Duménil and Lévy (1993) for the period 1869-1989 and extended, following the same methodology, by us until 1996. The cointegration between real wage and labor productivity is also investigated in a panel data for 38 countries in the period 1965-1990. Kyung Im, Hashem Pesaran and Yongcheol Shin (1997) proposed a panel unit root test that allows to expand the analysis of cointegration for a sample of cross section units observed over a period of time. The advantage of panel unit root test is the higher power to reject the unit root hypothesis than the univariate test.

Causality between real wage and labor productivity is also studied for the US economy in the period 1869-1996. Granger (1988) pointed out that in the case of cointegration between a pair of series there exists a 'long-run' causality in at least one direction. Causality is tested in the sense of what variable, real wage or labor productivity, help to predict the other. In fact, we found unidirectional Granger causality from real wage to labor productivity. This result gives support to the conception that real wage above the switchpoint drives profit seeking capitalists to increase labor productivity as their main weapon to defend their profitability.

1. Cointegration, Granger non-causality and unit root test in heterogeneous panels

As it is well know Ordinary Least Squares (OLS) regressions are, in most cases, spurious for non-stationary series. However, it does not apply when the series follow stochastic trends and move together. In this case a long run relation is said to exist between the series and they are cointegrated in the sense of Engle and Granger (1987).

The cointegration tests in the paper follow the two-step procedure suggested by Engle and Granger (1987). The first step consist of testing if the variables have a stochastic trend through a unit root test. A cointegration relationship does not exist between series that are integrated of different order.

In a univariate time series the basic test for unit root is to estimate a Dickey-Fuller regression, the DF test, when the error terms are independent and identically distributed, iid, or an augmented Dickey-Fuller regression, ADF test, when the error term is not iid. The ADF regression in the presence of intercept and deterministic time trend is obtained by

$$\Delta y_t = a + bt + cy_{t-1} + \sum_{j=1}^{p} d_j y_{t-1} + e_t ,$$

where $\Delta y_t = y_t - y_{t-1}$, and y represents real wage and labor productivity. The number of lags must be sufficient to make the residuals serially non-correlated. The null hypothesis that the time-series is non-stationary, H_0: c = 0, i.e., integrated of order one, I(1), or greater, is tested against the alternative hypothesis that the series is stationary, H_A: c < 0, i.e., integrated of order zero, I(0). If c = 0, a ≠ 0, and b = 0, then y is a unit root with drift. In this case y has a linear time trend. If c = 0, a ≠ 0 and b ≠ 0, then y is a unit root with a quadratic trend. F test are employed to test the joint null hypothesis about a and b. Peter Phillips and Zhijie Xiao (1998) present a review of literature on univariate unit root tests.

The second step consist in testing if the stochastic trends in the variables are connected. It is investigated by estimating the following cointegration regression $w_t = a_0 + a_1 x_t + e_t,\ t = 1,...,T$ and, then, testing if the residual e presents a unit root. If the residual is stationary, then the series are cointegrated.

The question of Granger non-causality in cointegrated time series has been subjected to intense debate, mainly over the distribution of the Wald tests. Granger (1988) pointed out that in the case of cointegration between a pair of series there exist a 'long-run' causality in at least one direction. The two-step procedure by Engle and Granger (1987) provides all that is needed to test non-causality hypotheses in a bivariate error-correction model. However, more recently Toda and Phillips (1993) suggested that the increase in the dimension of the cointegration space might complicate the testing procedure with the parameters assuming nonstandard limit distribution.

For the bivariate case the Granger non-causality test is based on the following vector error correction model

$$w_t = a_1 + c_1 \hat{e}_{t-1} + \sum_{j=1}^{p} d_{1j} w_{t-1} + \sum_{j=1}^{p} f_{1j} x_{t-1} + v_{1t}$$, t = 1, …, T,

$$x_t = a_2 + c_2 \hat{e}_{t-1} + \sum_{j=1}^{p} d_{2j} w_{t-1} + \sum_{j=1}^{p} f_{2j} x_{t-1} + v_{2t},\ t = 1,...,T$$, where e is the residual of the cointegration regression. Real wage does not Granger cause labor productivity if $c_1 = 0$. Similarly, labor productivity does not Granger cause real wage if $c_2 = 0$.

