

## CAN TAX WEDGE AFFECT LABOR PRODUCTIVITY? A TSLS FIXED MODEL ON OECD PANEL DATA

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### **Abstract**

This paper studies the econometric relationship between labor productivity and tax wedge by using two-stage least square (TSLS) fixed effect model on two panel data of OECD countries to address endogeneity problem. I use two response variables, i.e., the growth rate of GDP per hour worked and the log of value added per hour worked for total manufacturing industry in 1997 dollar from two data sources, to verify whether the estimates of the effect of tax wedge are consistent each other. I do find that they are consistent and one percentage increase in tax wedge can lead to about 0.09 percentage decrease in labor productivity growth rate.

Keyword: tax wedge, labor productivity, instrument variable estimation, fixed effect model, welfare state

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### **1. Introduction and Literature review**

This paper studies the econometric relationship between labor productivity and tax wedge by using two-stage least square (TSLS) model on panel data of 28 OECD countries from 1991 to 2004. High tax wedge imposed and high welfare level provided by government characterizes welfare state economic system whose effect on economic efficiency is highly controversial (see, for example, Jonas Agell(1996)). As far as my knowledge, there has been no but one paper studying this topic directly despite voluminous literature on the relationship between unemployment, labor market performance or even economic growth and tax wedge.

Aspal and Vork(2007) suggests that the falling levels of labor taxation in some new members states of OECD might have a positive effect on productivity growth. They estimate a regression using panel data on OECD countries in the period 1970-1999 with labour market institutions as explanatory variables, specifically, they estimate a growth regression in the following form:

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$$\Delta y_{i,t} = \alpha y_{i,t-1} + \beta' X_{i,t} + \eta_i + \varepsilon_{i,t},$$

where  $y$  is the logarithm of real GDP per worker (GDP per hour worked was also used),  $X$  is a set of explanatory variables,  $\eta$  is a country-specific effect, and  $\varepsilon$  the error term. The  $i$  and  $t$  subscripts denote country and time period, respectively. The set of explanatory variables includes investment share in GDP, labour tax rate, an index of employment protection, unemployment benefit replacement rates, union density, the degree of centralization of collective bargaining, and active labour market policies. Separate sets of equations were estimated with growth of GDP per worker and GDP per hour worked as the dependent variable, as well as with and without country-specific fixed effects.

The estimation results from the growth regressions show that the tax rate variable was significant and with a negative coefficient in the fixed effects equations. However, it turned insignificant when growth of GDP per hour worked was used as the dependent variable. The inconsistency of significance of the parameters of labor tax rate for two measures of labor productivity, GDP per worker growth and GDP per hour growth implies potential estimation problems in their model. One critical issue for estimation consistency is just ignored, the endogeneity of explanatory variables, such as tax rate despite the fact that fixed effect model can eliminate a certain type of omitted variables, particularly when they include a lagged value of dependent variable as explanatory variable. In strict econometrics sense, we can have no confidence with the consistency of estimated  $\beta$ .

Kaitila (2006) analyzes the development of labour productivity and hours worked by the working-aged population in the EU25 countries and other OECD countries in 1960-2004. Although he claimed that one of his finding is “the tax/benefit systems do not seem to affect productivity”, he did not specifically show the relationship between tax and productivity at all, instead, he studied other possible determinants, i.e., level of education and investment into information technology, communication equipment and software as a percentage of GDP and R&D % of GDP. He only claimed that “as for taxes, no correlation was found between the tax wedge and the rate of productivity growth in either the 1980-1990 period or the 1995-2004

period”. His study method is essentially a scatter plot with labor productivity growth rate on the vertical axis and one determinant candidate on the horizontal axis.

This approach is like layman’s article on economic analysis. One such example is an online article on Wikipedia (an online encyclopedia) about economic performance of welfare states, which claims that “*Within developed economies, however, there is very little correlation between economic performance and welfare expenditure... the higher levels of social expenditure in the European Union are not associated with lower growth, lower productivity or higher unemployment, nor with higher growth, higher productivity or lower unemployment. Likewise, the pursuit of free market policies leads neither to guaranteed prosperity nor to social collapse*”. As an evidence to support this claim, the article presents a table with a column of Welfare expenditure (% of GDP) and a column of GDP per capita (PPP US\$) to show that they are not correlated. If this kind of analysis can prove economic effect of public policy, what is the necessity of economist’s existence?

