Wage Rigid: The Relationship between Real Output and Wage with or without Monetary Policy

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Abstract. The relationship between real wage and output is a major area of interest within field of both macroeconomic and microeconomic. Labour market has intimate relationship with wage determination, and the wage level, representing individual's earning and in turn affect level of poverty and living standard to some extent. This paper uses a series of regression econometric models to examine the relationship between real wage and real output level. This paper also assesses impact of different monetary policy on this relationship, either under interest target or free interest rate. Additionally, results from the economic models would be used to compare with that from Keynesian theory. Identify the relationship between wage and output would be helpful for the government to make policy decision. In a way to boost economic growth sustainably and raising living standard.

Keywords: Output; Wage; Monetary Policy.

1. Introduction

The relative movements between real wage and output has been studied by many researchers from different countries. For instance, the Keynesian macroeconomic theory assumes in the labour market, the nominal wage is inflexible (or sticky) in a downward direction. Because in his model, workers are not willing to accept a reduction in the money rate when the labour demand decrease and resulting in a certain level of unemployment. In his theory, nominal wages are considered an exogenous factor and can be determined by the union. The labour union will protect labour rights and negotiate a higher nominal wage rate to maintain real wages, and union's strength would increase when labour participation rise. Keynesian points out that the increasing wage might cause involuntary unemployment which might further harm the economic. Therefore, when the real wage increase, following the Keynesian upward-sloping AS curve, the level of output would eventually fall. However, previous research has established some shortcomings in the Keynesian IS-LM model framework, therefore the relationship between GDP and wage determined under this model might be controversial. This paper is then going to use different econometric model to examine the relationship then compare the results with Keynesian theory and investigate whether or not the Keynesian IS-LM model is insufficient to describe the entire image of economics. This paper would be divided into five parts: 'data and methodology', 'empirical results', 'discussion' ,'restriction of the model' and 'conclusion with political suggestion.' Specifically, 'empirical results' consists the main data analysis of this paper. Moreover, the 'discussion' part is an extension of the data analysis, which would give a view of whether the results after the OLS regression agree with the relationship described from the Keynesian model and the corresponding reasons.

2. Literature review

Although many researchers had examine the relationship between wage and GDP, there have not been a clear final conclusion of exactly what this relation is. Also since different methods are employed by each researcher, this relationship concluded in several papers become more confusing. For instance, Afia Malik and Ather Maqsood Ahmed, they concluded that, on the basis of the empirical literature studied, the relation between the evolution of wages and output does not exist in any particular direction. Moreover, the study estimates that the relationship between real wages and production is complex and inconclusive. This paper notes that any fluctuation in the real wage rate has a major impact on poverty and income distribution. However, when the relationship between

output and real wages is estimated separately for the agriculture, transportation, communications and construction sectors in the form of the first logarithmic difference, none of the coefficients is significant. In addition, Amarasekara , C and Bratsiotis , concludes results that are consistent with the assumption, that the increasing return to scale can reverse the countercyclicality of real wages during demand shocks in favor of the pro-cyclicality of real wages. As a result, higher wages may have a positive effect on GDP.

Also, another factor that cause the difference result in different research regards to relationship between wage and GDP, is the the degree to which wages are rigid. In Takeshi Kimura and Kazuo Ueda's paper, they investigates the degree of wage rigidity in Japan applied national data, and including the time when Japan experienced a period of inflation close to zero. This dissertation estimates wage equations and tests the hypothesis of downward wage rigidity. The author then concludes that there is sufficient evidence to show that downward wage rigidity exists based on the data he used. Which is agreed by the book 'Macroeconomics 7th Global edition' by Olivier Blanchard, and also a negative relationship between wage and GDP is concluded under IS-LM model framework. Takeshi Kimura and Kazuo Ueda then use the information from the same data set, extended it to cover the period until the beginning of 2000. However, the results shows the downward rigidity disappears. Additionally, in the text book written by Ghosh, C. and Ghosh, A. N, supports this view that wage rigidity may not exist and points out the shortcoming of the old Keynesian model with deep analysis. Specifically, it states that the linkage between the real sector and the financial sector described in Keynesian IS-LM models are highly inadequate. They cannot ,therefore, be used at all for any meaningful analysis of capitalism.

