The capital intensity factor that contributes to the United States Skilled Worker's Average Wage Stagnation

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Abstract: Over the past 45 years, whereas the GDP has grown, skilled workers in America have experienced trivial increase in real wage. We find the stagnation a result of two periods of increase and one period of decrease in wage. This research aims to analyze this phenomenon and contributes to the study of the causes of wage fluctuation through a microscopic lens. This paper is unique from previous studies in methodology. We present our analysis by combining both macro and micro indicators. We incorporate capital investment and Marginal Revenue Productivity Theory, which we relate to productivity, in our study. Further, we use a multiple linear regression to establish a more solid quantitative support to the discussion. The variables we use in the regression are work hours, productivity, capital input, capital intensity, and real wage. The paper finds a strong correlation between average wage and capital intensity. This conclusion could help policymakers to design policies beneficial to skilled workers in the future.

1. Introduction

Beginning in early 1970s, American workers have experienced unprecedented wage stagnation, despite flourishing economy overall; While there has been a fourfold increase in real Gross Domestic Product (GDP), real hourly wage for average workers have stagnated. This observation contradicts with the instinct that wage and GDP are related. In 1972, the average hourly wage was $3.90, an equivalent of $23.39 in 2018; in 2018 (as of Oct 1st), the average hourly wage is $22.61.

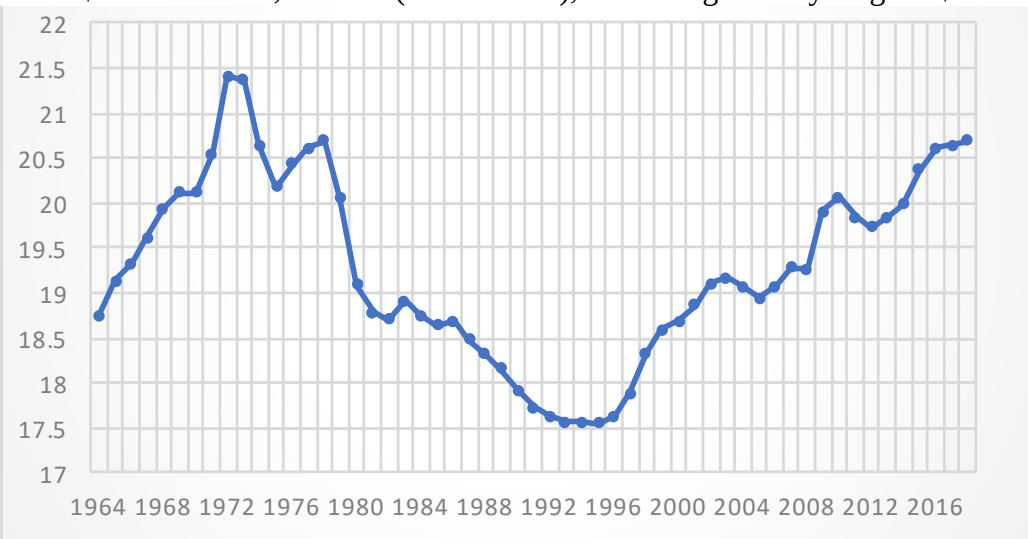

Fig. 1: Real Wage in Dollars/Hour

This paper, essentially, uses the MRP theory to establish an explanation for wage growth. By the nature of productivity and MRP, we can evaluate the correlation between wage and MRP by evaluating the correlation between wage and productivity. We argue that for wage to increase, capital deepening must be at a certain rate. As capital intensity increases, production increases to reach the point where marginal revenue product equals to the wage rate on the micro scale, thus allowing workers' wage to increase. We argue the relationship between wage and MRP through two intermediary steps. First, we relate MRP to productivity. Second, we relate productivity to capital intensity. Thus, a relationship between wage and MRP is determined.

All the data used in this research comes from Federal Reserve Economic Data from the Federal Reserve Bank of St. Louis unless otherwise specified. For raw data in a monthly format, we average the raw data of all 12 month in a calendar year to find the average of that year. For calculating real values (as opposed to nominal values), we used the CPI formula where Price(X) x [CPI(Y) / CPI(X)] = Price(Y). The former method is common and standard for annualizing monthly data. The latter method is common and standard for calculating real values, given nominal values and CPI.

The article is organized as follows. Section 2 presents the literature review. Section 3 discussed wage determination method in the labor market. Section 4 presents the results. Section 5 presents the discussion and the conclusion. Section 6 presents the conclusion of the research.

2. Literature Review

Previous work has shown that there are associations between wage and technology, investment and productivity, and capital intensity and wage. For wage and technology, using firm- level data from Colombia, Mexico, and Taiwan, researchers find that technology investments lead to large wage premiums for skilled workers (Tan and Batra 1997). Studies using plant-level surveys also support the correlation between technology use and wages. For example, Liu used plant-level data to show that technologically advanced plants pay higher wages and employ a greater fraction of skilled workers in the United States (Liu *et al.* 2001). For investment and productivity, studies show that there is a correlation between the two. While investment may not necessarily be sufficient condition, it holds true that investment is a necessary condition for growth. The research uses a production function based upon the Cobb-Douglass model to show that there is a minimum capital requirement for productivity to grow (Solow 1964).[1]

In the West, John B. Clark and Knut Wicksell proposed The Marginal Revenue Productivity Theory of Wages. The Marginal Revenue Productivity Theory of Wages states that wages are paid at a level equal to the marginal revenue product of labor (MRP), which is the increment to revenues caused by the increment to output produced by the last laborer employed. The theory states that workers will be hired up to the point when the marginal revenue product is equal to the wage rate. If the marginal revenue brought by the worker is less than the wage rate, then employing that laborer would cause a decrease in profit.

