Working Papers in Economics

The Neoclassical Determinants of Real Wage

Mehmet Ivrendi[*]
* Department of Economics, Pamukkale University, 20070, Denizli, Turkey

Bulent Guloglu[**]
** Department of Econometrics, Pamukkale University, 20070, Denizli, Turkey

Hakan Yetkiner[***]
** Department of Economics, Izmir University of Economics, 35330, Izmir, Turkey

Working Paper # 13/04

April 2013

Izmir University of Economics

Department of Economics

Sakarya Cad. No:156

35330 Balçova Izmir

Turkey

[*] Email: mehmet.ivrendi@pau.edu.tr
[**] Email bguloglu@pau.edu.tr
[***]Email: hakan.yetkiner@ieu.edu.tr.

Working Paper # 13/04

The Neoclassical Determinants of Real Wage

Abstract
This paper presents empirical evidence that the neoclassical explanation of real wage has a high explanatory power at macro level. The factor endowments explanation of wage is surprisingly rare in the literature, at least at empirical level. In this paper, using panel data from 26 OECD countries, we show that technology and factor endowments (physical capital and labor stocks) have a significant explanatory power on the determination of real wage. Based on our results, we speculate that the supply-side rather than demand-side variables may be the major source of wage differences across countries.

Keywords: wage, factor endowment, inter-country wage differences, panel data
JEL classification: J31, C23, E23, E24

1 Introduction

Although large wage differences across countries are an empirical fact, the sources of those wage differences are the subject of debate. One possible source is at micro level: varying firm, employee and employer characteristics can be the source of wage differences. However, the empirical evidence suggests that they have only limited explanatory power on wage differences. For example, Caju et al. (2010) show that wage differences across countries and industries are neither explained by worker, job and firm characteristics, nor by a number of institutional variables (such as product market regulations, barriers to competition and to entrepreneurship, trade union density), and by rents and industry structure.[1] Similarly, in an analysis of the three underlying forces for wage differentials, namely differences in skills, in prices of skills and in the returns-to-skill functions, Behr and Pötter (2010) find that the effect of differences in individual characteristics explains surprisingly little of the observed wage differences. Clemens et al. (2009) also show enormous wage differences across countries, even for workers in the same sector with the same or similar jobs, even when employee, employer and job characteristics are taken into consideration. In addition to this, neither the communication and transportation revolutions, nor globalization helped to close wage gaps between rich and poor countries for workers with equal productivity, even though they brought prices of basic commodities to near purchasing power parity among countries.[2] All in all, while the micro literature on wage differences can explain the sources of inter/ intra industry wage differentials to a limited extent, it is unable to offer a satisfactory answer regarding wage difference across countries.

In this paper, therefore, we return to the Neoclassical (endowment) view to develop a macro explanation for wage determination across countries. We argue that factor endowments of economies have a significant explanatory

[1] Some early studies on international wage differentials are Gittleman and Wolff (1993), Alback et al. (1993), Wagner (1990), and Erdil and Yetkiner (2001).
[2] See O'Rourke and Williamson (2000) for convergence in product prices and widen wage gap between rich and poor countries.

power on their average real wage, as suggested by the neoclassical theory. The macro explanation for the wage determination is surprisingly unusual in the empirical literature. This would be more understandable if the focus were the determination of wage across industries within a country, because the free movement of labor, at least theoretically, implies identical real wages across industries.[3] However, when the focus is at the international level, given the lack of mobility of labor across borders, neoclassical theory is perfectly suited to defining the determinants of real wage. In this respect, this paper adds value to the literature. In addition, the use of frontier econometric methods to test the theory may be considered as a contribution.

The organization of the paper is as follows. Section 2 discusses data, methodology, and the econometric equation, and presents the findings. We show that representatives of factor endowments, namely, technology, physical capital stock and labor stock are statistically significant determinants of real wages for 26 OECD countries, as suggested by theory. Section 3 concludes the paper.

2. Data, Specification Tests and Estimation Results

This paper aims to investigate empirically the impact of productivity and factor endowments on determination of the wage rate at the macro level. The theoretical base for this approach is well-established. Suppose that aggregate production function is $Y = K^{\gamma}\left(A^{\alpha} \cdot N\right)^{1-\gamma}$, where Y is real GDP, K is real capital stock, γ is production elasticity of capital, A is productivity (technology) level, α is the identifier of productivity, and N is labor stock. Alternatively, one may easily interpret A as skill index (human capital), á la Lucas (1988). Neoclassical theory suggests that real wage would be

[3] Though this is what neoclassical theory suggests, empirical regularity is different. See, for example, Dickens and Katz (1987), Krueger and Summers (1987, 1988) and Groshen (1991).