Thus by comparing Keynesian model and NEO-classic model , summarize by Rosalind Levacic and Alexander rebmann. In their book, it compares and explained the contradict findings about relationship between wage and output. Where former and negative and the later is positive. Moreover, the paper 'Relative Movements of Real Wages and Output' written by Keynes Mar, expecting both the real wages and money wages developed and fluctuated along the same line as each other.

In addition, the intervention by the government may or may not disrupt the impact of interest rate to GDP level. Amarasekara , C and Bratsiotis of the paper ' Monetary Policy and Real Wage Cyclicality' conclude the influence of Monetary policy is insignificant. 'Three Essays on Effects and Responses of Monetary Policy' states although the effects of monetary policy on real GDP in Korea are different across halves, but the monetary policy always has strong wage rigidity under the current wage setting practice in Korea. The analysis is carried out using a simple DSGE model in the essay 'Monetary policy when wages are downwardly rigid', using a simple DSGE model where money serves a medium of exchange and the cost of nominal wage changes may depend on both sign and magnitude of the adjustment of monetary policy. 'What Does Downward Nominal-Wage Rigidity Imply for Monetary Policy' observed that: Based on observations on how the distributions of prices and wages grow over time. There is little or no significant evidence of downward wage or price rigidity. Furthermore, there is no evidence that the Phillips curve in the UK is significantly non-linear.

3. Empirical results

3.1 Data

In order to identify the real relationship between 'GDP' and 'Wage', a qualitative case study is a well-established approach. Recall this essay will focus on identifying whether a causal relationship exists between the two variables, and in which direction are those impacted. Therefore, econometric models are specified to study real-wage output relationships, based on the collected dataset. The data used in this paper are from the World Development Indicators in the world bank website, which are statistical data from governments and other institutions. The data contains changes in seven variables between 1991 and 2021, each of the variables has data size of 22. Including the dependent variables such as 'GDP（current US）'and important independent variables like 'wage and salaried workers, total' with mean of 93.058 and the 'Real interest rate (%)' with mean around 2.65.

Variable	Obs	Mean	Std. dev.	Min	Max
Years	22	2010.5	6.493587	2000	2021
GDPcurrentUS	22	1.59e+13	3.74e+12	1.03e+13	2.30e+13
GDPgrowtha~l	22	1.997632	1.978999	-3.40459	5.671107
Realintere~e	22	2.651265	1.613746	-.8692492	6.813424
Wageandsal~l	22	93.058	.4808584	92.43	93.91
Employment~o	22	59.71927	2.119105	55.979	63.455
ExpenseofGDP	22	22.64465	3.037576	17.92654	32.93573
Exportsasa~t	22	1.83e+12	4.35e+11	1.23e+12	2.52e+12
Finalconsu~c	22	1.28e+13	2.76e+12	8.20e+12	1.74e+13
Giniindex	22	40.86	.4213357	40	41.5
Inflationc~u	22	2.242779	1.178895	-.3555463	4.697859
TradeofGDP	22	26.73692	2.623024	22.28637	30.84249
Unemployme~l	22	5.956364	1.801659	3.67	9.63
Realeffect~d	22	110.123	9.133056	95.00913	126.2221
Portfolioi~P	22	-3.40e+11	2.67e+11	-8.08e+11	3.22e+10
Netinvestm~a	22	2.23e+11	5.22e+10	4.27e+10	2.90e+11
Grossnatio~r	22	1.61e+13	3.41e+12	1.06e+13	2.20e+13
R	0				

