

**INDUSTRY AGGLOMERATION AND WAGE DIFFERENTIATION:
AN EMPIRICAL STUDY ON TAIWAN'S MANUFACTURING INDUSTRY**

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Abstract

In this paper, we applying the segmented regression model to test the concept of critical mass in the model of agglomeration externality by setting agglomeration degree(AD) as the threshold variable to investigate the relationship between the industry agglomeration and the wage differentiation of employees in Taiwan's manufacturing industry. Our estimated results prove that there exists a threshold effect of AD as determining wage rate of an employee and confirm that the AD of an industry can significantly influences the wage rate of an employee, no matter where he/she works. The marginal effect of AD on wage rate is higher for workers who work outside the cluster than the insiders in the manufacturing industry, as well as in the high-tech industries.

JEL Codes:

Keyword: industry agglomeration, wage differentiation, segmented linear regression, manufacturing industry

1. Introduction

The importance of industrial clusters has been emphasized by Porter(1990). The most famous example is the Silicon Valley in the United States, a industry cluster of electronic and computer industry. Saxanian(1994) compared the regional developments between Silicon Valley and Route 128 area in Massachusetts, and conclude that the culture and industry organization are more open in the former and thus resulted in a better development of computer industry after the microcomputer revolution. She also pointed that the agglomeration externalities happened because the workers in different companies can exchange their thoughts and ideas easily and conveniently speeded up the spillover effects in this area under this open atmosphere and the agglomeration of computer companies.

As concerning with the main sources of agglomeration economies, Marshall (1920) suggests that the sharing of inputs whose production involves internal increasing returns to scale, the pooling of labor market pooling where agglomeration allows a better match between an employer's needs and a worker's skills, and the spillovers in knowledge because the clustering of firms allowing their workers to learn from each other. Other theoretical foundations for the existence of agglomeration externalities are also discussed. Fujita et al.(1999)'s book heavily rely upon the Dixit-Stiglitz model of monopolistic competition that offers a analysis framework to deal with the effects of increasing returns at the level of the individual firm. Fujita and Thisse(2002) further explain the trade-off between various forms of increasing returns and different types of mobility costs. It explores several kinds of the formation of agglomerations and the discussed the existence of imbalance development between regions. Duranton and Puga(2004) provided three types of micro-foundations mechanisms of urban agglomeration formation, such as sharing, matching, and learning. Besides, the effects of industrial agglomeration are also

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mentioned extensively. For example, Krugman(1991) pointed out that the comparative advantage of a country might be changed because of the rises of industrial productivity resulted from its industrial clusters. Henderson(1980) and LaFountain (2005) discussed the location problem of an industry or a firm as considering of effects of industrial agglomeration.

As for the empirical evidences on the effects of agglomeration externalities for manufacturing industries, Beeson(1987) investigated the determinants of productivity growth in the manufacturing sector with special emphasis on the effects of a state's urbanization characteristics on productivity growth. The results showed that no relationship is found between urbanization and overall productivity growth. Ciccone and Hall (1996) focused on the differences in labor productivity as concerning with local geographical externalities and with the diversity of local intermediate services which might result in aggregate increasing returns. They concluded that the average labor productivity increases as the degree of employment agglomeration (employment density) rises. Ciccone(2002) estimated the agglomeration-effects for European countries and show that this effect and the elasticity of average labor productivity with respect to employment density in these countries were slightly smaller than the ones in the US. Finally, Rosenthal and Strange (2003) find that the average labour productivity in manufacturing industry increases as the agglomeration increases. Accordingly, we might conclude precisely that the agglomeration externalities will raise the labour productivity.

