# THE EFFECT OF OUTSOURCING ON THE CHANGE OF WAGE SHARE

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ABSTRACT

The technology breakthroughs and tariff reductions of the last several decades have reduced the costs of trade. The classical Heckscher-Ohlin model cannot explain the pattern of the change in nonproduction wage share: the relative wages of nonproduction and production workers increased steadily since 1980s. The increasing wage gap leads to increasing income inequality, growing poverty and strains the social fabric. Hence, we need an alternative approach to explain the increasing "wage gap" between nonproduction and production workers.

Feenstra developed a trade in intermediate model which estimates the how much outsourcing contributes to the total change in nonproduction wage share and compared it with the contribution of computers. He estimated the change in nonproduction wage share in his book, Advanced International Trade (2004). Using the NBER productivity data (Bartelsman and Gray 1996) and imported intermediate inputs data (Feenstra and Hanson 1990) to run his regression, he found that outsourcing and high-tech capital are the main factors. Specifically, he reported that the outsourcing contributed 15-24% and computers (high-tech capital) contributed 13-31% to the total change in nonproduction wage share from 1979 to 1990. Moreover, whether outsourcing is more or less important than computers, depends on how we measure the computers. If we measure computers with the share of investments, it will be more important than outsourcing. If we measure computers with ex-post or ex-ante rental prices, it will be less important than outsourcing.

For this paper, I use an updated data and compare my results with Feenstra's. The NBER data I use is for the years 1958 to 2009 (Bartelsman and Gray 2014) and the intermediate inputs data is updated through 1997. I find that outsourcing contributed 17-28% while computers contributed 9-45%. If we measure computers as the share of investment, it contributes 45%, which is more important than outsourcing. In other measurements like ex-post, computers contribute 14%, which is less important than outsourcing. The fact that my findings are similar to Feenstra's, provides a robustness check on his original findings and gives us more confidence in them.

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# 1. Introduction

In the evolution of the global economy, the last several decades -- which have often been described as the second "golden age" of world trade – have been characterized by dramatic decreases of transportation costs and subsequent rounds of bi- and multi-lateral reduction of trade barriers. The associated increase in the volume of international commerce has not been confined to final goods; there has also been a significant increase of trade in the "production activities". What we mean by this is that different stages of production can occur at different places and the production stages need not be tied to where the ultimate consumer is located. Thus, the fragmentation of production is being assisted by the fall in transportation costs. Not only has transport costs fallen, but improved (communication) technology has increased the fragmentation of the production process. These relatively new features of globalization invite us to look at the consequences of outsourcing and fragmentation of the production process. The classical models of international trade have trouble explaining the observed pattern of trade and the impact trade has on factor prices; in particular, the Heckscher-Ohlin model cannot account for the observed rise in the skill-premium that have taken place in many countries. Therefore, we need an alternative approach to estimate and explain the increasing "wage gap" between nonproduction and production workers. The wage gap between nonproduction and production workers leads to increasing income inequality, growing poverty and strains the social fabric.

Since around 1980 many economies, especially the United Sates, have experienced a significant increase in the wages of skilled workers (nonproduction) relative to those with less ability (production workers). In the United States the wage share of nonproduction/production increased from 1.53 in 1979 to 1.72 in 2009. Moreover, the relative employment of nonproduction/production increased along with the wage share from 0.36 in 1979 to 0.45 in 2009. This means that there must be an outward shift in the demand for nonproduction workers. As Feenstra illustrated in his book, Advanced International Trade (2004), outsourcing and high-tech capital are the main factors of this outward shift.

We know that if companies decide to purchase intermediate inputs overseas and move the labor-intensive activities there as well, this will definitely reduce the employment in the home country, like the United States, which is the outsourcing effects on the employment in the home country. And we can expect that this effect would affect differently the employment of nonproduction workers verse the employment of production workers. In this way, outsourcing has the similar quantities effects to use of computer services on the reduction of the change of the employment share of nonproduction/production workers. In this paper, we will find which one is more important for the change of the wage share of nonproduction/production workers by extending Feenstra's models used in his book.