Im, Pesaran, and Shin (1997) proposed a test for unit root in heterogeneous panel data in a sample of N cross section units observed over T periods of time based on the Dickey and Fuller tests. The t-bar statistic test is obtained by the average of the N individual ADF t-statistics $\bar{t}_{NT} = \frac{1}{N}\sum_{i=1}^{N} t_{iT}$, where t_{iT} is the ADF t-statistics in the individual ADF regression

$$y_{it} = a_i + b_i t + c_i y_{i,t-1} + \sum_{j=1}^{p_i} d_{ij} y_{i,t-j} + e_{it},\ i = 1,...,N;\ t = 1,...,T$$. The null hypothesis of unit roots is H_0: $c_i = 0$ for all i, against the alternative H_A: $c_i < 0$, i = 1, 2,…, N_1, $c_i = 0$,

$i = N_1 + 1, N_2 + 2, \ldots, N$. This formulation of H_A permits c_i to differ across groups and that a fraction $\delta = N_1 / N$ of the individual series are stationary. The Im, Pesaran, and Shin (1997) test allows for variation in the ADF lags and error structures in the cross section units that were not possible in the previous panel unit root tests.

Considering that the error terms are not correlated across groups Im, Pesaran, and Shin (1997) suggested the utilization of the following standardized t-bar statistic

$$\Psi_{\bar{t}} = \frac{\sqrt{N}\{\bar{t}_{NT}(p) - \frac{1}{N}\sum_{i=1}^{N} E[t_{iT}(p_i) \mid c_i = 0]\}}{\sqrt{\frac{1}{N}\sum_{i=1}^{N} Var[t_{iT}(p_i) \mid c_i = 0]}}$$

, where the mean, $E[t_{iT}(p_i) \mid c_i = 0]$, and variance, $Var[t_{iT}(p_i) \mid c_i = 0]$ were evaluated via Monte Carlo simulation and are reported for a number of sample size and lag structures, given by p, for ADF regressions with intercept and with intercept and time trend on Table 2 of their paper. The $\Psi_{\bar{t}}$ is supposed to weakly converge to a standard normal distribution.

Im, Pesaran, and Shin (1997) panel test is not valid in the case that the disturbances are dependent across groups. If the dependency across groups is due to a time-specific effect in all units, then it is possible to apply the test only after a demeaning procedure in the ADF regression.

The cointegration test follows a panel version of Engle and Granger (1987) procedure presented above. First, we test for the integration order of the series. Second, we test if the stochastic trends in the variables are connected. The following heterogeneous cointegration regressions with varying intercepts and slopes are estimated $w_{it} = a_i + c_i x_{i,t-1} + e_{it}$, i = 1, …, N; t = 1, …, T, and, then, we test if the residual e presents a panel unit root based on the ADF regression

$$\hat{e}_{it} = c_i \hat{e}_{i,t-1} + \sum_{j=1}^{p_i} d_{ij} \quad \hat{e}_{i,t-j} + u_{it}$$

, i = 1, …, N; t = 1, …, T, where e is the residual of the heterogeneous cointegration regressions. The standardized $\Psi_{\bar{t}}$ statistics is employed in the panel unit root test. If the residual is stationary, then the series are said to be cointegrated.

2. Empirical results in a time series setting

In this section we investigate the existence of a long-run relationship and the direction of the Granger non-causality between real wage and labor productivity for the US economy over the period 1869-1996. These variables were obtained in Duménil and Lévy (1993) for 1869-1989 and extended, following the same methodology, by us until 1996. Real wage is the total compensation per hour worked by employees deflated by the Gross National Product (GNP) deflator. Labor productivity is the ratio between the private Net National Product and total number of hours worked deflated by the GNP deflator.

The time-series plot of both series in levels and logarithms are presented, respectively, in Figures 2 and 3. The inspection of both plots suggests the presence of basically the same trend in these series. Figure 4 plots the (x, w) pair. The inspection of the plot suggest the existence of a stable and linear relationship between real wage and labor productivity. The Figures indicate a strong possibility of cointegration between the series.

Figure 2. The time-series plot of the real wage and labor productivity for the US economy, 1869-1996, considering 1869 = 100. Both series display a very similar trend. (Duménil and Lévy, 1993).

