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Wage-Productivity Gap in OECD Economies

Ceyhun Elgin and Tolga Umut Kuzubas

Abstract

The Walrasian theory of labor market equilibrium predicts that in the absence of any market frictions, workers earn a wage rate equal to their marginal productivity. However, this observation is not supported empirically for various economies. Based on the neoclassical tradition, the ratio of the marginal product of labor to real wages is generally defined as the Pigouvian exploitation rate. In this paper, the authors calculate this specific wage-productivity gap for the manufacturing sector in OECD economies and investigate its relation to the unemployment rate along with other variables such as government taxation, capital expansion, unionization, inflation. The authors find that the wage productivity gap gives a robust and significantly positive response to shocks to the unemployment rate and negative response to shocks to unionization.

JEL J24 J30 J64
Keywords Wages; marginal productivity of labor; panel-VAR; OECD economies

Authors

Ceyhun Elgin, ✉ Bogazici University, Department of Economics, Bogazici University, Natuk Birkan Building, 34342 Bebek, Istanbul, Turkey, ceyhun.elgin@boun.edu.tr
Tolga Umut Kuzubas, Bogazici University, Istanbul

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1 Introduction

In the absence of any market distortions, perfect competition in the labor market and profit maximizing behaviour of firms under constant returns to scale imply that real wages should be equal marginal product of labor (MPL). When competitive firms take product and factor prices as given and maximize their profit function, it is immediate from the profit maximization of the firm that real wages should equal marginal product of labor. However, this theoretical result is not supported empirically for various economies. For example, in Elgin and Kuzubas (2012) we investigate the evolution of the relationship between real wages and marginal product of labor in Turkish manufacturing sector and find that there is a significant gap between these two variables. More importantly, using different time-series techniques we also find that this gap is foremost affected by unemployment rate in Turkey.

Aiming to generalize this result, in this paper we conduct this analysis using a cross-country panel data set consisting of 31 countries and over a time span of 50 years between 1960 and 2009 and investigate the interaction of the wage-productivity gap with various variables. The availability of panel data allows us to examine both the cross-country and time-series variation in the wage-productivity gap. In order to understand how the wage-productivity gap is related to several other variables, we use the Panel-VAR approach a la Holtz-Eakin et al. (1988) to capture possible endogeneity between wage-productivity gap and the variables potentially affecting this gap. We examine the effects of unemployment rate, capital deepening, unionisation, inflation on the wage-productivity gap. Among these four variables, our empirical results indicate that the wage-productivity gap gives a robust and significantly positive response to shocks to unemployment and negative response to shocks to unionisation.

The rest of the paper is organized as follows: In the next section, we briefly describe how our paper is related to the both the empirical and the theoretical literature and focus on the contribution of our paper. Next, in section 3 we outline the theoretical framework behind our analysis. Section 4 presents the methodology and results of the empirical analysis and finally, section 5 concludes.

2 Related Literature

Walrasian theory of labor market equilibrium predicts that in the absence of any distortions, workers earn a wage rate which is equal to their marginal productivity, measured in units of output. Among other factors, our main focus in this paper is to uncover the relationship between real wages and the unemployment rate. In a competitive labor market without any frictions, the observed wage-productivity gap is an outcome of temporary disequilibrium dynamics which disappear in the long-run. The rationale behind this prediction is that, when wages are below the productivity level of workers, firms have an incentive to hire more workers which puts an upward pressure on wages and if wages are above the productivity level it is profitable for the firm to reduce the labor force which drives wages down. Therefore equilibrium in the labor market requires that wages are equal to the marginal productivity of labor. Empirical literature relying on the competitive markets investigates wage-productivity gap as a determinant of unemployment. For example, Bruno and Sachs (1985) identifies the increase in the wage-productivity gap as the main determinant of high unemployment in OECD countries during 1970's. Gordon (1995), on the other hand, provides evidence that there is no cross-country correlation between these two variables in 1980's. Following these studies, an extensive literature analysing wage-productivity gap as a determinant of unemployment emerged[1] and found little empirical support on the effect of wage-gap on unemployment. One exception is Lopez-Villavicencio and Silva (2011) who reestablish the empirical result by introducing labor market regulations.