I follow the approach of Feenstra, who regressed the change in nonproduction wage share on shipments of each industry; the capital/shipment ratio; outsourcing, measured by imported intermediate inputs; and the share of computers and other high-tech capital. Feenstra used NBER productivity data (Bartelsman and Gray 1996) and imported intermediate inputs data (Feenstra and Hanson1990) to run his regression. He found that the outsourcing contributed 15-24%.  While computers contributed 13-31% to the total change in nonproduction wage share from 1979 to 1990. Moreover, if we measured computers with ex-post or ex-ante rental prices, computers contributed 13% and 8% respectively. If we measured computers with the share of investment, it contributed 31%.

For this paper, I use an updated data set and I compare these results to what Feenstra found in his book; NBER data year range is 1958 to 2009 (Bartelsman and Gray 2014) and intermediate inputs data year range updated to 1997. And the results from my regression are similar with Feenstra's but the magnitude is different. For outsourcing, my result is 17-28% and for computers, it is 9-45%. Under ex-post and ex-ante rental prices measurements they are 14% and 9% respectively. And under the share of investment measurement, it is 45%.

Compared to Feenstra's results, we can see that outsourcing contribution increased slightly from 1990 to 1997, but the contribution of computers under the share of investment measurement increased dramatically from 1990 to 1997 (from 31% to 45%). Whether outsourcing is more or less important than computer services depends on how we measure computers and other high-tech capital. All in all, with the new version data, the result is consistent with Feenstra's results in the direction of the effects of outsourcing and computers. My findings mean that we can have more confidence in Feenstra's original estimates

# 2. Literature Review

Outsourcing has a qualitatively similar effect on reducing the relative demand for unskilled labor within an industry as does skilled intensively technology change, like the increased of computers.

This point of view was first mentioned by Feenstra in his book, *Advanced International Trade-Theory, and Evidence*.

## 2.1 Methodology Development

Some researchers used Heckscher-Ohlin-Vanek (HOV) model to compute the change in the factor of trade and prices in the early 1980s. And they were failed. However, the result from the HOV model suggests another method to find the cause: model the intermediate inputs trade instead of relying on an HOV equation. The method sometimes called *production sharing*, or we can call it in a simpler way, *outsourcing*.

Bernard and Jensen estimated the industry-level decomposition of the change in the share of employment and wages of nonproduction workers from 1973 to 1990. Then he compared both of the change in the share of employment and wages, between industries with the change within industries. The results showed that the trade shifts the composition of activity within an industry. And later they did the estimate again but with plant-level data. The results suggested that trade has an effect on factor demand and wages by shifting the demand for labor within industries. This provides that outsourcing is the cause of those shifts.

## 2.2 Data Resources

In this paper, we need to use three part of data. First, we need NBER productivity dataset to estimate the changes in wages and employment from 1979 to 2009 (Bartelsman and Gray 2014). Second, we need imported intermediate inputs dataset. This dataset made by Feenstra and Hanson (1990). We need this dataset and combined with trade data to form the input-output matrix. The last, we also need high-technology capital dataset. This dataset made by Bernd and Morrison (1995).

# 3. Model

## Simple Model: Trade in Intermediate Inputs

In this paper, we will use the same model in Feenstra's book. We assume that there are two inputs $y_i, i = 1,2$. To produce inputs $y_i, i = 1,2$, we use unskilled labor $L_i$, skilled labor $H_i$, and capital $K_i$. Then we have a linear homogeneous production function:

$$y_i = f_i(L_i, H_i, K_i) \quad i = 1,2 \tag{1}$$

Let suppose $y_1$ is the unskilled labor intensive input and $y_2$ is the skilled labor intensive input. So, $y_1$ will represent the unskilled labor intensive activities like assembling components. And $y_2$ will represent the skilled labor intensive activities like marketing, R&D and, services. Both of $y_1$ and $y_2$ are needed to the produce final manufacturing product. However some of those activities occurred in factory, which could be outsourced overseas. It is imported from aboard. It also means that some of activities $y_2$, those skilled labor intensive activities, can be exported aboard to support production overseas.