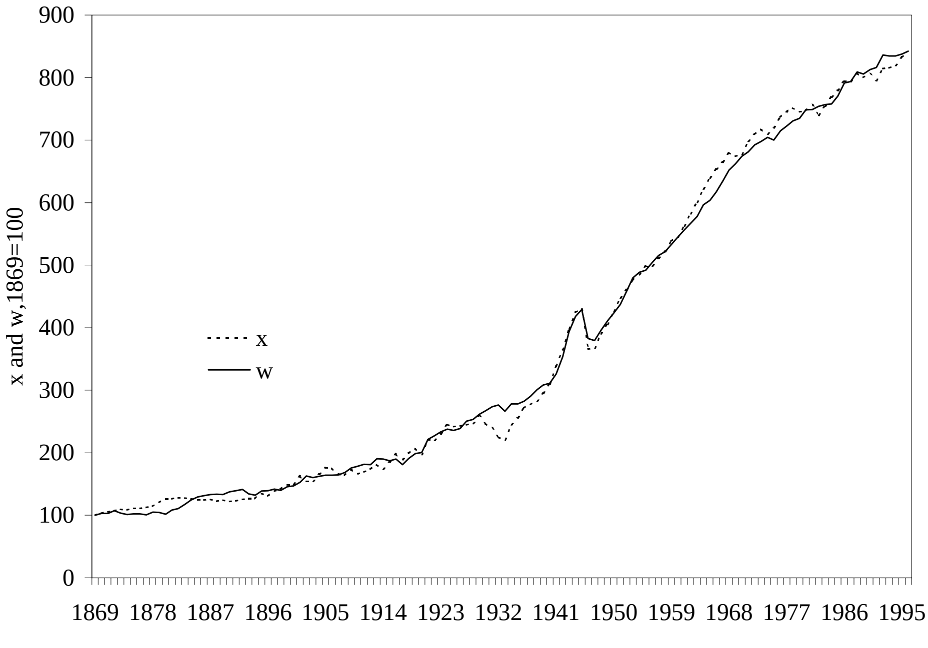


Figure 3. The time-series plot of the logarithms of real wage and labor productivity for US economy, 1869-1996. Both series display a very similar trend. (Duménil and Lévy, 1993).

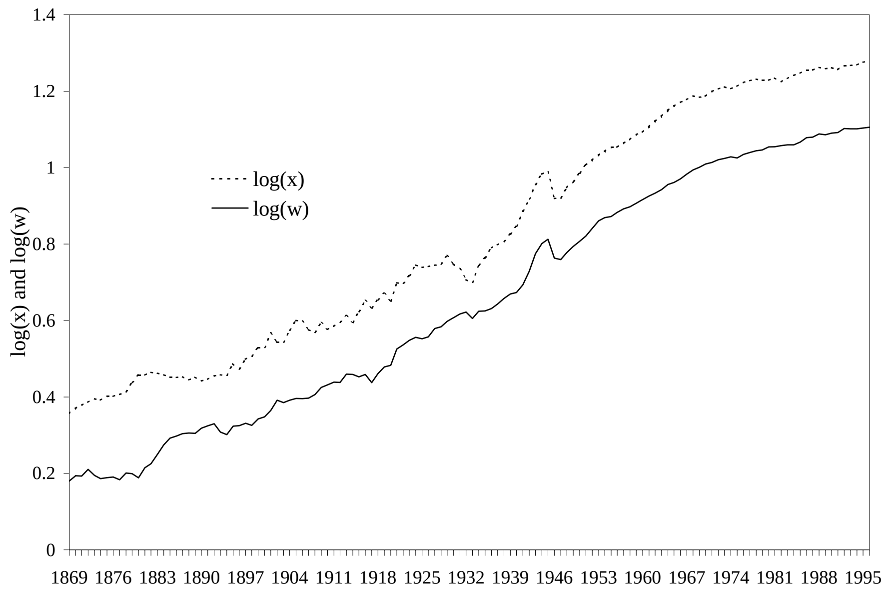


Figure 4. The plot of the pair labor productivity and real wage for the US economy, 1869-1996 displays a linear and stable relationship between the two variables. (Duménil and Lévy, 1993).