Another way to think about the theoretical predictions is to rely on the models which explicitly account for the frictions in the labor market. Considering the benchmark Mortensen-Pissarides model[2], the observed gap between wages and productivity is determined by the bargaining powers of the workers and aggregate labor market conditions. For our purposes, this model predicts a positive correlation between wage-productivity gap and unemployment because a higher unemployment rate reduces the outside option of the workers in their bargaining process with the firm and push them to settle for lower wages. Actually, the effect of unemployment on the wages becomes more significant if we tie bargaining power of the workers to aggregate unemployment rates[3].

This prediction is not tested by the empirical literature described above which treats wage-productivity gap as exogenous when examining the relation between these two variables. However, theory suggest a two-way causation between wage-productivity gap and unemployment. This paper is an attempt to fill in this gap in the empirical literature by relying on Panel-VAR techniques which account for the possible endogeneity of these variables and allow to control for the country-specific effects.

[1] Also see Junankar and Madsen (2004), Pascalau (2007), Madsen (1994)

[2] See Pissarides (2000) for a discussion.

[3] See Elgin and Kuzubas (2012) for a version of bargaining game which derives bargaining power of the workers as a function of aggregate unemployment rate.

3 Theoretical Framework

In the introduction, we briefly discuss the theoretical predictions on the relationship between wage-productivity gap and unemployment. Walrasian theory has been extensively analyzed by the empirical literature however the effect of search and bargaining frictions on this relationship received relatively less attention. In this section, we elaborate the predictions of the literature by relying on the well-established Mortensen-Pissarides framework.

In this type of models, wages are determined as an outcome of Nash-bargaining between workers and firms. Therefore they are related to bargaining powers and the outside options which are determined by the labor market conditions. Note that, this type of wage-determination reduces the wage-productivity gap when we give all the bargaining power to the worker and in the opposite case, any positive bargaining power of the firm will lead to a higher gap. This shows that the bargaining power is critical in determining the size of the wage-productivity gap implied by the model. Unemployment rate on the other hand, affects the wages through its indirect effect on the outside options of workers. In other words, a higher unemployment rate reduces the job finding rates of the workers and hence their outside options, therefore, workers will settle for a lower wage. Taking productivity as given, this will increase the wage-productivity gap. So according to this mechanism, bargaining power and unemployment will be the main determinants of wage-productivity gap.

In another paper, Elgin and Kuzubas (2012), we link the bargaining power of the worker (which is usually treated as exogenous in these type of models) to the unemployment rate by introducing a bargaining game between the worker and the firm to the standard Mortensen-Pissarides framework in the line of Cahuc, Postel-Vinay and Robin (2003). We derive the bargaining power of the workers as a function of the unemployment rate and show that there is a negative relationship between the bargaining power and unemployment rate. Noticeably, this reinforces the effect of unemployment on the wage-productivity gap.

The theoretical mechanism we have outlined above suggests that, combining with the Walrasian equilibrium, there is a possible two-way causation between wage-productivity gap and unemployment. However, the empirical literature focusing on the effect of wage-gap on unemployment mostly neglects unemployment as a determinant of the wage-productivity gap and is not consistent with these theoretical prediction which calls for an empirical analysis to account for this observation. Also, a robust empirical analysis should control for the factors which potentially affect the bargaining power of the workers such as unionization rates. That is why we conduct an empirical analysis controlling for the possible two-way causation and country specific effects with a rich set of control variables using a Panel-VAR framework in our estimation.

4 Empirical Analysis

4.1 Methodology

We use panel-data vector autoregression (VAR) methodology which fits the purpose of this paper well as the theoretical predictions indicate a two-way causation between wage-productivity gap and unemployment rate. Panel-VAR framework extends the traditional VAR approach to a panel data setting and allows us to control for country level heterogeneity. In the estimated model, we treat both wage-producitivity gap and unemployment as endogenous (along with potential other variables) and pose the following specification:

$$y_{it} = \sum_{j=1}^{p} \beta_j y_{i,t-j} + \sum_{j=1}^{p} \delta_j x_{i,t-j} + f_i + s_{c,t} + \upsilon_{it} \tag{1}$$