Fig. 1 Descriptive Statistics

3.2 Module Assumption

According to Woodridge's Introductory of econometrics 5th edition book we applied the same SLR and MLR model assumption for model1 and model2 respectively. These assumptions include: (1) the model is linear(2) there is no multicollinearity; (3) the independent variables and error terms are not correlated; (4) the error terms are homoskedastic and are not(5) the error terms follow a normal distribution. Each of these five assumptions is essential to ensure the existence, consistency and validity of the OLS results. Ignoring them may lead to biased estimates of the parameters of the econometric model. There are allowances for some of the assumptions(2-4) of not holding so strictly. However, Linearity is the key assumption of the normal linear model and if it fails, then the linear model is inadequate.

Therefore, a simple linearity test is necessary before we build a linear econometric model for rest of the paper. To test relationship between dependent variable 'GDP' and the main control variable 'wage' is carried out by plotting a scartter graph, 'wage' against 'GDP', which displayed as plot-1 below. It shows a strong association and linear relationship between two variables. The second graph plots other variable 'interest rate' against 'GDP' and 'interest rate' against 'wage'. It is obvious that the association is not that strong, however, they are still related. Therefore, it is safe to draw the conclusion, both two models that mentioned earlier, are safe to use to investigate their effects further.

The primary method of this paper is to build several econometric models. Regress the explanatory variable to each of the controlled variables. Then running regression using STATA, and identify both the economic and statistical implications behind the model regression results. Generally, the constant $\beta_0 \ldots \beta_i$ are the parameters of the econometric model, and they describe both the directions and strengths of the relationship between independent variables and dependent variable 'GDP'. Particularly for this essay, the hypothesis is equivalent to $\beta_1 = 0$.

Firstly, start with a simple model. In model 1, only wage is considered as the explanatory variable(i.e. a simple linear model). Where β_0 denotes the interception term, β_1 represent

coefficients for the explanatory variable 'logwage', ε denote error term, which include other factors that can influence GDP level other than 'log wage'. According to Figure-1, β_1 is around 38.9, which means a one percent increase in wage, total GDP would rise by about 38.9%, at ceteris paribus. The P value for variable 'logwage' is 0.000. That is, at 0.01% significant level, P value is smaller than the significant level, thus we have sufficient evidence to reject null hypothesis that $\beta_1 = 0$. Thus variable 'logwage' is significant to determine 'GDP'. The Adjusted R -squared is 0.7338, which indicates that around 73% of the sample variation in the 'GDP' is explained by the variable wage'.