$w = (1-\gamma)A^{\alpha(1-\gamma)}K^{\gamma}N^{-\gamma}$. For panel data analysis, real wage estimation equation can be defined as follows:

$$\ln w_{it} = cons + \alpha(1-\gamma)\ln A_{it} + \gamma \ln K_{it} - \gamma \ln N_{it} + \mu_i + \lambda_t + u_{it} \quad (1)$$

where $\ln(1-\gamma) = cons + \mu_i + \lambda_t + u_{it}$. The term μ_i and λ_t represent individual (country) and time effects, respectively and the term u_{it} is the error term. In the empirical use of equation (1), we will approximate K by net capital stock, N by labor stock and unemployment rate (of workers with secondary education), and A by productivity growth and the share of labor force with tertiary education.

2.1 Data

Wage data is from OECD, whose average wage estimates, derived from OECD National Accounts, include all sectors of the economy and all types of dependent employment. Therefore, these averages are expected to give consistent time-series and cross-country comparisons. Average annual wage for each country is expressed in 2011 USD exchange rates and 2011 constant prices. Net capital stock is from Eurostat (the Statistical Office of the European Commission) in EUR. Labor force, unemployment with secondary education, and employment with tertiary education are obtained from the World Bank database.[4] Labor productivity growth data is from OECD Database. Wage, labor force and net capital stock are all in logarithmic form. Based on the availability of data, 26 countries were chosen for this study: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Japan, Luxembourg, Netherland, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, the United Kingdom and the United States.

2.2 Specification Testing

[4] We are forced to use unemployment with secondary education statistics in order to include more countries in our analysis. Since education levels of workers in OECD countries are high, this inclusion is acceptable.

Notice that individual (country) and time effects in equation (1) can be treated as either fixed or random. If our aim is to make inferences solely about the set of cross-section units, then the use of fixed effect models may be appropriate. If, on the other hand, the aim is to make inferences about the population from which the cross-section data units are taken, the use of a random effects model is more convenient. Baltagi (2005) stated that the fixed effects specification is appropriate when our focus is on a specific set of N countries, such as OECD member countries. In this study, we deal with a specific number of countries (26) and an 11-year time period. Although our interpretation of equation (1) is based on Feasible Generalized Least Square (FGLS) estimator, we also estimate the equation by Fixed Effect (FE), Random Effect(RE) and Maximum Likelihood(ML) estimators. Before proceeding to estimation, we test existence of specific fixed effects using Fisher's F-tests. It is well known that the omission of individual and/or time effects in panel data models may lead to biased estimates. Therefore, the significance of such effects should be tested before the main empirical results are reported. Below we discuss and test five hypotheses using F-tests. The first hypothesis is that there is neither significant country (μ_i) nor significant time (λ_t) effects on wage in equation (1). This hypothesis can be formed as

$H_0 : \mu_1 = \mu_2 = \mu_3 = \ldots\ldots.. \quad \mu_{N-1} = 0$ and $\lambda_1 = \lambda_2 = .\lambda_{T-1} = 0$.

The second hypothesis is that there is no significant country effect (μ_i) on wages,

$H_0 : \mu_1 = \mu_2 = \mu_3 = \ldots\ldots.. \quad \mu_{N-1} = 0$ (time effects are free ($\lambda_t \neq 0$)).

The third hypothesis is that there is no significant time effect (λ_t) on wages,

$H_0: \lambda_1 = \lambda_2 = .. \lambda_{T-1} = 0$ (individual effects are free ($\alpha_i \neq 0$)).

The second and the third hypotheses can be modified in such a way as to provide two additional hypotheses. Accordingly, the fourth hypothesis is that there is no significant country (μ_i) effect. This hypothesis can be formed as

$$H_0: \mu_1 = \mu_2 = \mu_3 = \ldots\ldots \mu_{N-1} = 0 \quad \text{(time effects } \lambda_t \text{ do not exist in (1)).}$$

and the fifth hypothesis is that there are no time effects,

$$H_0: \lambda_1 = \lambda_2 = .. \lambda_{T-1} = 0 \text{ (country effects } \mu_i \text{do not exist in (1)).}$$

Note that when we test the fourth and the fifth hypotheses, we assume that time effects and individual effects do not exist in our model.