Applying the VAR methodology to panel data presents a problem associated with lagged dependent variables in both fixed and random effects settings. In order to address this problem we use the methodology proposed by Holtz-Eakin (1988). In the traditional VAR, one needs to impose the restriction that the data generating process is the same for each cross-section of observation which usually does not hold. Therefore, in order to control for country level heterogeneity we introduce fixed effects, f_i in the model. In the VAR setting, because of the dynamic nature of the estimation, lagged dependent variables are correlated with the disturbance term. For the fixed effect estimator transformation of variables eliminates f_i however, the regressor $y_{it-1} - \bar{y}_{i.-1}$, with $\bar{y}_{i.-1} = \sum_{t=p+1}^{T} y_{it-1}/(T-p)$, will still be correlated with the error term $v_{it} - \bar{v}_{i.}$, where $\bar{v}_{i.} = \sum_{t=p+1}^{T} v_{it}/(T-p)$, because y_{it-1} is correlated with $\bar{v}_{i.}$ by construction. Therefore, the mean-differencing procedure commonly used to eliminate fixed effects would create biased coefficients especially with a limited number of time-series observations. In order to eliminate this problem, we use forward mean-differencing, known as the "Helmert procedure". This procedure only subtracts the mean of all the future observations available for each country-year. This transformation satisfies the orthogonality assumption between transformed variables and lagged regressors. Therefore, we can use lagged dependent variables as instruments and estimate the coefficients by system GMM.[4] We also include time dummies for each country in order to capture country level shocks to macroeconomic conditions. These dummies are eliminated by subtracting the means of each variable calculated for each country-year.

[4] See Love and Zicchino (2006) and Arellano and Bover (1995) for details of estimation procedure.

A model with individual effects that relaxes the time stationarity assumption is the one we use in our estimation, where we modify the empirical model as follows:

$$y_{it} = \alpha_{0t} + \sum_{j=1}^{m} \alpha_{jt} y_{i,t-j} + \sum_{j=1}^{m} \gamma_j x_{i,t-j} + f_i + u_{it} \tag{2}$$

where y and x will be the endogenous variables we use in our specification and f_i is the unobserved individual effect.

Before, estimating this system, we will first use a second generation unit root test developed by Pesaran (2007) which is based on the augmentation of the Augmented Dickey-Fuller regression with lagged cross-sectional mean and its first difference capturing the cross-sectional dependence. We will use the critical values reported in this paper with the null hypothesis of the presence of the unit root.[5] Moreover, we will also test the presence of cointegration for the variables having a unit-root. If such a relationship does not exist, then we will use the first-differences series in a Panel VAR analysis.

Finally, once the estimation is done, we analyze impulse-response functions and also present variance decompositions. As well known, impulse response functions aim to describe the response of an endogenous variable over time to a shock in another variable in the specified system. On the other hand, variance decompositions report the contributions of each shock to the variance of each endogenous variable, at a specified forecast horizon. Moreover, when constructing the confidence intervals of the impulse-response functions we apply bootstrap methods. Following Love and Zicchino (2006) we calculate standard errors of the impulse functions generating confidence intervals using Monte-Carlo simulations.[6]

4.2 Data

Motivated by Persky and Tsang (1974), we use 5 different variables for our empirical analysis. These are unemployment rate, unionization density, inflation rate, capital deepening and the wage-productivity gap. Inflation data is constructed using the CPI from the International Financial Statistics.[7] Unemployment and unionization density data obtained from OECD Database and World Development Indicators. Capital deepening is defined as the growth rate in the aggregate capital stock. We constructed the aggregate capital stock series for each country using the perpetual inventory method using the following system of equations:

[5] We have also employed several other panel unit-root tests and obtained similar results. These are also available upon request from the corresponding author.

[6] Reported results are based on 1000 Monte-Carlo simulations. Results are similar when one performs different numbers of simulations.

[7] Results are similar when we construct inflation using GDP deflator from Penn World Tables.

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

$$\frac{K_{1960}}{Y_{1960}} = \frac{1}{10}\sum_{t=1951}^{1960}\frac{K_t}{Y_t}$$

The first equation is the standard law of motion for capital and the second one is based on the assumption that the capital-output ratio of the initial period should match the average capital-output ratio over some reference period. Here, we choose the capital stock so that the capital-output ratio in 1950 matches its average over 1951 - 1960. These two equations, along with the amount of investment, I_t, allows us to obtain the series of K_t, for all t. Data for investment and GDP needed to construct the series are obtained from the Penn World Tables.[8]

Finally, as a measure for the wage-productivity gap we use the ratio of Marginal Product of Labor to real wages in manufacturing. The wage data come from OECD and Eurostat. To create a series for the marginal product of labor, we we assume that the production in the manufacturing is characterized by the following production function for any year t in each country i:

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}, \tag{3}$$

where Y_t is the total value added (in real terms) in manufacturing, K_t is the amount of capital and L_t is the amount of labor used in production. In order to calculate marginal productivity of labor, $MPL = (1-\alpha)\frac{Y_t}{L_t}$ we need an estimate of α. Here we use hours of work in manufacturing as the measure of labor. Then, we obtain an estimate of α, by running the following regression equation for each country i:

$$log(Y_t) = \beta_0 + \beta_1 K_t + \beta_2 L_t + \varepsilon_t, \tag{4}$$

where ε_t is the error term.