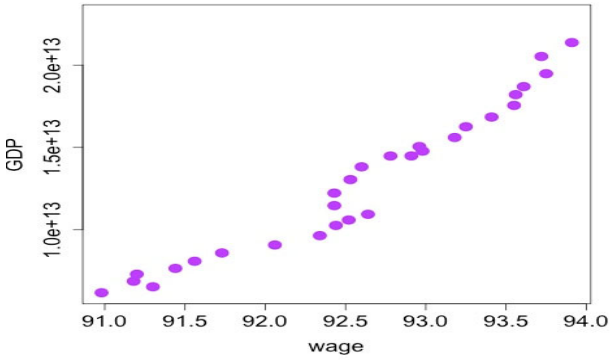


Fig. 2 Relationship of Wage and GDP

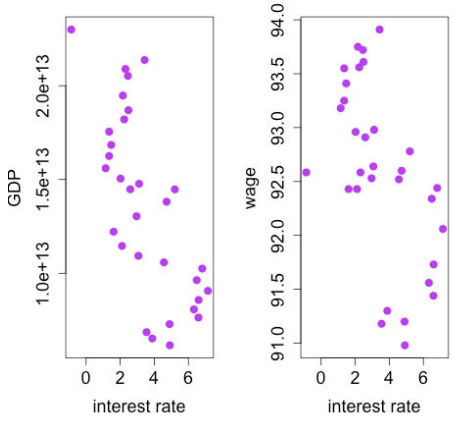


Fig. 3 Relationship of Interest Rate and GDP, Wage Respectively

$$logGDP = \beta_0 + \beta_1 * logwage + \varepsilon \quad (1)$$

Source	SS	df	MS	Number of obs	=	22
				F(1, 20)	=	47.27
Model	.848198245	1	.848198245	Prob > F	=	0.0000
Residual	.358881758	20	.017944088	R-squared	=	0.7027
				Adj R-squared	=	0.6878
Total	1.20708	21	.05748	Root MSE	=	.13396

loggdp	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
logwage	38.91314	5.659894	6.88	0.000	27.10681	50.71947
_cons	-146.032	25.65751	-5.69	0.000	-199.5527	-92.51142

Fig. 4 Relationship between Wage and GDP

Then equation 2 includes a new variable real interest rate, denote as 'interest rate' in equation 2. (i.e. multiple linear models). Similarly, β_0 denotes the interception term, β_1 represent coefficients for the explanatory variable 'logwage', and β_2 represent coefficients for the explanatory variable 'interest rate', ε denote error term, which include other factors that can influence GDP level other than 'log wage' and 'interest rate'. Referring to Figure 2, coefficient for 'logwage' and 'interest rate' are around 34.1 and -0.04. Negative value of β_2 indicates, a one unit increase in 'interest rate' would decrease 4% in 'GDP'. P value for 'log wage' and 'interest rate' are 0.000 and 0.034 respectively. These means that at 0.01% significant value and 5% significant level respectively, we have sufficient evidence to reject null hypothesis. Thus both variables 'logwage' and 'interest rate' are significant determining the dependent variable 'GDP'. The adjusted R-squared is 0.797, suggesting around 80% of the variation in 'GDP' can be explained by the controlled variable 'interest rate' and 'Wage'.

Source	SS	df	MS	Number of obs	=	22
				F(2, 19)	=	31.27
Model	.925822002	2	.462911001	Prob > F	=	0.0000
Residual	.281258001	19	.014803053	R-squared	=	0.7670
				Adj R-squared	=	0.7425
Total	1.20708	21	.05748	Root MSE	=	.12167

loggdp	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
logwage	34.09268	5.555019	6.14	0.000	22.46589	45.71947
Realinterestrate	-.0407113	.0177784	-2.29	0.034	-.077922	-.0035006
_cons	-124.0719	25.19998	-4.92	0.000	-176.8161	-71.32777

Fig. 5 Relationship between Wage,Interest Rate and GDP

$$logGDP = \beta_0 + \beta_1 * logwage + \beta_2 * interest\ rate + \varepsilon \quad (2)$$

In addition to equation 2, equation 3 also includes a new variable inflation rate, denote as 'inflation'. Similarly, β_0 denotes the interception term, β_1 represent coefficients for the explanatory variable 'logwage', and β_2 represent coefficients for the explanatory variable 'interest rate', β_2 is the coefficients for the explanatory variable 'inflation', ε denote error term, which include other factors that can influence GDP level other than 'log wage' , 'interest rate' and 'inflation'. Referring to Figure 3, coefficient for 'logwage' and 'interest rate' are around 36.9 and -0.039 respectively. Also, β_2 is around 0.032, meaning one unit increase in 'inflation' would decrease about 3.2% in 'GDP'. P value for 'log wage' and 'interest rate' are 0.000 and 0.037 respectively. These means that at 0.01% significant value and 5% significant level respectively, we have sufficient evidence to reject null hypothesis. Thus both variables 'logwage' and 'interest rate' are significant determining the dependent variable 'GDP'. By contract, P-value for 'inflation' is large, at 0.191, meaning that at 1% significant level, we have insufficient evidence to reject null hypothesis. This suggest, 'inflation' shows weak influence to 'GDP'. Thus, 'inflation' should been dropped in order to keep the model simple and easier for analysis.

$$logGDP = \beta_0 + \beta_1 * logwage + \beta_2 * interest\ rate + \beta_3 * inflation + \varepsilon \quad (3)$$

According to all three table, the p value for 'wage' is all small, meaning the variable 'wage' is significant when determining real output level. Therefore, it is safe to say that the economic model are valid to analysis relationship between 'wage' and 'GDP'. And worth for further analysis.