Why are there always extensive controversies over economic effect of public policy, particularly tax policy adopted by welfare states? The answer is simple, economists are not sure themselves, they cannot convince each other on this critically important issue. Because of what? Because of the hardest part of econometrics, i.e., endogeneity in multiple regression, which often cause the loss of internal validity of the whole research. Nunziata finds that tax wedge has a positive effect on unemployment rate while Baccora and Rei (2005) finds that tax wedge seem negatively associated with changes in unemployment, even though the coefficients are (mostly but not always) insignificant. Nickell (2003) presents a table 4 in his paper summarizing recent results on the impact of taxation on Employment , more specifically, long-run impact on unemployment rate of a 10 percentage point rise in the tax wedge. 6 studies on this topic are included in the table. The estimates of tax wage obtained from a variety of time series, cross-section, fixed effect and random effect panel models range from 1.1 to 5.5, but none of these studies take into account endogeneity of tax wedge even after controlling for various labor market institution

variables. Unfortunately, omitted variables that are specific to countries and changing with time cannot be accounted for by either country effect or time effect model.

This paper aims to addressing this difficulty. To address endogeneity of explanatory variable tax wedge in various regressions, I combine instrumental variable estimation with fixed effect model by using actual hours worked as instrument, the justification of and validity check for which turns out to be consistent with Ohanian etl. (2006)'s finding, which suggest that tax wedge can account for much of the variation in hours worked both over time and across countries for the panel data of OECD nations over the period 1956-2004.

Of course, there are many factors affecting labor productivity. It is impossible to include all of them in any study. So human capital investment on education and scientific research, and other variables, are considered in Guisan and Cancelo(2006), Guisan and Aguayo(2007), and other studies, with interesting results.

Including extra control variables in addition to the variable of our interest, tax wedge in our case, can increase efficiency of its estimate, as long as they are strictly exogenous, but the determinant candidates for labor productivity growth rate are very likely to be endogenous, they may either be correlated with other omitted variables or have feedback effects from labor productivity or suffer from severe measurement errors. Including additional endogenous variables without extra valid instruments can mess up the estimates of tax wedge, leading to an inconsistent estimate. So possible increase in estimation efficiency is at the risk of loss of consistency. Taking this into account, I do not include any other business-cycle-related, technology-shock-related, institutional or policy factors of possible determinants of labor productivity growth (such as IT revolution, education or R&D input, etc.) as control variables in the IV regression specifications for tax wedge effect on productivity, in addition to exogenous dummy variables for countries and years.

## **2. Variable definition and data sources**

As OECD Fact Book points out, "Productivity growth can be measured by relating changes in output to changes in one or more inputs to production. The most common productivity measure is

labour productivity, which links changes in output to changes in labor input. It is a key economic indicator and is closely associated with standards of living.”

I use two response variables to measure labor productivity, i.e., the growth rate of GDP per hour worked and value added per hour worked for total manufacturing industry in 1997 dollar from two data sources, hoping to verify that the estimates of the effect of tax wedge are consistent each other. The data source of the former is OECD Fact Book 2006, which covers 28 OECD nations (1991-2004) while that of the latter is O'Mahony and van Ark (2003)'s Manufacturing Productivity and Unit Labor Cost Level Database (CD-ROM), which covers 14 EU nations and USA(1991-2001).

Tax wedge is the ratio of labor taxes to gross wages (net wage and all taxes paid by an employee or employer), or tax proportion of labor cost<sup>2</sup>. All the data of tax wedge and its instrument in IV regression, actual hours worked, i.e., hours per year per person in employment are from OECD Fact Book 2006.

### **3. Methodology and results**

**3.1. Overall Estimation Approach.** Generally, the major threats to Internal Validity of Multiple Regression Analysis include:

1. Omitted variable bias (OV)
2. Errors-in-variables bias
3. Sample selection bias
4. Simultaneous causality bias
5. Functional form mis-specification

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<sup>2</sup> The tax wedge can be split into payroll taxes (all taxes paid by an employer or employee) and (general) income taxes (all taxes paid by an employee). The tax wedge is the difference between workers' take-home pay and the costs of employing them, including income taxes and social-security contributions. Given the characteristics of the (European) labor tax system, the tax wedge consists of personal income taxes (PIT) (paid by the employee) and social security contributions (SSC), the latter paid partly by the employee and partly by the employer. General income taxes are the sum of PIT and the employee's part of SSC.