Now, let us denote $x_1 < 0$ as the imports of input 1 and $x_2 > 0$ as the exports of input 2. And $p = (p_1, p_2)$ denote the price vector of the traded intermediate inputs.

Therefore, the "bundle" production function of the final manufacturing product is

$$y_n = f_n(y_1 - x_1, y_2 - x_2)$$

And the total factor usage is

$$L_n = L_1 + L_2, \qquad H_n = H_1 + H_2, \qquad K_n = K_1 + K_2 \qquad (2)$$

With perfect competition assumption, we solve the optimal output for the value of output from the final manufacturing product plus the net of trade by maximizing the revenue function subject to the resource constraints (equation 1 and 2)

$G_n(L_n, H_n, K_n, p_n, p) \equiv \max_{x_{i,L_i,H_i,K_i}} p_n f_n(y_1 - x_1, y_2 - x_2) + p_1 x_1 + p_2 x_2$, subject to

$y_n = f_n(y_1 - x_1, y_2 - x_2), \quad L_n = L_1 + L_2, \quad H_n = H_1 + H_2, \quad K_n = K_1 + K_2$

Next, we derive the revenue function $G_n(L_n, H_n, K_n, p_n, p)$ foreach industry

n $= 1, \ldots\ldots,$ N, where $p = (p_1, p_2)$. Because $G_n(L_n, H_n, K_n, p_n, p)$ is linearly homogeneous in prices, so we can re-write it as

$$p_n G_n\left(L_n, H_n, K_n, 1, {}^{p}\!/_{p_n}\right)$$

Then we get the real value-added function

$$Y_n = G_n\left(L_n, H_n, K_n, 1, {}^{p}/_{p_n}\right) \tag{4}$$

This function measures the $y_n$ plus the real net exports. Then we assume that the levels of capital and output are fixed, we get the short-run cost function,

$$C_n\left(w, q, K_n, Y_n, {}^{p}/_{p_n}\right) \equiv \max_{L_n, H_n} w\, L_n + qH_n \,,$$

subject to $$Y_n = G_n\left(L_n, H_n, K_n, 1, {}^{p}/_{p_n}\right) \tag{5}$$

To keep track of import price we will measure the expenditure on imported intermediate inputs for each industry. And we denote all the structural variables by $z_n$ (we treated as an error terms in our cost function before), which have effects on costs in each industry (include outsoucring variable, one of $z_n$ variables, and computers and other high-tech capital, others $z_n$ variables). So we need to re-write our cost function into

$C_n(w, q, K_n, Y_n, z_n)$.

Next, we use the costs function from the Feenstra's book, and translog the cost function (drop the industry subscript n)

$$\ln C = \alpha_0 + \sum_{i=1}^{M} \alpha_i \ln w_i + \sum_{k=1}^{K} \beta_k \ln x_k + \frac{1}{2} \sum_{i=1}^{M} \sum_{j=1}^{M} \gamma_{ij} \ln w_i \ln w_j +$$
$$\frac{1}{2} \sum_{k=1}^{K} \sum_{l=1}^{K} \delta_{kl} \ln x_k \ln x_l + \sum_{i=1}^{M} \sum_{k=1}^{K} \varphi_{ik} \ln w_i \ln x_k \tag{6}$$

Where $w_i$ is the wages of the optimal inputs $\mathrm{i} = 1, \dots, \mathrm{M}$ and $x_k$ is either the quantities of the fixed inputs or outputs k=1,… ,K, or other structural parameters. Take the first derivatives, $\partial \ln C/\partial \ln w_i = (\partial C/\partial w_i)(w_i/C)$. $\partial C/\partial w_i$ is the demand for the input i and $(\partial C/\partial w_i)$ $(w_i/C)$ is the payments to factor i relative to total costs. We will denote the payments to factor i relative to total costs as costs shares $s_i$. Differentiate equation (6) with repect to $\ln w_i$, we obtain

$$s_i = \alpha_i + \sum_{j=1}^{M} \gamma_{ij} \ln w_j + \sum_{k=1}^{K} \varphi_{ik} \ln x_k, \quad i = 1, \dots, M \tag{7}$$