Comparing important statics of Figure 1 and 2, first noticing the estimated value of coefficient of 'wage' β_1 decreased from 38 to 34. This indicates, statistically, that model1 introduced omitted variable bias, the module tends to overestimate the significance of 'wage' when delivering the estimated result. Also this means that change in 'interest rate' impact negatively on 'wage'. Meanwhile, it is also worth mentioning the economic meaning of the change in β_1 value. Equation

2 provides a ceteris paribus condition of keeping 'interest rate' fixed while we analysing how change in 'wage' would affect 'GDP'. This simulation is equivalent as keeping an interest rate target in real life. Thus a smaller β_1 value implies, that when the interest rate is kept fixed, a change in the 'wage' would have relatively reducing effect on 'GDP'. The improved adjusted R-squared implying that after adding the variable' interest rate', more variation in 'GDP' can be explained. The increased P-value also emphasizes to use model2 would be more appropriate than the model1, In a way that the estimated result is closer to the real result, and the underlined economic relationship can be explained closer to reality.

Source	SS	df	MS	Number of obs	=	22
				F(3, 18)	=	22.39
Model	.951994927	3	.317331642	Prob > F	=	0.0000
Residual	.255085076	18	.014171393	R-squared	=	0.7887
				Adj R-squared	=	0.7535
Total	1.20708	21	.05748	Root MSE	=	.11904

loggdp	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
logwage	36.97177	5.833495	6.34	0.000	24.71605	49.22749
Realinterestrate	-.0391717	.0174318	-2.25	0.037	-.0757946	-.0025488
Inflationconsumerpricesannu	.0322515	.0237318	1.36	0.191	-.0176071	.0821101
_cons	-137.1999	26.48125	-5.18	0.000	-192.8349	-81.56482

Fig. 6 relationship between wage, interest rate, inflation and GDP

Another discovering from above two figures, is that in Figure 2, the new variable 'Real interest rate' shows a negative relationship with 'GDP'. Meaning when there is no interest rate target(i.e. we allow the interest rate to respond to the change in other economic terms) the real interest rate increase by one unit(percentage), and the relevant GDP level would fall. This makes sense, as a rising interest rate not only raises the cost of borrowing that reduces the level of investment, but also the exchange rate would rise, namely appreciation. This appreciation in domestic currency will leads to a rise in price of domestic goods relative to foreign goods. Which generate a decrease in net exports, resulting a fall in aggregate demand and therefore a decrease in output level. The above analysis are based on the view of Keynesian economic. According to the IS-LM model, assumed in an open economy, is given by:

$$IS: Y = C(Y-T) + I(Y,i) + G + NX\left(Y, Y^*, \frac{1+i}{1+i^*}\bar{E}^*\right) \tag{4}$$

$$\text{LM}: \ \text{i} = \text{i}^* \tag{5}$$

Where i denote 'interest rate' and relationship as shown as $I\big(Y(+), i(-)\big)$. Also, the relationship can be shown in the following diagram FirgureA-1 . To conclude. when the interest rate increase, the opposite effect would happen to component I, therefore have negative impact on Y, which is equivalent to 'GDP' in our model.