The appropriate tests for the five aforementioned hypotheses are, respectively,

$$F_1 = \frac{(RSS_r - RSS_{ur})/(N+T\text{-}2)}{RSS_{ur}/(N.T\text{-}N\text{-}T\text{-}K+2)} \sim F_{N+T-2,}\, N.T\text{-}N\text{-}T\text{-}K+2$$

$$F_2 = \frac{(RSS_r - RSS_{ur})/(N\text{-}1)}{RSS_{ur}/(N.T\text{-}N\text{-}T\text{-}K+2)} \sim F_{N-1,}\, N.T\text{-}N\text{-}T\text{-}K+2$$

$$F_3 = \frac{(RSS_r - RSS_{ur})/(T\text{-}1)}{RSS_{ur}/(N.T\text{-}N\text{-}T\text{-}K+2)} \sim F_{T-1,}\, N.T\text{-}N\text{-}T\text{-}K+2$$

$$F_4 = \frac{(RSS_r - RSS_{ur})/(N\text{-}1)}{RSS_{ur}/(N.T\text{-}N\text{-}K+1)} \sim F_{N-1,}\, N.T\text{-}N\text{-}K+1$$

$$F_5 = \frac{(RSS_r - RSS_{ur})/(T\text{-}1)}{RSS_{ur}/(N.T\text{-}T\text{-}K+1)} \sim F_{T-1,}\, N.T\text{-}T\text{-}K+1$$

where RSS_{ur} and RSS_r represent the residual sum of squares for unrestricted and restricted models, respectively. In the first three tests (statistics), the RSS_{ur} represents the residuals from the model in which both the time and country effects are present. In the fourth and the fifth tests, the RSS_{ur} stands for the residuals obtained from the models in which there are only country and only time effects, respectively. The RSS_r denotes the residuals of the model without time and individual effects (pooled model) in the first, fourth and fifth tests. In the second and third tests, the RSS_r refers to the residuals of the models with only time effects, and with only individual effects, respectively.

2.3 Testing for Heteroscedasticity and Serial Correlation

To test the null hypothesis of no heteroscedasticity, we use the LM test developed by Greene (2008). The hypothesis and the LM test statistic can be expressed as

$$H_0 : \sigma^2_{u1} = \ldots = \sigma^2_{uN}$$

$$LM_{het} = \frac{T}{2}\sum_{i=1}^{N}\left[1 - \frac{\hat{\sigma}^2_{u_i}}{\hat{\sigma}^2_u}\right]^2 \sim X^2_{N\text{-}1}.$$

To test the null hypothesis of no auto-correlation we use Wooldridge (2010) test. This consists of two steps: In the first, the first difference of the equation is taken,[5] thus eliminating country effects. In the second, the first differenced residuals obtained from the preceding step are regressed on their first lag. Then the significance of coefficient obtained from this regression is tested using standard t statistic as follows

$$\Delta u_{it} = \phi \Delta u_{i,t-1} + e_{it}$$

$$H_0: \phi = -0.5$$

The rationale behind the test is that correlation between Δu_{it} and Δu_{it-1} is -0.5. The empirical results of the above-mentioned tests are shown in Table 3. These reveal that we reject the first four hypotheses, but fail to reject the fifth. Accordingly, we estimate one-way model without time effects. The estimated results of the model reveal that the residuals of the model suffer from the heteroscedasticity and autocorrelation, as shown in table 1.

[5]After excluding time effects.

Table 1. The Fisher F, Heteroscedasticity and Autoregression tests

F_1	F_2	F_3	F_4	F_5	X_{het}	W_{sc}
355.35***	909.20***	3.77***	826.02***	0.303	291.25***	101.60***

*** statistics are significant at 1 % level of signification

2.4 Estimation results

The results obtained by fixed effects, random effects, Maximum Likelihood (ML), and Feasible Generalized Least Squares (FGLS) estimators are illustrated in table 2. The effect of capital stock (K) on the log of wage rate is positive and significant at one percent level of significance in all estimates, which is consistent with the neoclassical theory of determination of real wage. As our model predicted, the effect of log of labor force on the log of real wage rate is negative in the RE, ML and FGLS estimates and statistically significant.[6] The parameter of labor productivity growth is negative in FE, RE, and ML and positive in FGLS and statistically insignificant in all runs. Theory suggests a positive relationship between labor productivity and the wage rate. We nonetheless fail to show a statistically significant positive relationship. This contradiction has been considered previously, and it is argued that real wage and labor productivity do not always line up in the data. Mankiw (2006) discusses some possible reasons for this. The effect of the rate of unemployment with secondary education on the log of wages is negative and statistically significant at one percent level in all estimates, consistent with mainstream theories that emphasize the negative relationships between the wage rate and unemployment. Our estimates show that the share of tertiary labor in the labor force, which is an indicator of skill (human capital), has a significant positive effect on the log of real wage rate at one or five percent level of significance in all runs. Finally, as theoretically expected, the constant term is positive and statistically significant in all estimators at one percent significance level.

[6] We employ FGLS to get rid of the heteroscedasticity and autocorrelation that we detected in FE, RE, and ML estimators. The FGLS estimator corrects the standard errors of estimated parameters and increases the reliability of the interpretations based on the estimated coefficients and their t-statistics.