Our data has no sample selection bias since the choice of countries in the study is only related to data availability, not to any endogenous variable. Errors-in-variables bias seem also not be a prominent problem. Even if there is minor measurement error problem, say for the growth rate of GDP per hour worked, the TSLS estimation approach used in this paper will correct bias from this in the same way it correct biases from OV and reverse causality problem. Besides, two measures of labor productivity from two different data sources can significantly lesson measurement error problem.

The major problems fall on the first, forth and fifth bias on the above list. Having panel data allows us to control for unobserved time effect and/or country effect, but we still need to use instrumental variable (IV) (also called two-stage least square, or TSLS) estimation methods to handle the endogeneity bias that arises from the omitted variable (OV) problem or possible simultaneous causality and measurement error.

The overall estimation strategy of this paper is:

- i) Use fixed effect model for panel data to eliminate fixed time effect and fixed country effect, two certain types of OV bias by using Binary regressor approach ( $n - 1$  entity dummy variables and/or  $T - 1$  time dummy variables).
- ii) Use TSLS to handle other OV and/or simultaneous causality bias, the instrument for the variable of interest, tax wedge, is actual hours worked, namely Hours per year per person in employment, the validity check of which follows.
- iii) I will check for serial correlation and functional misspecification too since the data are panel data.

### **3.2. Serial correlation and clustered standard error.**

The classical heteroskedasticity-robust standard error used in general TSLS model for panel data assumes that given explanatory variables, the error terms are uncorrelated over time within a country. If units are correlated over time, or in our case there is serial correlation among the error terms within a country, we don't have as much information (as much random variation) as we would were they uncorrelated. If the errors are serially correlated, the usual H-robust SEs are wrong (they don't allow for serial correlation and are typically too small). This

problem is solved by using “heteroskedasticity and autocorrelation-consistent standard errors”, or clustered SEs, which are robust to both heteroskedasticity and serial correlation of the error terms. Clustered SEs are valid whether time dimension is large or small. So, if serial correlation is a concern, which is also our case, we should use clustered standard errors. Hetero-robust (or homosk-only) SEs don’t allow for this correlation, but clustered SEs do.

Since omitted factors entering the model for productivity determination are typically to be correlated over time within a country, we have to use “heteroskedasticity and autocorrelation-consistent standard errors or clustered S.E., where the clustering is by entity, country. The usual H-robust SEs are wrong (they don’t allow for serial correlation). Clustered SEs are robust to both heteroskedasticity and serial correlation of the error terms. Clustered SEs are valid whether T is large or small.

### **3.3. Checking exogeneity of the instrument.**

Does hours worked directly affect productivity growth measured by the growth rate of GDP per hour worked or productivity itself measured by value added per hour worked for total manufacturing industry in 1997 dollar? No, because both measures of productivity have eliminated time effect, they are obtained after dividing GDP per worker or value added per worker by actual hours worked, i.e., hours per year per person in employment, so that unlike the measures of growth rate of GDP per worker or value added per worker, these measures of labor productivity cannot be affected by working hours itself, which can affect GDP per worker or value added per person in employment but not these measures.

On the other hand, hours worked per worker is closely related to an OECD nation’s welfare policy, welfare states typically have lower legal working hours and national’s higher tendency of working less time due to various “generous“ welfare programs. One important measure of welfare policy is tax wedge, the tax proportion of labor cost, so hours worked has strong positive correlation with tax wedge. Hours worked cannot have any effect on productivity other than through its correlation with tax wedge and tax wedge’s effect on

productivity. This is exactly what is required for exogeneity of instrument. The dummy variables for years are exogenous—because the passage of time is exogenous—and so they act as instruments of endogenous explanatory variable.