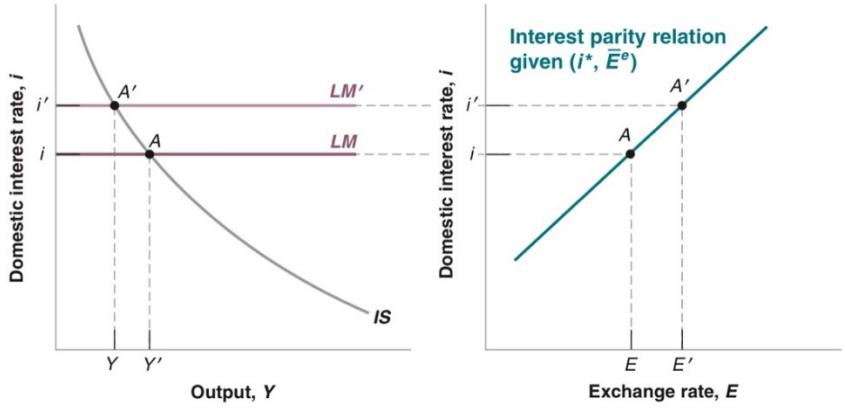


Fig. 7 relationship between interest rate and output, interest rate and exchange rate respectively

Above all, above Figures (A-1) shows that 'wage' have a positive impact on 'GDP'. This important result, however, contradicts with the relationship described in the Keynesian IS-LM model. One possible explanation for this positive relationship, could be that rising real wage would increase labour productivity and individual incomes thus improve level of output, based on the premise that the resulting inflation is not too high. However, the later view suggest rising real wage not only generate unemployment but also reduce final output.

4. Discussion

Follow Keynesian economic framework, the increased real wage would eventually decrease the demand of labour, therefore results in certain level of unemployment. Then the output level, that could be produced by the current employment level, determined by the AS curve Y0, is less than the current demand output level Y1. This implies the final level of output would fall. Which in contract, different from the results in empirical results analysis.

However, Keynesian's model fails to capture the influence of the rising real wage on aggregate demand. In a way, this could raise individual earnings. Which in turn could induce more consumption, or choose savings instead. Savings, in reality, is the most important source of new credit. Obviously, this model underestimates these intimate interrelationships completely. Figure A shows the relationship between wage to aggregate saving level. Secondly, another reason why in Keynesian model wage would impact final output level negatively, is that it excludes the intimate relationship between personal savings and investment. In his model, only factor that could possible influence investment is the change interest rate. Obviously this is not realistic. According Figure B, the p values is 0.05. This implies that at 5% significant level, we have sufficient evidence to reject null hypothesis, that personal savings, has significant effect on determining the investment level. More over, Figure C shows the importance of 'Investment' to 'GDP'. The p-value for 'portfolio investment' is 0.012.

Source	SS	df	MS	Number of obs	=	21
				F(1, 19)	=	65.34
Model	.88042539	1	.88042539	Prob > F	=	0.0000
Residual	.256025945	19	.01347505	R-squared	=	0.7747
				Adj R-squared	=	0.7629
Total	1.13645133	20	.056822567	Root MSE	=	.11608

logsaving	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
logwage	39.64551	4.904705	8.08	0.000	29.37984	49.91117
_cons	-151.1197	22.23407	-6.80	0.000	-197.6562	-104.5833

Fig. 8 relationship of wage to savings

Meaning that at 5% significant level, we have sufficient evidence to reject null hypothesis, Thus gives the conclusion that investment is significant to determine GDP level.

In summary, Keynesian model underestimates the importance of the financial sector in determining the real output level. This is one of the shortcomings of his IS-LM model. This implies his result is highly biased and misleading. Therefore, the positive relationship resulted in above regression analysis might be closer to the reality than the Keynesian's.