The paper is unique from previous works that while most literature study wage from a microscopic lens, this paper concentrates on factors contributing to wage from a macroscopic lens. Further, the conclusion is not only theoretical but supported by the statistics.

The paper does not use the Mincerian model for that only imprecise and obscured data is available on the macro scale. Hence, when the paper performs a multiple regression analysis, we do not account in the factors discussed in the Mincerian model.

3. Wage Determination Method in the Labor Market

A firm in a competitive market that wants to maximize profit and determine quantity of production will set the price of a product equal to marginal cost of production.

$$P = MC \quad (1)$$

Similarly, a firm in a competitive market that wants to determine the quantity of labor will set wage equal to the marginal product of labor.

$$W = MP_L \times P \quad (2)$$

From the two equations above, we can see that the marginal cost of production equals to the cost of production, which is wage in this case, divided by the marginal product of labor. Mathematically,

[1] By the nature of production and non-supervisory workers, they are skilled workers. The paper, hence, concerns about skilled labor.

$$MC = \frac{W}{MP_L} \ (3)$$

$$\mathrm{W} = \mathrm{P} \times MP_L \ (4)$$

Dividing both side of the equation by MP_L we get,

$$\text{Equation 5: } \mathrm{P} = \frac{W}{MP_L} \ (5)$$

Substituting (5) with (3), we get (1), which is the profit maximizing rule.

To test out hypothesis we need information on nominal wage, inflation rate, capital input, productivity, work hours, and labor force. For capital input, we use the Current-Cost Net Stock of Fixed Assets: Private: Nonresidential. For nominal wage, we use Average Hourly Earnings of Production and Nonsupervisory Employees: Total Private. For nominal income, we use Personal income per capita. This measure is used because the labor force generates the vast majority of revenue. We calculate inflation rate from the Consumer Price Index (CPI). For labor force we use Civilian Labor Force. For productivity, we use Private Non-Farm Business Sector: Labor Productivity. For work hours we use Average Annual Hours Worked by Persons Engaged for United States.[2] All data come from FRED St. Louis.[3]

We chose the non-residential and private category for two reasons. First, residential capital input does not involve in the production of goods and services directly. Second, government capital input does not directly affect the production of goods and services; While subsidy may function as an incentive for a firm to increase the production, it does not significantly affect the wage of the workers.[4]

We choose nonsupervisory and production employees over all employees for two reasons. First, outsourcing has become a central part of the U.S. economy that supervisory positions will benefit from foreign capital input. If we included supervisory workers, we would have to use a different set of capital input data that is less relevant to the U.S. domestic economy. Second, the output of workers in the secondary sector of the economy are more reliant on capital input than other sectors.[5]

4. Descriptive Analysis on U.S. Employment Composition

On the surface, the American economy has achieved economic success. Unemployment has been falling and reached its low in nearly fifty years (3.7% as of November 2018). The loss of 8.7 million jobs from the Great Recession has recovered, and the market continues to add jobs to the existing labor force. However, the number of manufacturing workers has declined by 71 thousand every year. The majority of the added employment is in the service sector.

[2] Similar methodology and data was used in Mincer's study on income distribution and human capital (1958).
[3] FRED data on civilian labor force is monthly. The paper take the average of the 12 month in each year between 1964 to 2015 to obtain an annualized data.
[4] Similar methodology and data was used in Asano's study on costly reversible investment with fixed costs (2002).
[5] Similar data was used in Hummels' *et al.* (2014) study on the impact on wage from offshoring in Denmark.

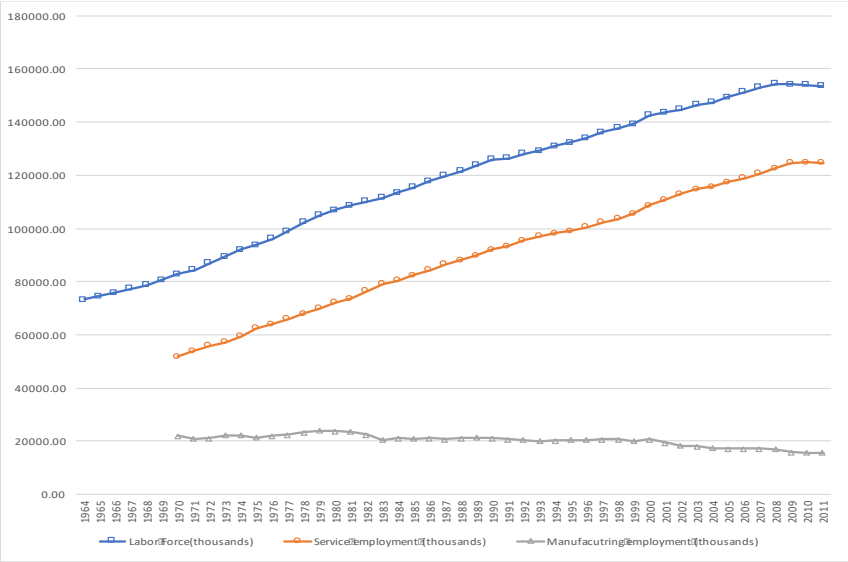

Fig. 2: Labor Force, Manufacturing Employment, and Service Employment (in Thousands)