### **3.4. Checking the relevance of the instrument.**

In addition to Ohanian et al. (2006)'s finding that change in log hours is negatively related to change in tax wedge between 1956 and 2004, Kaitila(2006) also find a very clear negative relation between the average number of hours worked by each 15-64 year old and the average of a single person's and a married person's tax wedge in 2000-04. They also find a negative correlation in 1979-83 albeit with a lower R<sup>2</sup> of 0.403. However, both of them did not give economic explanation for this relationship. As a preliminary inspection of the relationship between tax wedge and its instrument used in this paper, hours worked per worker, I first present a pooled scatter plot of hours worked vs. tax wedge, which clearly shows a negative association between them, workers in welfare states with higher tax wedges, such as Sweden and France tend to work less time than their counterparts in low-tax free capitalist countries, such as USA and Japan. Of course, country-specific institutional or cultural factors play a role here, so I use fixed models with various specifications to examine this relationship rigorously following this initial visual check. I use fixed effect model on the panel data of 28 OECD countries from 1991 to 2004 to check the relevance of the instrument, hours worked, the economic justification for which is as follows: Actually hours worked per worker is determined mainly by three factors, 1) overall technology level, whose advancement with time can "liberate" labor input; 2) specific country's welfare policy regarding labor regulation; 3) specific country's culture regarding national 's attitude towards the relationship between labor and leisure.

Despite the existence of cross-country difference in technology level among OECD nations at each time point, I do not expect it can lead to significant difference in hours worked since this gap among all developed economies in OECD "club" is not prominent. In other words, I expect the factor one is a pure time fixed effect, which is universal to all entities but changing over time. The factor two is



proximately country fixed effect since labor welfare policy is an institutional factor with high time rigidity (constancy). The factor three is also a country fixed effect closely related to the factor two. Typically, welfare countries whose nationals have higher preference to leisure tend to have lower legal working hours and have higher tax wedge than free capitalist countries since labor regulation is closely related to tax policy, both of which constitute two important parts of welfare policy, the institutional infrastructure of welfare nations.

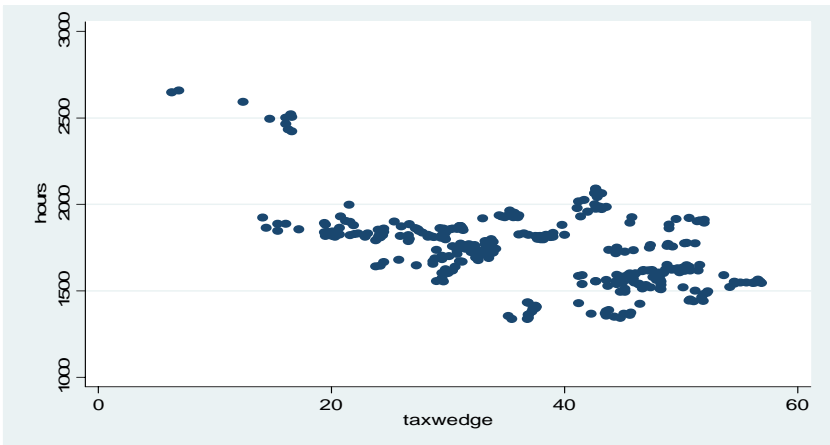


Figure 1.

In the first stage regression used to check the relevance of the instrument, hours worked, the dependent variable is tax wedge and the explanatory variables are hours worked and fixed effect dummy variables for possible country effect and time effect. The regressions (1) to (6) are based on the correlation between working hours and tax wedge represented by the factor two and three in the previous paragraph but now the country and time fixed effects have different explanations. Now the fixed country effect for the factor two and factor three in the last paragraph is captured by explanatory variable, hour worked in the regressions in table 1, the fixed country effect represents country-specific institutional factors affecting tax wedge and the fixed time effect represents time trend of overall tax

policy change for all OECD nations. Comparing the regression (3),(5) and (6) with clustered standard error, we conclude (6) is the best specification for the following reasons: The regression (3) is inconsistent with (5) in that (3) indicates country fixed effect is not statistically significant at 5% level while (5) the opposite when time fixed effect is included. The regression (5) and (6) are consistent in that both indicate significant time fixed effect no matter country effect is included or not.

Table 1 First-stage estimates of the relationship between tax wedge and actual hours worked. Dependent variable: tax wedge

Regressors	(1)	(2)	(3)	(4)	(5)	(6)
Hours worked	-	0.0068	0.0068	-	-0.004	-
	0.026** (0.002)	(0.007)	(0.017)	0.026** (0.002)	(0.022)	0.026** (0.006)
Country fixed effects?	no	yes	yes	no	yes	no
Time fixed effects?	no	no	no	yes	yes	yes
Clustered S.d.?	no	no	yes	no	yes	yes
observations	329	329	329	329	329	329
R-squared	0.285	0.95	0.95	0.29	0.96	0.29
F-statistics for hours (instrument)	180.68	0.96	0.15	174.3	0.04	16.97
Prob>F	0	0.33	0.7	0	0.85	0.0003
F-statistics for country effect	-	717	3.33	-	98924	-
Prob>F		0	0.08	-	0	-
F-statistics for time fixed effect	-	-	-	0.21	2.87	5.0
Prob>F	-	-	-	0.99	0.01	0.0003

