The Neoclassical Determinants of Real Wage

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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 the real 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 the factor endowments-technology, physical capital stock and labor stock- have a significant explanatory power on the determination of the real wage. Based on our findings, we speculate that the supply-side rather than the demand-side variables may be the major source of the wage differences across countries.

Keywords**:** Wage, factor endowment, inter-country wage differences, panel data, panel SUR

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1. Introduction

Although large wage differences across countries are an empirical fact, the sources of the 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 the wage differences. However, the empirical evidence suggests that they have only limited explanatory powers on the wage differences. For example, Caju et al. (2010) show that the wage differences across countries and industries are neither explained by workers, by jobs and by firms' characteristics, nor by a number of institutional variables (such as product market regulations, barriers to competition, to entrepreneurship, and to trade union density), and nor by rents and by industry structure.[1] Similarly, in the analysis of the three underlying forces for the real wage differentials, which are 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 explaining 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 communication and transportation revolutions, nor globalization helped to close wage gaps between the rich and the 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 the wage differences can explain the sources of inter/ intra industry wage differentials to a certain extent; however, it is unable to offer a satisfactory answer for the wage difference across countries.

We, therefore, return to the Neoclassical-factor endowment- view to develop a macro explanation for the real wage determination across countries. We argue that the factor endowments of economies have a significant explanatory power on the average real wage across countries as suggested by the neoclassical theory. The macro explanation for the wage determination arising from the country specific factor endowments is surprisingly not exist in the empirical literature to the best of our knowledge. This would be more

[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.

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 the labor across borders, neoclassical theory perfectly fits to explain the determinants of the real wage. In this respect, this paper fulfills this gap and contributes to the literature.

The organization of the paper is as follows. Section 2 briefly discusses data and methodology. Section 3 shows that representatives of the factor endowments: technology, physical capital stock and labor stock are statistically significant determinants of the real wages for the whole 26 OECD countries, as suggested by the neoclassical theory. Section 4 presents the conclusion of the paper.

2. Data and Methodology

This paper aims to empirically investigate the impact of productivity and factor endowments on the determination of the real wage rate at the macro level. The theoretical basis for this approach is well-established by the neoclassical theory. Suppose that aggregate production function is $Y = K^{\gamma}\left(A^{\alpha} \cdot N\right)^{1-\gamma}$, where Y is real gross domestic product(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 a skill index (or human capital), á la Lucas (1988). The neoclassical theory suggests that the real wage would be

$$w = (1-\gamma)A^{\alpha(1-\gamma)}K^{\gamma}N^{-\gamma} \qquad (1)$$

To empirically analyzing the factors that affect the real wage, we take natural logarithms of the variables in equation (1) and use them in the panel estimation of the variables as follows:

$$\ln w_{it} = cons + \varphi \ln A_{it} + \gamma \ln K_{it} - \gamma \ln N_{it} + \beta X_{it} + \mu_i + \lambda_t \qquad (2)$$

where $\varphi = \alpha(1-\gamma)$, the term μ_i and λ_t represent individual country (i) and time (t) effects, respectively. X_{it} is a matrix containing control variables[4]

[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).

[4] We tried many variables to control for real wage. Only unemployment and tertiary

(unemployment, the share of labor force with tertiary education, etc.) and the term u_{it} is the error term. In the empirical use of equation (2), we will approximate K_{it} by the net capital stock, N_{it} by the labor stock, and A by the productivity growth.

2.1. Data

The data for the real wage is obtained from the OECD database. In this database, the average real wages for the OECD countries are estimated from the National Accounts for the member countries. These estimations 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. The average annual wage for each country is expressed in 2011 US dollar exchange rates and constant prices. Annual data on net capital stock are obtained from Eurostat (the Statistical Office of the European Commission). Data on labor force, unemployment with secondary education, and employment with tertiary education are all from the World Bank database. Labor productivity growth data comes from the OECD Database. Wage, labor force and net capital stock are all in logarithmic form. Based on the availability of the data, 26 countries were chosen in 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