Once we have an estimate of α, say $\hat{\alpha}$ we can easily calculate $MPL = (1-\hat{\alpha})\frac{Y_t}{L_t}$, and hence the MPL-to-wage ratio.

Descriptive statistics of all the variables along with the number of observations we have for each variable are provided in Table 1. We have an unbalanced panel data for 31 countries over the period 1960-2009. The list of countries used in the analysis is provided in the appendix.

[8] The depreciation rate δ is assumed to be equal to 0.08

Table 1: Complete Dataset Summary Statistics

	Mean	Std. Deviation	Minimum	Maximum	Observations
Unemployment	5.88	4.00	0.00	23.90	1229
Unionization	37.76	19.97	1.08	94.30	1232
Inflation	8.75	20.69	-9.63	555.38	1345
Capital Deepening	0.38	2.96	-9.42	25.95	1431
Wage-Prod. Gap	0.87	0.30	0.45	2.66	1176

4.3 Empirical Analysis

Table 2: CADF Panel Unit Root Tests

	Level		First. Diff.	
Variable	Test Stat.	P-value	Test. Stat	P-Value
Unemployment	0.48	0.69	-.3.13	0.00
Unionization	1.94	0.97	-3.75	0.00
Inflation (%)	0.14	0.34	-4.99	0.00
Capital Deepening	1.79	0.89	-5.32	0.00
Wage-Prod. Gap	0.20	0.42	-3.17	0.00

The test statistic is based on the Cross-sectionally Augmented Dickey Fuller (CADF) Test following Pesaran (2007). The test has the null hypothesis of the presence of a unit-root.

As discussed in the previous section, we first conduct a unit-root test on all the variables used in the analysis. To this end, Table 2 reports the results of the CADF panel unit root test[9] a la Pesaran (2007).[10] According to the results reported in Table 2, for levels of all the five variables, namely, unemployment, unionization, inflation and wage-productivity gap the null hypotheses that a unit-root is present cannot be rejected. As we reject these hypotheses for their first differences, we conclude that they are integrated of order one.[11] Therefore, in our panel of 31 OECD countries, we conclude that the variables are non-stationary in their levels but stationary in first-differences.

Next, in Table 3 we report the results of the cointegration test developed by Westerlund (2007). Here, we test whether a cointegrating relationship exists

[9] We determined the lag order in the country-specific ADF-type regressions for each series using the Akaike information criterion (AIC) model selection criterion.
[10] Again, we also conducted several other unit root tests and ended up with similar results.
[11] We also obtained similar results using the four bootstrap tests of Smith et al. (2004).

Table 3: Panel Cointegration Tests

Statistic	Value	P-value
G_τ	-2.28	0.23
G_α	-4.10	0.92
P_τ	-7.96	0.20
P_α	-3.40	0.18

P-values are robust critical values obtained through bootstrapping with 1000 replications.

between the five variables we use in the analysis. Basically, our aim here is to test for the absence of cointegration which we conduct by determining whether error correction exists for the panel as a whole or for individual panel members. This test also also takes through bootstrapping cross-section interdependence into account. Here the null hypothesis is that the cointegration does not exist. The G_τ and G_α statistics test whether cointegration exists for at least one country whereas the P_τ and P_α statistics pool information over all the individual country series and test whether a cointegrating relationship exists for the panel as a whole. Moreover, cross-section interdependence is taken into account by computing the robust p-value is through bootstrapping with 1000 replications. According to the results in Table 3, we cannot reject the null hypothesis of no cointegration in any of the four tests.