These regressions were estimated using panel data for 28 OECD countries for 1991-2004 (excluding 1992). Heteroskedasticity-robust standard errors in parentheses. + significant at 10%; \* significant at 5%; \*\* significant at 1%

Since the significance of time fixed effect is invariant to specification change, it is confirmed that overall advancement of technology level over time is the major determinant of working hours. We can not, however, rule out the possible existence of fixed country effect due to its high correlation with explanatory variable, hours worked as explained above. The F-statistics for the instrument variable, hours worked for the regression (6) is about 17, far exceeding the conventional threshold for instrument relevance check: 10, thus eliminating the weak instrument problem. The relevance of the instrument is confirmed. The change in hours worked is strongly positively related to tax wedge. In fact, one hour increase can lead to 0.26 percentage increase in tax wedge and hours worked accounted for almost 29% of the variation in tax wedge.

### **3.5. Checking serial correlation in the first stage regression.**

To check possible serial correlation among errors in the regression (6) of table 1, I regress the OLS residuals from the regression (6) on all independent variables, including an intercept, and the lagged residual. The t statistic on the lagged residual is a valid test of for the AR(1) model for residuals from the regression (6). The coefficient and t statistic (heteroskedasticity-robust t statistic) for lagged residual are 0.99 and 106.13 respectively, indicating a strongly positive correlation among the residuals. To correct for AR(1) serial correlation, I use the approach of Prais-Winsten transformed Feasible GLS (FGLS) estimation with AR(1) errors. The Prais-Winsten AR(1) regression on quasi-differenced data (with a  $\rho$  value 0.99) gives a coefficient -0.012 (with heteroskedasticity-robust standard error 0.005) and t statistics -2.37 for the explanatory variable hours, confirming the relevance of the instrument hours, despite the fact that the magnitude of the coefficient for hours decreases by about one half after serial correlation correction.

#### *3.5.1. The second stage regression result for productivity growth*

In the second stage, I also test various specifications of different combinations of country and time fixed effects for productivity growth and test their significance separately. The response variable is the growth rate of GDP per hour worked. The estimates from the

regressions (1) to (5) are not reliable since IV estimation is not applied thus endogeneity bias is not taken account, they are there only for comparison purpose. In the TSLS regressions (6) to (9), the instruments for tax wedge is hours worked and dummy variables for fixed time effect. The extra dummy variables for country and time fixed effects on productivity are used and joint significance of them is tested. The IV regressions (6) to (9) suggest neither country fixed effect nor time fixed effect is robust to specification variation, so the regression (9) which is a pooled TSLS estimation gives the best result.

Table 2 Second-stage regression of the effect of tax wedge on the growth rate of GDP per hour worked. Dependent variable: productivity growth

Regressor	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Tax wedge	-	-	-0.017	-	-	0.05	0.107	-	-
	0.0000	1.76e-	(0.056	0.01	1.76e-	5	(0.19)	0.086*	<b>0.08</b>
	2	06	)	7	06	(1.2		*	<b>5**</b>
	(0.02)	(0.01)		(0.0		4)		(0.03)	<b>(0.0</b>
				8)					<b>3)</b>
Country effects?	no	no	yes	yes	no	yes	yes	no	no
Time effects?	no	yes	yes	yes	yes	yes	no	yes	no
Clustered s.d.?	yes	no	no	yes	yes	yes	yes	yes	yes
IV estimation	no	no	no	no	no	yes	yes	yes	yes
F-statistics for country effect	-	-	7.71	159	-	320	0.40	-	-
				4		7			
Prob>F	-	-	0	0	-	0	0.53	-	-
F-statistic for Time effects	-	0.74	0.78	1.96	1.51	1.88	-	1.53	-
Prob>F	-	0.71	0.67	0.07	0.18	0.09	-	0.17	-
Obs.	327	327	327	327	327	324	324	324	324
R-square	0	0.02	0.29	0.29	0.02	0.28	0.24	-	-

These regressions were estimated using panel data for 28 OECD countries for 1991-2004 (excluding 1992). Heteroskedasticity-robust standard errors in parentheses. + significant at 10%; \* significant at 5%; \*\* significant at 1%

The nonexistence of both fixed entity effect and time effect indicates that there is no country-specific determinant of labor productivity

*growth* that is constant across time, this may be due to the fact that the effect of institutional factors that affect productivity and have higher time persistency (constancy) is partially captured by tax wedge or in other words, there is high collinearity between them.