Notice that individual (country) effects and time effects in equation (2) 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 of cross-section data units, the use of a random effects model is more convenient. Baltagi (2008) 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 consider 26 member countries of the OECD and an 11-year time period. Before proceeding to estimation, we carry out a bundle of tests. We first test the existence of specific fixed effects using Fisher's F-tests. By using this test, we also consider the impact of omitting the individual and/or time effects in panel data models that may lead to biased

education was found significant.

estimates. Below we discuss and test three hypotheses using Fisher's F-tests. The first hypothesis is that there is neither significant country (μ_i) nor significant time (λ_t) effects on the real wage in equation (1). This hypothesis can be formed as

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

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

$$H_0 : \mu_1 = \mu_2 = \mu_3 = \ldots\ldots\ldots \quad \mu_{N-1} = 0 \quad (\lambda_t \text{ is free of time effect}).$$

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

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

The appropriate tests for the aforementioned hypotheses are

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

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

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

where RSS_{ur} and RSS_r represent the residual sum of squares for unrestricted and restricted models, respectively. The test results shown in Table 1 indicate that we do not reject both the time and individual effects. Therefore, we use the fixed effects model to analyze both the time and the individual effects.

2.3 Testing for Unit Roots and Cointegration

To check the stationarity of variables used in the study we use Pesaran's (2007) the Covariate Augmented Dickey Fuller(CADF) test. As shown in Table 2, we reject the null hypothesis of unit root for two out of six variables. Since some series seem to be stationary, whereas some are not, we test whether there is a cointegrating relationship between our non-stationary variables. We use both Westerlund (2008) tests, which he called Durbin-Hausman test and Pesaran (2004) test - well known panel cointegration tests. The Durbin-Hausman cointegration tests the absence of cointegration among

the series with different order of integration to be tested. Furthermore, they consider cross-sectional dependence by including the group dimension (DHg) and the panel dimension (DHp). The Durbin-Hausman panel (DHp) test assumes that the autoregressive parameter is the same for all cross-sections, both under null and alternative hypotheses. The rejection of the null hypothesis means that the cointegration exists for all cross-sections. The Durbin-Hausman group (DHg) test permits the autoregressive parameter to differ across cross-sections under alternative hypothesis. Thus, the rejection of the null hypothesis means that cointegration does not exist. Our findings with regard to the tests are presented in Table 3. Westerlund's DHp and DHg tests reveal that there is a cointegrating relationship between our variables.

2.4 Testing for Cross Sectional Dependence

In this study, we assume that there is a correlation across cross sections units. We, therefore, test the validity of this assumption by using Pesaran's CD test (2004). The test statistics reported in Table 3 show the strong evidence of cross-section dependence. This result suggests that we use panel seemingly unrelated regression (SUR) model to take the cross section dependence across countries into account. Therefore, our main interpretations are based on panel SUR models that we used. Nevertheless, we also report fixed effect (FE) estimations results to compare with that of the panel SUR models.

2.5 Testing for the Equality of Coefficients

As it can be seen in equation (2), the theoretically expected coefficients of capital and labor have the same absolute value but opposite signs. We test this hypothesis using F- test whose result, **F*=3.81**, shown in Table 4. The test result (**F*=3.81**) indicates that the null hypothesis of "the coefficients have the same absolute value but different sign" cannot be rejected at 5% level of significance. Thus, we estimate equation (2) by imposing this restriction in our SUR_r and FE_r models and report the results in the third and fifth columns of Table 4.

2.6 Panel SUR Regression

We consider our equation (2) as panel SUR due to the correlation of the disturbances across equations. Baltagi (2008) emphasizes that in the case of correlation of the disturbances across equations, Panel SUR estimator is more efficient than FE estimator. Since the Pesaran's CD test reveals a strong evidence of cross-section dependence in our data, we use the panel SUR model to estimate equation (2). Even though we estimate equation (2) with FE, FE_r, Panel SUR, Panel SUR_r estimations, our main interpretations are based on Panel SUR_r estimation as we emphasized above.