Source	SS	df	MS	Number of obs	=	21
				F(1, 19)	=	4.39
Model	2.5537e+23	1	2.5537e+23	Prob > F	=	0.0498
Residual	1.1055e+24	19	5.8183e+22	R-squared	=	0.1877
				Adj R-squared	=	0.1449
Total	1.3608e+24	20	6.8042e+22	Root MSE	=	2.4e+11

PortfolioinvestmentnetBoP	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
Grossdomesticsavingscurrent	.1695632	.080937	2.10	0.050	.00016	.3389664
_cons	-8.17e+11	2.26e+11	-3.62	0.002	-1.29e+12	-3.44e+11

Fig. 9 relationship of savings to investment

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. reg GDPcurrentUS PortfolioinvestmentnetBoP Netinvestmentinnonfinanciala
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Source	SS	df	MS	Number of obs	=	22
				F(2, 19)	=	7.16
Model	1.2600e+26	2	6.3002e+25	Prob > F	=	0.0048
Residual	1.6721e+26	19	8.8008e+24	R-squared	=	0.4297
				Adj R-squared	=	0.3697
Total	2.9322e+26	21	1.3963e+25	Root MSE	=	3.0e+12

GDPcurrentUS	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
PortfolioinvestmentnetBoP	6.710995	2.424652	2.77	0.012	1.636141	11.78585
Netinvestmentinnonfinanciala	31.64938	12.39846	2.55	0.019	5.699102	57.59966
_cons	1.11e+13	2.96e+12	3.76	0.001	4.93e+12	1.73e+13

Fig. 10 relationship of investment to GDP

5. Limitations of the model

Firstly, one limitations in the modelling approach of structural econometric models: the 'simple to complex' approach to structural analysis leads to different researchers saying different things about the same issue, with results varying widely and even being completely incomparable. The economic, logical and mathematical foundations of structural analysis for aggregates are solid and reliable, but it can only be used for structural analysis of aggregates, not samples. In this case, if model1 or model2 is tested using data that from different labour market(e.g.:manufacture, argriculture, technology etc.). Obviously, the model might come out with different result, so the positive correlations that we observed could be misleading. . Another reason why model might be restricted, is the Data recourse. There is no guarantee the process of data collection is completely random, so the empirical result will be biased to some extent. In addition, each country has different economic and political background. Such as the degree of wage stickiness appears different between countries. Therefore the magnitude of the coefficient term under same econometric model could turns out be very different. Indicates the previous empirical result can only be used to emphasis importance of wage to GDP in the U.S., but not applicable to other nations.

Secondly, regards on the method we use while deciding the econometric model. The p-value tests used in this paper can only identify variables that are not significant if they are included, but not if they are not. This means, at the end, there is still a change the final model has omitted variable bias. More importantly, if the three explanatory variables included in the model are not completely independent of the two missing variables (which is hardly ever the case in real economic activity), then their parameter estimates are not a true reflection of their relationship with the explanatory variables.

Thirdly, in economics, the overall regression model must reflect real economic behaviour, and the relationships between variables in real economic activity are complex. If only some of the variables

are introduced into the model, the structural relationship between the explanatory variable and particular variable that we are interesting about is correct only at ceteris paribus condition. Unfortunately, in reality this condition is not achievable.

Finally, 'Exogeneity' as a model necessarily assumptions. In order to let the regression results to be valid, it is necessary to ensure that the independent variables in the econometric model are exogenous. If the variables are endogenous, this will result in the estimation results not satisfying the parameter consistency condition. But in reality there is no guarantee that the increase in wage is completely exogenous. So this assumption may not be satisfied by either the econometric model this paper used or by Keynesian's economic theory.

6. Conclusion

According to the result of the study, and the possible restriction of the econometric model, the relationship between GDP and wage is sophisticated to define and also inclusive. It is controversial to define the relationship simply, based on only one economic model, not to mention that data is only collected from one country. However, the implication behind the model is reasonable and worth further exploration. In the U.S., statistically, wage has a positive effect on the level of output, although this result departure from what the Keynesian model expected.

Different country has different political system, therefore it is sophisticated to give any political implication. However, the empirical result does show that interest rates will reduce a certain degree of the positive impact on the level of output in U.S.

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