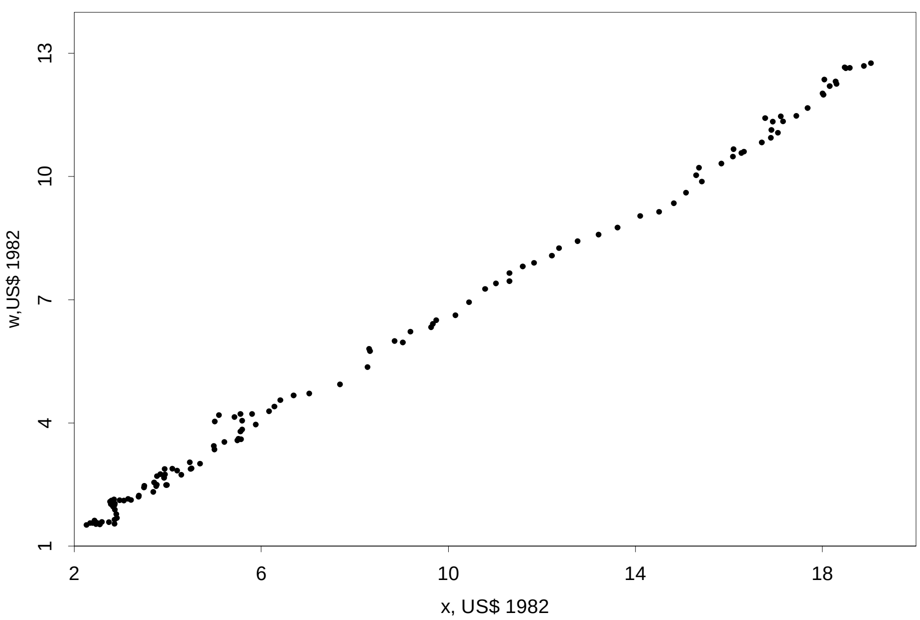


Table 1 presents the ADF test for both series in levels and logarithms. The number of lags to perform the tests was chosen based on Akaike Information Criterion (AIC). Because this method tends to give parsimonious models with 0 and 1 lags we also present the results with 2 lags. The null hypothesis of a unit root in real wage and labor productivity for levels and logarithms cannot be reject at 5 percent of statistical significance for the period 1869-1996 in the US economy. Hence, we can apply the cointegration tests. Further tests, not reported, showed that both labor productivity and real wage in levels have a deterministic trend without drift, while the logarithm of real wage has just a drift and the logarithm of labor productivity has a drift and a deterministic trend. Thus, real wage in level is described as a random walk process about a non-linear trend and in logarithm as a random walk about a linear trend. Labor productivity in both level and logarithm is described as a random walk about a non-linear trend.

Table 1. Unit root tests. (Duménil and Lévy, 1993).

		Drifted Model			Trended Model		
1869-1996	Ho	0 lag	1 lag	2 lags	0 lag	1 lag	2 lags
x	0 unit root	2.02	1.49	1.46	-1.75	-1.81	-1.83
	1 unit root	-8.84*	-6.79*	-5.81*	-9.22*	-7.21*	-6.14*
log(x)	0 unit root	-0.34	-0.29	-0.28	-1.81	-2.00	-2.03
	1 unit root	-7.15*	-7.65*	-6.17*	-9.35*	-7.62*	-6.14*
w	0 unit root	2.90	1.94	1.93	-1.94	-1.93	-1.91
	1 unit root	-7.97*	-6.44*	-6.20*	-8.57*	-7.09*	-7.16*
log(w)	0 unit root	-0.34	-0.25	-0.35	-1.78	-2.28	-2.19
	1 unit root	-10.58*	-7.15*	-6.28*	-7.62*	-7.12*	-6.25*

Note: * indicates statistical significance at 1% level.

Table 2 reports the results for the cointegration regressions using levels and logarithms. Each row presents the coefficients of the cointegration regression and the ADF tests in the residuals. The ADF tests show that the residuals from both equations are stationary. Thus, real wage and labor productivity are cointegrated in levels and logarithms for the US economy in the period 1869-1996. There is a long run empirical relationship between real wage and labor productivity in the US economy over the period 1869-1996.

The hypothesis of a long run constancy of the relationship between real wage and labor productivity in the US economy is also confirmed by the coefficient in the logarithm of labor productivity. It is an estimation of the real wage elasticity present in Michl's (1997) model. The null hypothesis that the estimated coefficient for real wage elasticity is equal to 1 for the US economy in the period 1869-1996 cannot be rejected at 1percent level of statistical significance, indicating that real wage and labor productivity tended to growth at very similar rates in the long run.

Table 2. Cointegration regressions between real wage and labor productivity. (Duménil and Lévy, 1993).

	a_0	a_1	R^2	ADF tests	No Intercept			Driffed Model		
				Ho	0 lag	1 lag	2 lags	0 lag	1 lag	2 lags
Level	0.067 (-0.033)	0.659 (-0.003)	99.7	0 unit root	-3.21*	-3.68*	-3.52*	-3.20**	-3.67*	-3.50*
Logarithm	-0.397 (-0.015)	0.997 (-0.008)	99.3	0 unit root	-3.08*	-3.66*	-3.66*	-3.07**	-3.65*	-3.65*

Notes: * indicates statistical significance at 1% level. ** indicates statistical significance at 5% level. Standard deviations for the coefficients are in parentheses.
The LM and Q tests indicates serial correlation in the residuals in both regressions.

The cointegration between real wage and labor productivity indicates the presence of Granger causality in at least one direction. The analysis of the Granger-causality is done by regressing a vector error correction model (VECM). The results of this analysis is presented in Table 3. As can be seen c_1 is not statistically significant in all lags specifications of the VECM in levels and logarithms while c_2 is statistically significant for all lags specifications of the VECM in levels and logarithms. Real wage Granger-cause labor productivity while labor productivity does not Granger-cause real wage in the US economy over the period 1869-1996. This result supports the conception that real wage pressure drives profit seeking capitalists to increase labor productivity as their main weapon to defend their profitability.