In this paper, we assume that cost function is the same across all industries. In cost function $C_n(w, q, K_n, Y_n, z_n)$ we have two type of inputs- unskilled labor and skilled labor. However in the share equation (7), we focus on the share for skilled labor, capital, output, and other structural variables $z_n$. We can also estimate the change of the wage share of nonproduction workers by taking the difference between two years in industries

$$\Delta s_{nH} = \varphi_0 + \varphi_k \Delta \ln K_n + \varphi_\gamma \Delta \ln Y_n + \varphi_z{}' \Delta z_n\,, \; n = 1, \dots, N, \tag{8}$$

Where $z_n$is the vector of structural variables and $\varphi_z$ is the coefficients of the vector. This model will let us to observe that how much of increase is contributed by capital changes, output changes, and the structural variables if there is an increase in the wage share of nonproduction workers.

# 4. Results

## 4.1 Changes in Wages and Employment

Froom 1979 to 1995, the real wages of full-time workers with 12 years of education decreased by 13.4% and the real wages of full-time workers less than 12 years of education decreased by 20.2%. In the meantime, the real wages of full-time workers less than 16 years or more years of education increased by 3.4%, so the waged gap between the skilled workers and unskilled workers is 16.8%-23.6%, which increased a lot compared with 1979.

Used the formula below:

$$\text{Production worker wage rate} = \frac{\sum_i \text{production worker wage bill}_i}{\sum_i \text{production workers}_i},$$

$$\text{Non production worker wage rate} = \frac{\sum_i \text{Non production worker wage bill}}{\sum_i \text{Non production workers}_i}$$

$$= \frac{\sum_i (\text{total pay roll}_i - \text{production worker wage bill}_i)}{\sum_i (\text{total employment}_i - \text{production workers}_i)}$$

$$i = \text{industry}$$

and the data from NBER productivity database, we get the Figure 1 and Figure2.