What is more surprising is that there is no universal determinant of labor productivity growth, which is the same to all OECD nations and change with time. The absence of time fixed effect implies that technology promotion power for productivity *growth rate* vary among countries if technology is the major driving force of productivity growth. Some countries have faster productivity growth under global technology progress. This country-specific technology advancement over time, which is neither fixed country effect nor fixed time effect so cannot be captured by fixed effect model. Our model can only rule out a universal time effect for all countries. In another respect, the fact that labor productivity measured by GDP per hour worked has different growth rates among OECD nations during the period 1991-2004 may be partially explained by institutional factor tax wedge and possibly fixed effect from other institutional factors, which are country-specific and time-variant (possibly due to some policy changes over time). The absence of fixed country effect may only be due to multicollinearity problem rather than a real absence of fixed nation effect for institutional factors that affect labor productivity but remain constant across time.

### 3.5.2.. *The second stage regression result for log of productivity*

Now the response variable changes to log of value added per hour worked in 1997 US\$, then the estimate of tax wedge represent its effect on the growth rate of productivity too. Among the regressions (6)-(8), the specification of (6) is the best since the regression (7) and (8) includes individual country effect and time effect respectively, but neither of them is significant at 1% level, indicating that merely inclusion of one effect (either country or time effect) is not correct specification. On the other hand, the F-statistics for both country effect and time effect in the regression (6) are significant at 1% level, suggesting both effects should be included. Compare the regression (4), the pooled OLS version of fixed effect model with the regression (6), the TSLS version, the estimates for tax wedge change from being

insignificant to significant. The estimates of tax wedge for productivity growth from Table (2) and log of productivity from Table (3) are very close, -0.085 vs. -0.093 with clustered robust standard errors 0.03 vs. 0.038, verifying the accuracy of our estimate of the effect of tax wedge. The existence of both fixed entity effect and time effect indicates that there is country-specific determinant of labor productivity *itself* that is constant across time (most likely nation-level institutions), and there is a universal determinant of labor productivity itself (rather than productivity growth), which is the same to all OECD nations and advance over time, possibly global technology advancement.

Table 3 Second-stage regression of the effect of tax wedge on value added per hour worked in 1997 US\$: Dependent variable: productivity

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Tax wedge	0.021 (0.014)	0.021 (0.005)	- 0.02* (0.008)	-0.02 (0.02)	0.021 (0.014)	- <b>0.093*</b> ( <b>0.038</b> )	- 0.08 (0.048)	0.044 (0.027)
Country effects?	no	no	yes	yes	no	yes	yes	no
Time effects?	no	yes	yes	yes	yes	yes	no	yes
Clustered s.d.?	yes	no	no	yes	yes	yes	yes	yes
IV estimation	no	no	no	no	no	yes	yes	yes
F-statistics for country effect	-	-	739.2	107.2	-	737	3.53	-
Prob>F	-	-	0	0	-	0	0.08	-
F-statistic for Time effects	-	1.78	23.35	23.95	7.74	6.6	-	2.65
Prob>F	-	0.08	0	0	0	0	-	0.05
Obs.	148	148	148	148	148	145		145
R-square	0.15	0.24	0.96	0.96	0.24	0.86	0.81	0.06

These regressions were estimated using panel data for 15 OECD countries for 1991-2001 (excluding 1992). Heteroskedasticity-robust standard errors in parentheses. + significant at 10%; \* significant at 5%; \*\* significant at 1%