A further evidence on the long run stability of the relationship between real wage and labor productivity in the US economy over the period 1869-1996 would be if the wage share were stationary. Thus, we test for the presence of a unit root test on wage share. It is computed as the ratio between real wage and labor productivity. Figure 5 presents the wage share in the US economy in the period of study. The plot exhibits a constant mean series indicating that wage share might be stationary. It is also possible to observe the higher variance in the series in the period prior to the 1940's. It can be explained by the Keynesian policies to control the business cycle after Great Depression in the 1930's.

Table 3. Granger-causality tests between real wage and labor productivity. (Duménil and Lévy, 1993).

	lags	c_1	c_2	Standard

					Deviation
w	x	8	0.0260		0.0733
		6	-0.0199		0.0695
		4	-0.0277		0.0644
		2	-0.0533		0.0597
x	w	8		-0.4954*	0.1506
		6		-0.4874*	0.1381
		4		-0.4263*	0.1276
		2		-0.3846*	0.1168
log(w)	log(x)	8	0.0659		0.0578
		6	0.0139		0.0538
		4	0.0039		0.0476
		2	-0.0241		0.0449
log(x)	log(w)	8		-0.2134**	0.0825
		6		-0.1918*	0.0726
		4		-0.1796*	0.0642
		2		-0.1775*	0.0585

Notes: * indicates statistical significance at 1% level.** indicates statistical significance at 5% level.

Figure 5. Wage share in the US economy, 1869-1996. Wage share exhibits a constant mean in the US economy over the period 1869-1995. (Duménil and Lévy, 1993).

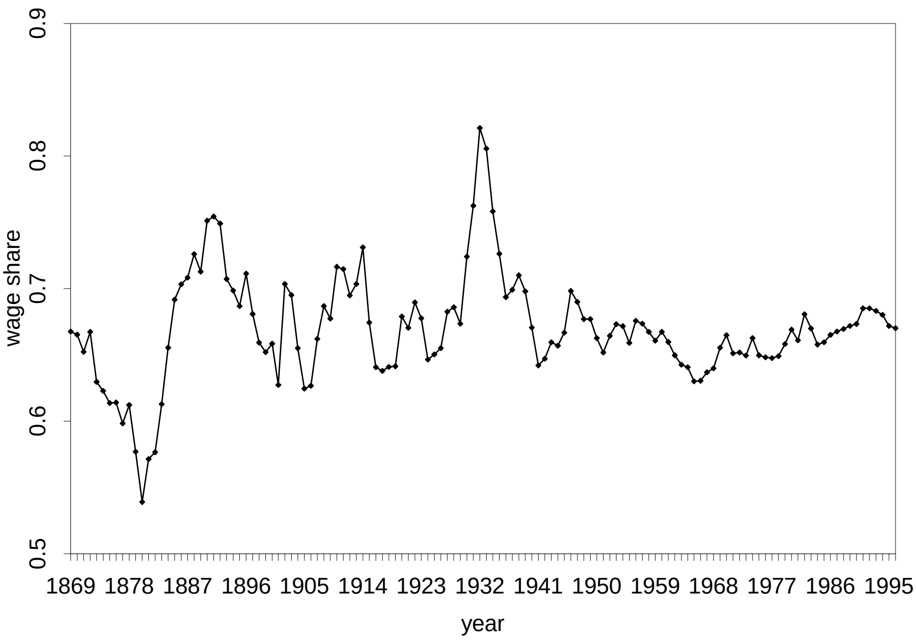


Table 4 presents the unit root tests for wage share. AIC indicates 1 lag in the unit root tests, but we also present the results for two lags. The null hypothesis of a unit root in wage share is rejected at 5 percent of significance for the period 1869-1996 in the USA. Further test, not reported, confirmed that wage share is a stationary variable with an intercept. Thus, again the long run relationship between real wage and labor productivity is confirmed for the US economy over the period 1869-1996.

Table 4. Unit Root tests for wage share. (Duménil and Lévy, 1993).