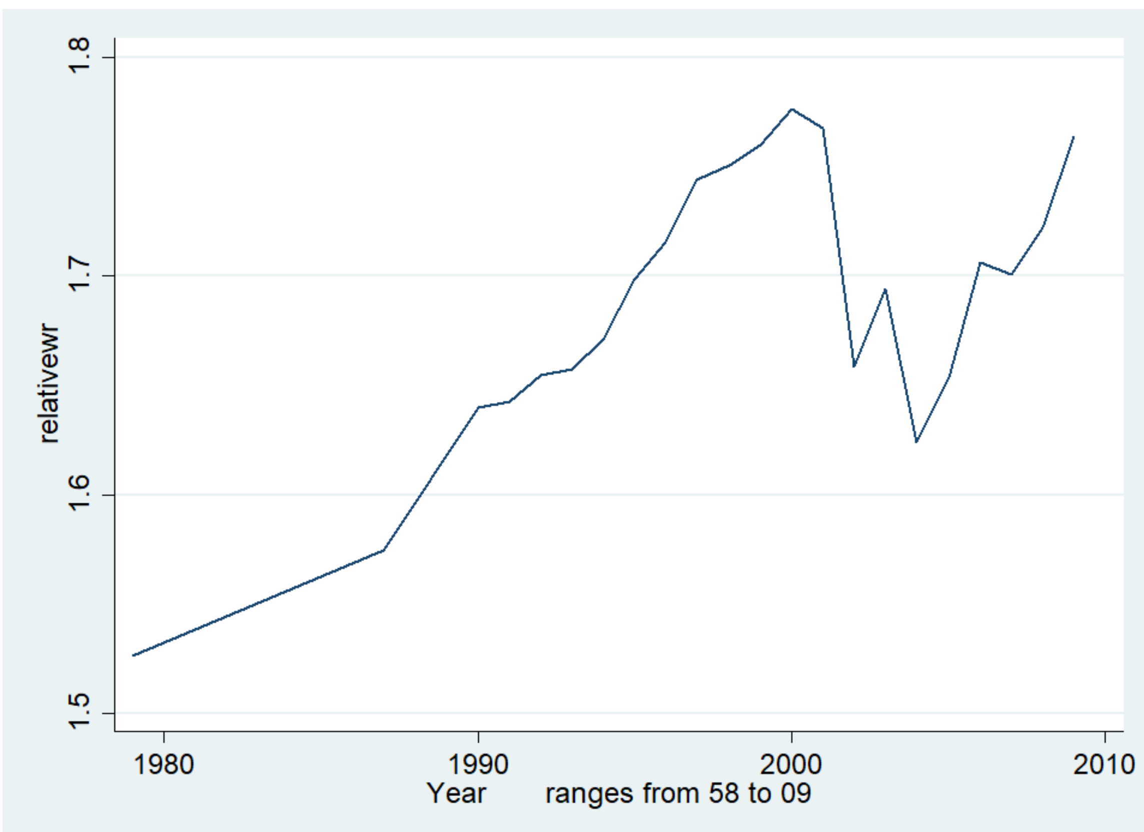

Figure 1

Note: The x-axis is the year range from 1958-2009 and the y-axis is the relative wages of nonproduction/production workers, U.S. Manufacturing


Figure 2

Note: The x-axis is the year range from 1958-2009 and the y-axis is the relative employment of nonproduction/production workers, U.S. Manufacturing

From Figure 1, we can see that the relative wage of nonproduction/production workers in 1990 is around 1.63 and it is around 1.53 in 1979. However, in 2009, the relative wage of nonproduction/production worker increases to 1.72. It means that the wage gap has still increased since 1990. And the increasing the wage of nonproduction workers should lead a decrease in the demand for nonproduction workers. However, Figure 2 shows that from 1958 to 1990 the relative employment of nonproduction/production workers increases along with the relative wages of nonproduction/production workers. And from 1990 to 2009, the relative employment of nonproduction/production workers decreased along with the relative wages of nonproduction/production workers.

Therefore, there is only one explanation can explain these facts is that there has been an outward shift in demand of nonproduction workers since 1980 and an inward shift in demand of nonproduction workers since 1990s. With the shift in demand, it makes sense that the relative employment of nonproduction/production workers increased and decreased along with the relative wages of nonproduction/production workers.

The outward shift proves that there are some factors affecting the demand for nonproduction workers, which are outsourcing and technology breakthroughs. However, we want to determine that among those increases how much is contributed by outsourcing and how much is due to high-tech equipment.

## 4.2 The Relative Demand for Nonproduction Workers

With the question above, we estimate equation (8) above with 447 industries within the U.S. manufacturing sector, over 1979-1997. The data are from the NBER Productivity Database at the four-digit Standard Industrial Classification (SIC) level. In our regression, we focus on nonproduction workers and use it as a proxy for production workers. Our dependent variable is the change in the share of nonproduction workers in total wages within each industry. From 1979 to 1997, the production wage share decreased substantially. At the same time, the nonproduction wage share has merely increased slightly and the capital share increased by an average rate of around 1 percent a year since 1979. For our regression, we will weight regressions by the industry share of the total manufacturing wage bill. Hence, larger industries will receive more weight in regressions. Our regressors are the 1.shipments of each industry, 2. The capital/shipments ratio, 3.outsourcing, 4.the share of computers and other high-tech capital in the capital stock.

We expect that outsourcing has the similar effects with computers and other high-tech capital yet it has more impact on the change in the share of nonproduction workers.