Table 1. Fisher F tests

F_1	F_2	F_3
355.35***	909.20***	3.77***

*** indicates significance at the 0.01 level

Table 2: Pesaran's CADF Unit Root Test Results (Intercept)

Series	CADF
Real wage	-5.478***
Net Capital	3.352
Productivity	-1.127
Labor Force	-1.081
Unemployment	1.296
Tertiary Ed.	-1.296*

*** and * show statistically significant coefficients at the 0.01 and 0.10 levels, respectively.

Table 3:Westerlund Durbin-Hausman and Pesaran's CD tests

DHp	DHg	CD
4.661***	148.14***	7.50***

*** indicates significance at the 0.01level.

2.7 Estimation Results

The estimation results obtained by FE and Panel SUR models with and without the restriction of "the coefficients of capital and labor have the same absolute value but different sign" are shown in Table 4. The results of restricted models are illustrated by _r extensions of estimators in the Table. The coefficients of productivity are positive and significant only in panel SUR regressions, which is consistent with mainstream theory. The effect of the log of capital stock (K) on the log of real wage 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.

The effect of the log of labor force on the log of real wage is negative and significant in all estimations but SUR without restriction. This result is consistent with our theoretical argument in the introduction section. The effect of the rate of unemployment on the log of real wage is negative and statistically significant at one percent level in all estimations. In other words, this finding is consistent with mainstream theories that emphasize the negative relationships between the real wage and unemployment.

Finally, our estimates show that the share of tertiary labor in the labor force, an indicator of skill (human capital), has a significant positive effect on the log of the real wage rate at one or five percent level of significance in all estimates. However, the **sign** of the tertiary labor is negative in FE and FE_r estimations and positive in SUR and SUR_r estimations. The sign of the labor force with tertiary education, when FE and FE_r models are used, are negative, which are contradictory to mainstream theories. As we point out before, there was a correlation of the disturbances across section units. In this case, panel SUR estimations are more efficient than FE estimation. We, therefore, rely on SUR and SUR_r estimations. While the sign of panel SUR estimator for the log of labor force is positive, the sign of the same coefficient is negative in panel SUR_r estimation and statistically significant at one percent level of significance. SUR_r estimates are consistent with mainstream theoretical expectations. This justifies using of SUR_r model to gauge the effects of macro variables on the real wage in this study.

Table 4. FE, FE_r,Panel SUR, Panel SUR_r Estimation Results

Dependent variable: Log of annual average real wage				
VARIABLES	**FE**	**FE_r**	**Panel SUR**	**Panel SUR_r**
Productivity	0.01578	0.0017	0.0491***	0.0576***
Log of net capital	0.236***	0.3421***	0.255***	0.275***
Log of labor force	0.433***	-0.3421***	0.0285	-0.275***
Unemployment	-0.0045***	-0.0043***	-0.0056***	-0.0056***
Labor force with Tertiary Education	0.0022**	-0.0025**	0.00332***	0.00517***
F*	3.81	3.81	3.81	3.81
R^2	0.66	0.66	0.99	0.99

** Significant at %5 confidence level, ***Significant at %1 confidence level FE_r and SUR_r denote estimation with imposed restriction.

Our findings provide evidence that the supply side factors - physical capital stock, labor stock, productivity, human capital and the unemployment rate- have statistically significant effect on the determination of the real wage in the 26 OECD countries. Hence, we argue that the real wage estimates should include not only the demand side factors or micro level variables as commonly used in the empirical literature, 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 the determinants of the real wage are technology (e.g., labor productivity or skill index) and factor endowments such as capital stock and labor stock. Surprisingly appears that the studies on the real wage determinants and real wage differences across countries have almost completely not considered this approach. One of the contributions of this study is to fulfill this gap in the empirical works, which overlooked the supply side factors affecting the real wage across countries. Moreover, our findings indicate that the hypothesis pertaining to the real wage determination across countries at macro level, rather than across countries comparisons of the same industries at micro level should also be taken into account. Furthermore, our study seems to pinpoint that this work needs extensions 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, employer characteristics, etc.) in order to make a comparison in explanatory powers of macro and micro approaches. That is the subject of our future study.

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