Given the results in tables 2 and 3 we conclude that our variables require estimation of the VAR in first differences. To this end, Table 4 reports the estimated coefficients of the system once the fixed effects and the country-time dummy variables are removed. As well known, choosing the right lag length is crucial for a robust panel VAR analysis. Given the results of the Lagrangian Multiplier test for residual autocorrelation, we choose to to use one lag for each model.[12] Moreover, we use Cholesky decomposition when computing the impulse response functions. It is well know that ordering of the variables matter in this regards. Particularly, the variables appearing earlier are assumed affect the other variables contemporaneously, while the ones appearing later in the VAR impact those impact the others with lag.

Table 4 illustrates estimation results of 4 different systems using different sets of variables in each. First, we estimate the system using only the wage-productivity gap (shortly denoted by Gap) and unemployment. Then, we add one by one unionization (shortly denoted by union), inflation and capital deepening (shortly denoted by capital) to the system. What we observe from Table 4 is that the

[12] However, in terms of the signs of the coefficients, models with two and three lags yield qualitatively similar results.

Table 4: Main Results of the Panel-VAR Model

Response of	Response to				
	Gap (-1)	Unemployment (-1)			
Gap	1.04*	0.002*			
	(0.04)	(0.001)			
Unemployment	-0.20	0.97*			
	(0.14)	(0.02)			
	Gap (-1)	Unemployment (-1)	Union (-1)		
Gap	1.03*	0.006*	-0.004*		
	(0.03)	(0.002)	(0.002)		
Unemployment	-0.08	0.94*	0.04**		
	(0.13)	(0.03)	(0.02)		
Union	-0.03	-0.03	0.93*		
	(0.08)	(0.03)	(0.03)		
	Gap (-1)	Unemployment (-1)	Union (-1)	Inflation(-1)	
Gap	1.03*	0.006*	-0.004**	0.0004	
	(0.03)	(0.003)	(0.002)	(0.001)	
Unemployment	-0.08	0.93*	0.05***	-0.001	
	(0.13)	(0.03)	(0.03)	(0.01)	
Union	-.0.03	-0.03	0.93*	0.004	
	(0.08)	(0.04)	(0.03)	(0.02)	
Inflation	0.15	-0.06	0.04	0.90*	
	(0.24)	(0.10)	(0.06)	(0.08)	
	Gap (-1)	Unemployment (-1)	Union (-1)	Inflation(-1)	Capital(-1)
Gap	1.03*	0.006*	-0.004**	0.0004	0.009
	(0.03)	(0.003)	(0.002)	(0.001)	(0.18)
Unemployment	-0.03	1.01*	0.02	-0.03**	23.09*
	(0.11)	(0.03)	(0.02)	(-0.03)	3.51
Union	-0.005	0.002	0.92*	-0.007	9.84*
	(0.07)	(0.04)	(0.03)	(0.02)	(2.85)
Inflation	0.10	-0.14	-0.02	0.93*	-23.52*
	(0.23)	(0.10)	(0.06)	(0.09)	9.40
Capital	-0.005	-0.005*	0.001***	0.0002	0.32*
	(0.003)	(0.0007)	(0.0006)	(0.0003)	0.08

Table 5: Variance Decompositions

	Gap	Unemployment	
Gap	0.95	0.05	
Unemployment	0.01	0.99	
	Gap	Unemployment	Union
Gap	0.89	0.08	0.03
Unemployment	0.01	0.95	0.04
Union	0.02	0.05	0.93

Percent of variation in the row variable (10 periods ahead) explained by column variable.

wage-productivity gap gives a robust and significantly positive response to shocks to unemployment and negative response to shocks to unionization.

As discussed in Section 3, previous literature treats wage-productivity gap as exogenous by neglecting the possible endogeneity between this gap and unemployment rate. This literature mainly tests the prediction of the theory relying on competitive markets and identifies wage-productivity gap as a disequilibrium dynamics which disappears in the long-run. However, the search-theoretic models of the labor market provides a link between aggregate unemployment rate and wage-productivity gap, which predicts a positive correlation between these variables. Our empirical analysis provides a more flexible specification, thanks to the VAR methodology, which embeds the testing of both theoretical predictions and eliminates potential endogeneity problems. Our empirical results indicates that lagged values of unemployment rate has a statistically significant effect on the wage-productivity gap, however lagged values of the gap has no significant effect on unemployment. Therefore our empirical results are in line with the predictions of the search-theoretic framework.

Next, in Table 5 we present variance decompositions for different models. In both models unemployment explains more of the wage-productivity gap variation 10 periods ahead in our sample, compared to the unionization density. However, the magnitude of the effect is rather small, unemployment explain about 5-8 % of total variation in wage-productivity gap.