**Table 1: Dependent Variable – Change in Nonproduction Wage Share, 1979-1997**

| | (1) Mean | (2) Regression | (3) Regression | (4) Regression | (5) Contribution |
|---|---|---|---|---|---|
| Δln(K/Y) | 0.73 | 0.06 | 0.05 | 0.05 | 9-11 % |
| | | (0.01) | (0.01) | (0.009) | |
| Δln(Y) | 1.55 | 0.025 | 0.02 | 0.02 | 8-10 % |
| | | (0.006) | (0.006) | (0.006) | |
| Outsourcing | 0.44 | 0.22 | 0.25 | 0.15 | 17-28% |
| | | (0.093) | (0.09) | (0.09) | |
| **Computer and other high-tech capital measured with ex-post rental prices:** | | | | | |
| Computer share | 0.26 | 0.21 | | | 14% |
| | | (0.091) | | | |
| Other high-tech share | 0.15 | -0.08 | | | -- |
| | | (0.14) | | | |
| **Computer and other high-tech capital measured with ex-ante rental prices:** | | | | | |
| Computer share | 0.08 | | 0.44 | | 9% |
| | | | (0.17) | | |
| Other high-tech share | 0.18 | | 0.006 | | 0.3% |
| | | | (0.07) | | |
| **Computers measured as share of investment:** | | | | | |
| Computer share | 6.59 | | | 0.027 | 45% |
| | | | | (0.009) | |
| High-tech share (ex-post rental prices) | 0.41 | | | 0.04 | 4% |
| | | | | (0.03) | |
| Constant | | 0.19 | 0.20 | 0.15 | 38-50% |
| | | (0.03) | (0.03) | (0.05) | |
| $R^2$ | | 0.14 | 0.14 | 0.18 | |
| N | | 447 | 447 | 447 | |

Note: the mean of dependent variable equals 0.397

Column (1) reports the mean values of the dependent variables and independent variables from 1979 to 1997. For column (2) we regress the computer and other high-tech capital shares by measuring with ex-post rental prices. And for column (3) we regress the computer and other high-tech capital shares by measuring with ex-ante rental prices. For column (4) we regress the computers by measuring as shares of investment. As we expected before, outsourcing has a positive effect on the change in share of nonproduction workers, which is similar to what the computer share does. In column (5), we divide the total changes in the nonproduction wages shares by multiplying the regression coefficients by the mean values for the change in each variable. We can see that outsourcing is contributed about 17-28% of the total changes in the nonproduction wages shares.

However, the results for computers depends on the measurements. If we measure computers and other high-tech capital as a share of the capital stock using ex-post rental prices, they account for 14% of the total changes in the nonproduction wages shares. If we measure computers and other high-tech capital as a share of the capital stock using ex-ante rental prices, they only account for 9.3% of the total changes in the nonproduction wages shares. In both cases above, we see that the contribution of outsourcing is larger than the contribution of computers and other high-tech capital. But, if we measure computers as a share of investment, it will account for 45% of the total changes in the nonproduction wages shares. In this case, the contribution of computers exceeds the contribution of outsourcing a lot. Hence, whether outsourcing is more or less important than computers depends on how we measure computers and other high-tech capital. Regardless of the measurements of computers and other high-tech capital, we can say that both outsourcing and computers services are important to explain the total changes in the nonproduction wages shares.

# 5. Conclusions

Tracking the intermediate inputs can help us to easily find the shift happened in relative demand for nonproduction workers within an industry. We regress the change in the share of nonproduction workers in total wages within each industry on shipments of each industry, the capital/shipments ratio, outsourcing, imported intermediate inputs, and the share of computers and other high-tech capital in the capital stock. Then we can argue that the effects of outsourcing are similar to the effects of computers and other high-tech capital. And both of them have positive impacts on the change of the wage share of nonproduction workers. Next, we see that in some cases outsourcing is more important than computers and other high-tech capital. But in some cases outsourcing is less important than computers and other high-tech capital. It depends on how to measure computers and other high-tech capital.

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