	Driffed Model		Trended Model	
Ho	1 lag	2 lags	1 lag	2 lags
0 unit root	-3.72*	-3.69*	-3.70**	-3.68**

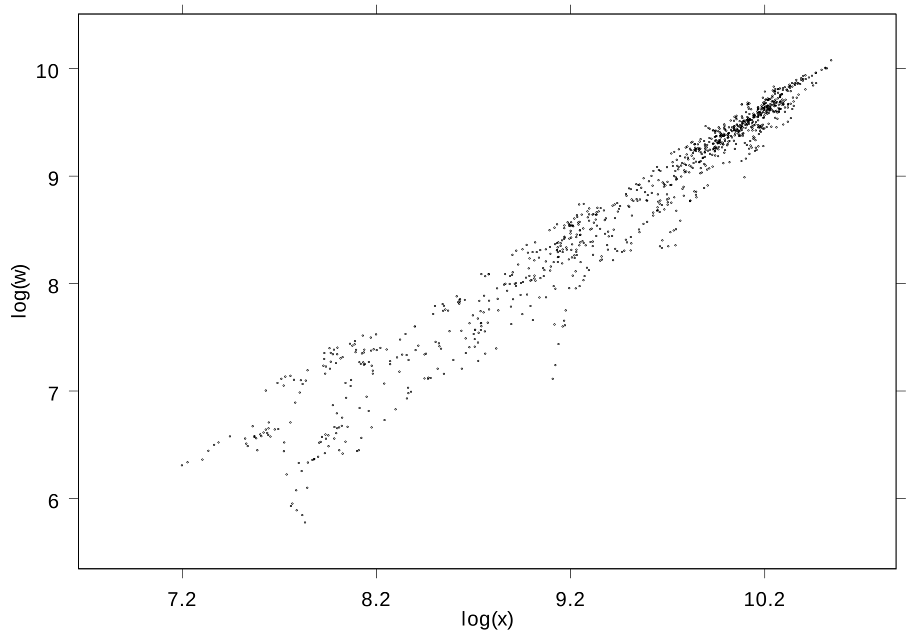
Notes:* indicates statistical significance at 1% level.
** indicates statistical significance at 5% level.

3. Empirical results in the panel data setting

In this section we analyze the cointegration between real wage and labor productivity in a panel data setting for 38 countries in the period 1965-1990. Labor productivity, measured as the ratio between Gross Domestic Product (GDP) and number of workers, was obtained from Summers and Heston (1991). It is expressed in purchasing power parity of the Penn World Tables v. 5.6 (PWT). The data on real wage is not obtained directly from the PWT v. 5.6. Real wage is the total compensation per worker in the GDP expressed in purchasing power parity from the PWT v. 5.6. This data set complemented with estimates of the wage share allow us to compute the real wage per worker. The wage share is the share of the employee compensation in the GDP. It was computed in current prices of the local currency and obtained from the *Yearbook of National Accounts Statistics* and the *National Accounts Statistics*.

Figure 6 displays the plot of the logarithms of the (x, w) pair. As can be observed, despite the heteroscedasticity in the data, there is a linear and stable pattern in the relationship between the logarithms of labor productivity and real wage. It is an indication that these series might be cointegrated.

Figure 6. The plot of the logarithms of the labor productivity and real wage for 38 countries in the period 1965-1990. There is a linear and stable pattern in the relationship between the logarithms of labor productivity and real wage. (Penn World Table data and our compilation of the wage share).



The panel unit root test involves the estimation of country-by-country t-statistics and, then, the computation of the standardized t statistics according to the procedure exposed above. Table 5 displays the country-by-country and panel unit root tests in heterogeneous panel based on the ADF regressions. The analysis is done in logarithms.

Taking into account the individual tests, Mauritius and Japan are trend stationary in real wage and labor productivity, Costa Rica, Netherlands, Portugal, and Spain are I (2) in both real wage and labor productivity. In four countries, Ecuador, France, Norway, and Switzerland, the hypothesis of a unit root cannot in labor productivity cannot be rejected at 10 percent level of statistical significance. For Colombia, Austria, Norway and UK the hypothesis of a unit root in real wage cannot be rejected at 10 percent level of statistical significance. Thailand, Belgium and Sweden are I(1) in labor productivity and I(2) in real wages. Ireland is I(2) in labor productivity and I (1) in real wage at 10 percent level of statistical significance. In all other countries the hypothesis of a unit root cannot be rejected at 5 percent level of statistical significance. The panel unit root test indicates that the logarithms of both real wage and labor productivity are I(1) at 5 percent level of statistical significance. Thus, we proceed with the cointegration tests in the panel setting.

The results for the cointegration tests are reported on Table 6. In the individual tests the cointegration hypothesis between real wage and labor productivity is rejected in twelve countries, Mexico, Ecuador, Paraguay, Thailand, Austria, France, Italy, Netherlands, Spain, Sweden, Australia, and New Zealand, is accepted at 10 percent level of statistical significance in four countries, West Germany, Greece, Ireland and Switzerland. For all other countries and for the panel data the hypothesis of cointegration between real wage and labor productivity cannot be rejected at 5 percent level of statistical significance.