Finally, Figure 1 presents the impulse-response functions and the 5 % error bands generated by Monte-Carlo simulations. We only report the results of the model with three variables, namely wage-productivity gap, unemployment, and unionization.

We observe from Figure 1 that the response of the wage-productivity gap is positive whereas its response to unionization is negative in the estimated coefficients and impulse responses.

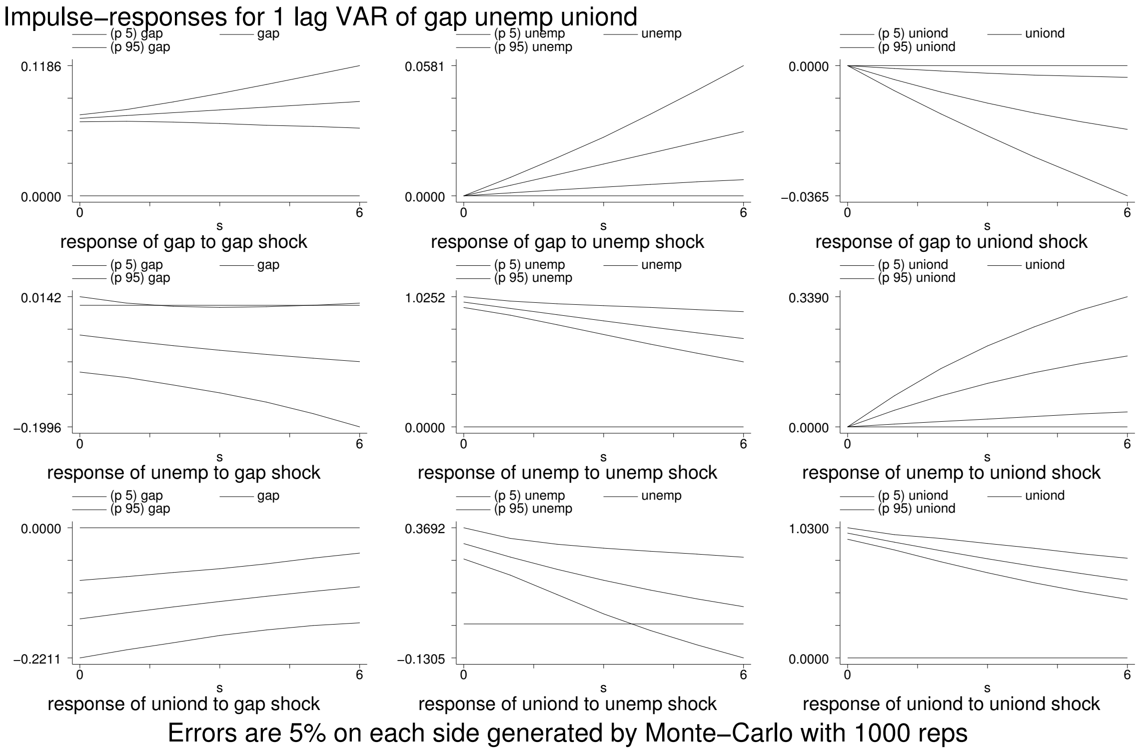

Figure 1: Impulse Response Functions

5 Concluding Remarks and Discussion

In this paper, we investigate the relationship between of wage-productivity gap and unemployment using a cross-country panel data set from 31 OECD countries spanning the period 1960-2009. A vast empirical literature analyzing the wage-productivity gap focuses on the effect of this gap on the unemployment rate which theoretically relies on the predictions of Walrasian equilibrium without any frictions in the labor market. On the other hand, labor market models which takes these frictions explicitly into account and depart from perfect competition assumption implies that unemployment rate is a determinant of wages. Therefore, an empirical analysis which treats wage-productivity gap as exogenous may suffer from the well-known endogeneity bias. In order to avoid this bias, we exploit the dynamic panel nature of our data set and rely on Panel-VAR estimation techniques. To the best of our knowledge, this is the first paper which employs this methodology to the research question posed in the paper.

One issue that deserves further attention is that the data we use in the paper is highly aggregate even in the macroeconomic sense. Future research should focus on the analysis of the wage-productivity gap and its relationship with different economic variables, preferably using sector, industry or firm-level data.

Appendix

List of Countries

Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, S. Korea, Luxemburg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States of America.

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