### **3.6. Checking serial correlation in the Second stage regression for productivity growth.**

I add the one-period-lagged values of the residuals from the IV regression (9) in the table 2 to the regression (9), re-run this extended model by TSLS, using the same instruments from before, in addition to one-period lagged residuals. I get a coefficient 0.322 with a heteroskedasticity robust t statistics 4.15 for the lagged residual, so there is evidence of positive serial correlation in the regression (9) errors. Alternatively, as the serial correlation check for the first stage regression, I change the dependent variable of the regression (9) to the residuals from this regression and add lagged residuals to explanatory variables, the transformed IV regression yields exactly the same parameter and t statistics for the lagged residuals. To correct for the presence of AR(1) serial correlation, I also use FGLS estimation by applying quasi-differenced data (including the dummy variables) to the IV regression (9). For example, the dependent variable becomes to:

$$productivity_{it} - 0.322 * productivity_{it-1}$$

The IV regression on the quasi-differenced data (including differenced dummy variables as instruments for differenced hours) yields a coefficient, a Heteroskedasticity-robust and clustered standard error and t statistic of **-0.082**, **0.031**, and **-2.67** respectively, which is quite close to prior-serial-correlation-correction results (**-0.085**, **0.031** and **-2.78**). In this particular case, the serial correlation among residuals from the IV regression does not bias the estimate for the explanatory variable of our interest.

**3.7. Re-checking endogeneity of tax wedge.** Since I have identified the best specification for structural equation for labor productivity growth, I can re-check endogeneity of tax wedge to confirm that TSLS rather than OLS is the appropriate estimation method. The procedure is as simple as follows:

(i) Estimate the reduced form for tax wedge by regressing it on all exogenous variables (including those in the structural equation and the additional IVs, i.e., hours and 12 dummy variables for years). Obtain the residuals,  $v^2$ .

(ii) Add  $\hat{v}^2$  to the structural equation (which includes tax wedge ) and test for significance of  $\hat{v}^2$  using an OLS regression. If the coefficient on  $\hat{v}^2$  is statistically different from zero, we conclude that tax wedge is indeed endogenous. We will use a heteroskedasticity-robust t test. The coefficient for  $\hat{v}^2$  turns out to be 0.12 with a standard error 0.02, a t value of 5.38 confirms that tax wedge is endogenous and we have used the **correct** estimation approach, taking into account that the instrument relevance was tested before and instrument exogeneity is quite reasonable (GDP per hour worked will never be affected by hours worked)

### **3.8. Checking functional misspecification of two stage regressions**

As pointed out in the beginning, one of the threats to internal validity of multiple regression is functional misspecification. I use Ramsey's (1969) regression specification error test (RESET) to check functional misspecification for the second stage regression. This test is adding the square and cubic of the fitted values from the regression (9) in the table 2 to the original regression (9) and testing the joint significance of the added terms. The F statistic for testing joint significance of added terms is 2.33, p value is 0.12, therefore we do not reject the specification of the regression (9), which seems to have no missing nonlinearity as shown by the test statistics. The same method applied to the IV regression (6) of table 3 for log of productivity yields a F-statistic of 2.22 with p value of 0.15, which indicate absence of missing nonlinearity too. The same test applied to the first stage regression gives a F statistic 0.05 and p value 0.96, strongly rejecting functional misspecification too.

## **4. Conclusions: Economic and Policy implication of the estimates**

The regression(9) in the table 2 and regression(6) in the table3 indicate that one percentage point increase in tax proportion of labor cost can lead to about 0.09 percentage decrease in labor productivity growth rate, which apparently has practical significance too. This relationship cannot be easily shown in a simple scatter plot of productivity growth against tax wedge because of the confounding effects of the omitted variables. Comparing the OLS regression (1)



with the TSLS in the table 2, we can see that the estimate of tax wedge effect on labor productivity growth changes from being strongly insignificant to strongly significant, likewise, the same pattern exists in the OLS regression (4) and TSLS regression (6) in the Table3. The endogeneity bias is the source of debates over economic performance of welfare states in both academia and press. Carefully addressing this critical issue can lead us to more accurate and robust conclusions.

The policy implication is stern: The major characteristic feature of tax policy for welfare states, also called democratic socialist countries, high tax wedge, which is also the foundation supporting modern welfare state system, is also one of the sources of productivity slowdown. In the long run, higher tax wedge in welfare states will lead to lower growth rate of labor productivity, thus lower standard of living, compared to developed countries with less government intervention in economy. Because small changes in a country's growth rate can have profound impacts on standards of living when compounded over time, this long-time neglected effect of tax policy on productivity (rather than on unemployment) should be a great concern for both researchers and policy makers and merits serious deliberation over the role of government's economic role and the extent of government intervention in economy.

More future work can be done to provide theoretical explanation for this economic effect of tax wedge on productivity, but empirical study based on robust econometric analysis gives us more evidence for doubting the future of welfare state economic system.

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