Table 2. FE, RE, MLE and FGLS Estimation Results

Dependent variable : Log of annual average real wage				
VARIABLES	**FE**	**RE**	**ML**	**FGLS**
Log of net capital	0.306***	0.452***	0.39200***	0.7378***
Log of labor force	0.011	-0.438***	-0.3500***	-0.74916**
Labor force productivity growth	-0.00257	-0.00252	-0.00278	0.0006534
Unemployment	-0.00491***	-0.00464***	-0.00474***	-0.001247***
Labor force with Tertiary Education	0.00346**	0.0046***	0.00482***	0.0025521***
Constant	8.5000***	14.50***	13.600***	17.39036***
R^2	0.541			
X^2		406***	243***	1168.7***

Significant at %10 confidence level,** Significant at %5 confidence level, ***Significant at %1 confidence level

Our findings provide evidence that the supply side factors such as physical capital stock, labor stock, human capital and the unemployment rate have statistically significant effect on the determination of the wage rates in the 26 OECD countries. Therefore, we argue that wage estimates should include not only the demand side factors or micro level variables, but also the supply side factors at macro level, which, rather surprisingly, have been neglected in the literature.

4. Concluding Remarks

The neoclassical theory suggests that determinants of real wage are technology proxies (e.g., labor productivity and skill index) and factor endowments such as capital stock and labor stock. It seems rather strange therefore that the empirical wage difference studies have almost completely failed to consider this approach. Our study shows that macro determinants of real wage are statistically significant and satisfy theoretical sign expectations for the 26 OECD countries.

This work needs extension in two main directions. First, the limited time coverage and number of countries should be expanded. Second, the estimation for the same countries and period should be repeated with micro variables (i.e. firm, employee, and employer characteristics) in order to make a comparison in explanatory power of the two approaches.

References

Alback, K., Arai, M., Asplund, R., Barth, E. and Madsen, E. S. (1993) Inter-industry wage differentials in the Nordic countries, Paper presented at the European Association of Labor Economists Annual Conference, Papers and proceedings, EALE, Maastricht, pp. 1- 23.

Baltagi B. (2005), Econometric Analysis of Panel Data Third Edition John Wiley & Sons Ltd,England.

Behr, A and U. Pötter (2010), "What Determines Wage differentials across the EU?" The Journal of Economic Inequality March 2010, Volume 8, Issue 1, pp 101-120

Caju, P.D., G. Kátay, A. Lamo, D. Nicolitsas and S. Poelhekke (2010) "Inter-Industry Wage Differentials in EU Countries: What Do Cross-Country Time Varying Data Add to The Picture?", European Central Bank Working Paper Series, No 1182 / April 2010

Clemens, M., C. Montenegro, and L. Pritchett (2008), "The Place Premium: Wage Differences for Identical Workers across The US Border," World Bank Policy Research Working Paper No. 4671

Dickens, W. T. and Katz, L F. (1987) Inter-industry wage differences and industry characteristics, in Unemployment and the Structure of Labor Markets, (Eds) K. Lang and J. Leonard, Blackwell, Oxford, pp. 48-89.

Erdil, E. and H. Yetkiner, (2001) A comparative analysis of inter-industry wage differentials: industrialized versus developing countries, Applied Economics, 33, 1639-1648.

Gittleman, M. and Wolff, E. N. (1993) International comparisons of inter-industry wage differentials, Review of Income and Wealth, 39, 235- 312.

Greene, W.H. (2008): Econometric Analysis, 6th Ed., Upper Saddle River, N.J.: Prentice-Hall.

Groshen, E. L. (1991) Five reasons why wages vary among employers, Industrial Relations, 30, 350- 81.

Kennan, J.(2012), "Open Borders", World Bank Policy Research Working Paper No. 18307.

Krueger, A. B. and Summers, L. H. (1987) Reflections on the inter-industry wage structure, in Unemployment and the Structure of Labor Markets, (Es) K. Lang and J. Leonard, Blackwell, Oxford, pp. 17- 47.

Krueger, A. B. and Summers, L. H. (1988) Efficiency wages and the inter-industry wage structure, Econometrica, 56, 259- 94.

Lucas, R. Jr., (1988). "On the mechanics of economic development", Journal of Monetary Economics, 22(1), 3-42.

Mankiw, N.G. (2006, August 29). "How are wages and productivity related?" Retrieved from http://gregmankiw.blogspot.com/2006/08/how-are-wages-and-productivity-related.html

O'Rourke, Kevin H. and Jeffrey G. Williamson (1999) "Globalization and History: The Evolution of a Nineteenth-Century Atlantic Economy". Cambridge, MA: MIT Press.

Wagner, J. (1990) An international comparison of sector wage differences, Economics Letters, 34, 93- 7.

Wooldridge, J.(2010) Econometric Analysis of Cross Section and Panel Data Second Edition MIT Press, London England