Therefore, our tests indicate that there is a stable relationship between the logarithms of real wage and labor productivity in a panel data for 38 countries in the period 1965-1990. Given the higher power of panel unit root tests this is a further and important indication of the strong links between real wage and labor productivity.

Table 6 also presents the estimated coefficient of the real wage elasticity for the individual countries and for the panel data. Of the 38 countries in our sample, 6 had the coefficient on wage elasticity significantly lower than 1 at 5 percent level of statistical significance, 16 had the coefficient significantly equal to 1 at 5 percent, and 16 had the coefficient significantly higher than 1 at 5 percent. The coefficient of the real wage elasticity for the panel data is equal to 1.102 and is obtained as an average of the coefficients of each group (Pesaran and Smith, 1995). However, the standard deviation obtained in this way are not valid ones. Hence, it is not possible to test in the present estimation if the coefficient of real wage elasticity for the panel is statistically different from 1.

Table 5. Country-by-country ADF t-statistics, lag order and standardized panel data unit root with intercept and time trend for 38 countries, 1965-1990. (Penn World Table data and our compilation of the wage share).

Countries	log(x)				log(w)			
	0 unit root	lags	1unit root	lags	0 unit root	lags	1unit root	lags

Mauritius	-5.471*	3			-4.667*	3		
Japan	-3.801*	1			-4.139*	2		
Kenia	-1.803	0	-5.174*	1	-3.025	0	-5.829*	1
Sierra Leone	-2.733	0	-4.685*	2	-1.418	1	-5.882*	0
South Africa	-1.048	0	-4.645*	0	-1.885	1	-4.688*	0
Zambia	-2.159	1	-4.238*	1	-2.138	0	-4.599*	1
Canada	-2.099	0	-4.508*	0	-2.099	0	-3.786*	0
Mexico	-1.549	2	-4.017*	1	-1.44	0	-4.198*	0
USA	-2.004	0	-3.870*	1	-2.647	1	-4.096*	1
Paraguay	-1.107	0	-4.073*	0	-0.444	0	-4.372*	0
Uruguai	-2.554	2	-4.090*	1	-2.553	1	-4.775*	2
Venezuela	-1.901	0	-4.578*	0	-1.696	0	-4.882*	0
Israel	-2.738	1	-4.525*	1	-2.279	2	-4.091*	0
Korean Rep.	-1.727	0	-4.081*	0	-2.218	0	-4.013*	0
Sri Lanka	-1.736	0	-4.533*	0	-2.49	0	-4.181*	0
Denmark	-2.687	0	-4.228*	0	-3.193	0	-5.034*	0
Finland	-2.899	1	-3.910*	1	-2.195	1	-3.686*	0
West Germany	-2.039	1	-3.682*	1	-2.824	2	-3.757*	1
Greece	-1.636	0	-4.019*	0	-1.206	2	-4.990*	1
Italy	-2.548	1	-4.608*	0	-2.07	2	-4.076*	0
Luxembourg	-2.401	1	-3.987*	1	-1.501	0	-4.076*	0
Australia	-2.809	1	-4.782*	0	-2.988	1	-5.243*	1
New Zealand	-2.747	2	-4.264*	0	-0.561	2	-4.924*	1
Colombia	-2.762	2	-4.104*	0	-1.298	1	-3.272**	1
Austria	-3.021	2	-3.727*	0	-1.894	0	-3.254**	0
UK	-2.506	1	-3.808*	1	-2.112	1	-3.587**	0
Ecuador	-0.254	0	-3.296**	0	0.435	0	-3.940*	0
France	-2.585	0	-3.529**	0	-1.207	0	-3.778*	0
Switzerland	-2.875	1	-3.348**	0	-3.021	1	-3.630*	1
Norway	-2.89	1	-3.484**	0	-2.873	1	-3.245**	0
Thailand	-1.973	1	-4.143*	0	-2.678	1	-2.72	1
Belgium	-1.923	0	-4.248*	0	-2.581	2	-3.154	0
Sweden	-2.918	1	-4.136*	1	-3.01	2	-2.54	0
Ireland	-1.546	0	-2.501	0	-2.379	1	-3.441**	1
Costa Rica	-2.222	1	-2.723	1	-2.216	2	-1.917	0
Netherlands	-3.109	0	-2.669	0	-2.751	1	-2.268	0
Portugal	-2.18	1	-1.635	1	-2.195	1	-2.246	0
Spain	-2.046	1	-2.308	1	-1.695	1	-2.844	0
Panel	-1.335		-12.069*		-0.708		-12.296*	

Notes: * indicates statistical significance at 5% level. ** indicates statistical significance at 10% level.

Table 6. Country-by-country cointegration equations, ADF statistics, lag order and standardized panel data unit root test for 38 countries, 1965-1990. (Penn World Table data and our compilation of the wage share).