The change in U.S. employment composition should be attributed to large-scale outsourcing of manufacturing jobs in the 1970s, when the U.S. economy transitioned from a manufacturing- oriented economy to a service-oriented economy. After 1970s, U.S.-based manufacturing and production companies have shifted their production facilities to China and other developing countries. Over the period between 1993 to 2011, for example, outsourcing has generated an overall decline in manufacturing sector employment of 13%. Although the service sector has also encountered outsourcing over the past 45 years, the scale is not comparable to that of the manufacturing industry. The number of people employed domestically in the service sector has been increasing steadily and constantly.

5. Empirical Analysis

We perform a multiple linear regression on the data using ordinary least squares through the SPSS platform. For dependent variable we use real wage, measured in dollars per hour. For independent variables we use capital input (measured in billions of dollar), productivity (2012 productivity = 100), work hours, and capital intensity (measured in billions of dollars over thousands of people). We obtain the following result.

Table 1: Summary and Analysis of Variance of the Wage Determination Model

	Model Summary
R	0.976
R square	0.952
R square (adjusted)	0.943
F statistic	113.304 (0.000)

Note: The parenthetical value is the significance of the F statistic.

From the computation, we see a strong linear relationship between the variables, as evidenced by the statistics. In Table 1, we see that the model has a R value of 0.976, and a R Square value of 0.952, which means that 95.2% of the variation in the data can be explained by the model. Further, the quality of the regression model is good. F statistic is 113.304, and p-value is 0.000. The p-value suggests the model is valid at 95% confidence level. F ratio and the associated p-value suggest that the overall regression model is a good fit for the data.

For functions with the form

$$y_i = \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_p x_{ip} + \varepsilon_i \qquad (6)$$

we have

and

$$S(\boldsymbol{\beta}) = \sum_{i=1}^{n} \left| y_i - \sum_{j=1}^{p} X_{ij}\beta_j \right|^2 = \|\mathbf{y} - \mathbf{X}\boldsymbol{\beta}\|^2 \quad (7)$$

$$\hat{\beta} = \operatorname{argmin}_{b \in \mathbb{R}^p} S(b) = \left(X^{\mathrm{T}}X\right)^{-1} X^{\mathrm{T}} y \quad (8)$$

Table 2: Coefficients of the Wage Determination Model

	Capital input*	Productivity*	Work Hours*	Capital Intensity*
Beta	0.001	-0.102	-0.006	-4.248
t statistic	6.697 (0.000)	-3.894 (0.001)	-3.559 (0.002)	-6.733 (0.000)
Sample Size	52	29	51	52

Note: * indicates that the variable is significant at α = 0.01. The parenthetical values are the respective p-value of the variables.

On individual variables, we see that all variables have a p-value of less than 0.05, which indicates they are all significantly different from 0 at 95% confidence level. The constant β_0 is 43.411. The coefficients β_i for each variable are 0.001, -0.102, -0.006, and -4.248. The t statistic for each variable are, respectively, 6.697, -3.894, -3.559, and -6.773. Hence, the general form of the equation to predict real wage from capital input, productivity, work hours, and capital intensity is:

$$Y_{Real\,Wage} = \beta_0 + (\beta_1 \times capital\ input) - (\beta_2 \times productivity) - (\beta_3 \times work\ hours) - (\beta_4 \times capital\ intensity)$$

6. Discussion and Conclusion

Despite steady increase in the proportion of the service sector in the economy, service sector requires significantly less capital input than the manufacturing sector. For individual workers, capital increment is equivalent to leverage. The more the capital, the higher the leverage, the more output generated, the higher the income. On a macroscale, the higher the capital intensity, the higher the marginal product, thus the higher the income. Hence, if capital intensity stagnates, wage would stagnate accordingly. A higher proportion of service sector would naturally drag down the growth of capital intensity, and then drag down the real wage of the workers.

This research presents practical values for policymakers when determining policies that would increase the benefits of skilled workers in the United States. For instance, state legislators may use the result of the finding to support bills that encourage growth in capital heavy industries.

Despite its novelty and significance, the power of the conclusion, due to its limited sample size, is not optimal. Only 60 years of data is available for use. To address this problem, future research should consider using statistics of greater generality, such as “national gross investment” vis-à-vis “Fixed Assets: Private: Nonresidential.” To further expand the general applicability of the research, future research should analyze data from foreign countries too.

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