Countries	a_i	standard deviation	c_i	standard deviation	ADF tests no intercept 0 unit root	lags
Kenia	0.799*	0.242	0.625*a	0.074	-2.936*	0
Mauritius	0.708*	0.307	0.725*a	0.08	-2.028*	0
Sierra Leone	-6.566*	1.051	2.718*c	0.306	-2.127*	1
South Africa	0.115	0.24	0.901*b	0.06	-3.936*	1
Zambia	-0.959	0.837	1.168*b	0.242	-2.945*	1
Canada	-0.529*	0.166	1.061*b	0.037	-2.648*	0
Costa Rica	-0.767	0.459	1.109*b	0.115	-3.058*	1
USA	-0.469*	0.153	1.055*b	0.034	-3.702*	0
Colombia	-1.121*	0.251	1.182*c	0.064	-2.385*	2

Uruguai	3.235*	0.739	0.097*a	0.183	-2.170*	0
Venezuela	-2.206*	0.465	1.414*c	0.107	-2.532*	0
Israel	-0.572*	0.247	1.059*b	0.058	-2.094*	0
Japan	-1.569*	0.153	1.306*c	0.037	-2.208*	1
Korean Rep.	-1.533*	0.064	1.283*c	0.017	-2.827*	2
Sri Lanka	-0.970*	0.201	1.167*c	0.055	-2.794*	0
Denmark	-0.759*	0.241	1.114*b	0.056	-2.911*	1
Finland	-0.725*	0.132	1.106*c	0.031	-3.289*	1
Luxembourg	-1.985*	0.504	1.392*c	0.114	-1.955*	0
Norway	0.049*	0.3	0.927*b	0.069	-2.792*	1
Portugal	-1.145*	0.345	1.204*c	0.086	-2.004*	1
UK	0.594*	0.204	0.809*a	0.047	-2.432*	1
West Germany	-1.007*	0.126	1.170*c	0.029	-1.662**	0
Greece	-2.196*	0.221	1.423*c	0.054	-1.764**	1
Ireland	-0.544*	0.201	1.064*b	0.048	-1.751**	1
Switzerland	-2.477*	0.365	1.506*c	0.082	-1.811**	1
Mexico	-0.54	0.919	1.014*b	0.219	0.269	0
Ecuador	0.304	0.694	0.771*b	0.178	0.874	0
Paraguay	0.446	0.308	0.753*a	0.082	0.237	0
Thailand	-1.418*	0.188	1.217*c	0.052	-1.458	0
Austria	-1.314*	0.154	1.238*c	0.036	-1.479	0
Belgium	-1.727*	0.318	1.333*c	0.072	-1.398	1
France	-1.665*	0.226	1.315*c	0.051	-1.393	1
Italy	-0.159*	0.336	0.965*b	0.077	-1.236	0
Netherlands	-0.425*	0.369	1.038*b	0.083	-0.864	0
Spain	-0.704*	0.232	1.090*b	0.054	-0.991	1
Sweden	-0.471	0.393	1.059*b	0.09	-1.597	0
Australia	0.47	0.338	0.831*a	0.076	-1.479	0
New Zealand	1.109	1.047	0.682*b	0.238	-1.115	0
Panel	-0.755		1.102		-2.657*	

Notes: * indicates statistical significance at 5% level. ** indicates statistical significance at 10% level. a, b, and c indicates, respectively, that the estimated coefficient of real wage elasticity is lower than , equal to, and higher than 1 at 5% level of statistical significance.

4. Conclusion

In this paper we investigate the long run relationship between real wage and labor productivity through cointegration test for the US economy over the period 1869-1996 and for a panel data for 38 countries in the period 1965-1990. In both cases the series cointegrated indicating that there is a link tying real wage and labor productivity in the long run. The series tend to increase at similar rates. The stationarity of the wage share in the US economy over the period of study gives further support at this result.

Granger-causality tests between real wage and labor productivity were also performed for the US economy in the period 1869-1996. The vector error correction models indicated that real wage Granger-cause labor productivity and that labor productivity does not Granger-cause real wage. The unidirectional Granger causality indicates that real wage predicts labor productivity. This result corroborates the conception that real wage above the switchpoint drives profit seeking capitalists to increase labor productivity as their main weapon to defend their profitability.

Overall our results confirm the constancy of the wage share as a stylized fact of economic growth. However, it is a theoretical puzzle from both the Classical-Marxian and Neoclassical perspectives. Why real wage and labor productivity tend to increase at similar rates is an open question. Actually, we can conclude saying that the constancy of the wage share is a stylized fact of economic growth and a theoretical puzzle.

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