As for the influences of urban agglomeration on wage rate, Hansen(1990) indicated that the agglomeration economies enhance plants' productivity within metropolitan area, but firms must pay for these benefits in high wages and land costs. Tabuchi and Yoshida(2000) estimated the urban wage premium and found that wages might increase by 10% if the city size doubles in Japan. Wheaton and Lewis(2002) found that workers in the manufacturing sector earn higher wages when they are in urban labor markets and the willingness of firms to pay more for equivalent workers in dense markets as evidence of an agglomeration economy. Glaeser and Mare (2001) and Yankow (2006) found that the agglomeration premium on wage accounting for a large portion of the urban wage premium as holding other factors be equal. Wheeler (2006) who shows that urban wage gains are due to more frequent job changes in large cities rather than to return-to-tenure differentials. As for a specific industry, Freedman(2008) showed that clustering makes it easier for workers to job hop within the software sector and earn higher earnings levels in more agglomerated areas. He also pointed that agglomeration improves labor market coordination and facilitates greater learning and human capital formation.

In this paper, we investigate the relationship between the industry agglomeration and the wage differentiation of employees in Taiwan's manufacturing industry. LaFountain (2005) theoretically points out that the geographic agglomeration of an industry might increase the productivity of firms which are located in the same area due to the production externality resulted from the economy of cluster, and thus increase the wage rate of the employees who are employed by these firms. It also implies that the wage rate of employees in the cluster might be higher than the ones who are employed outside the cluster. We apply the threshold model in econometrics with setting the degree of industry cluster in different geographic areas as the threshold variable to investigate this hypothesis. Our estimated results prove that there exists threshold effects of industry cluster on the wage rate differentiation and confirm LaFountain(2005)'s theory.

The paper proceeds as follows. The next section interprets our empirical econometric model used in this paper. Section 3 describes the data operation procedures and how we integrate the database "Industry, Commerce and Service Census" (held in every 5 years) held by the Directorate General of Budget, Accounting and Statistics (DGBAS) in Taiwan's Executive Yuan in 2001 into another dataset, the "Manpower Utilization Survey", which was also held by DGBAS in 2008 and offered the variable of wage rate of each employee. Section 4 turns to the empirical analysis and discusses the results in light of theoretical models. In addition, we will compare the average wage rate between the employees who work in the area with a agglomeration degree lower and upper the threshold criterion. In section 5 are some the conclusions and suggestions.

2. Methodology

In this section, we will discuss the theory which is related to the industrial agglomeration and wage differentiation and the reasons why we propose the econometric threshold model as our empirical method.

From the discussions above, it is sure that the agglomeration externalities rise up the average labor productivity. According to the subsection 2.2 in LaFountain(2005), he focus on how the land rent price in an region is influenced by if the firms in this region enjoy the local production externalities, a phenomenon exists when a firm's production possibilities expand as other firms located in the same region. This type of production externality might result from the knowledge spillovers which occur as employees in different firms have informal contact with each other, or because high turnover in local employees. Firms in this area benefit from the knowledge owned by its employees who accumulate such knowledge from their previous jobs. LaFountain(2005) also pointed out that the production externalities are classified as localization externalities and urbanization externalities. He mentioned that the formers exist when firms benefit from proximity to similar firms or other firms in the same industry and the latter exist when firms benefit from locating in a diverse location or from proximity to firms engaged in variety of different industries. In this paper, we only concern about the localization externalities because we are with specific interest on industrial agglomeration.

After his calculation of this production externalities model, LaFountain(2005) pointed out that the firms in an industry in a region will benefit not only from localization externalities but also from urbanization externalities. Thus, the regional share of employment in this industry in this region will positively affect the marginal productivity of labor, which will affect regional wages(which will in turn affect regional demand for land and thus regional land rents). The increase of productivity in this industry increases the marginal productivity of labor employed in the industry, and thus raises the real wage rate of employees in this region.

According to the theory proposed by LaFountain(2005), we infer to that the employees employed by firms located in the region with higher agglomeration degree will earn a higher wage rate as compare with the counterparts out of the industry clustered area because of the existence of localization externalities which increase the marginal productivity of labor. In other word, the agglomeration degree of an industry in a region(or an area) would be an important factor influencing the wage disparity(or gap) between the employees inside and outside the industry cluster.

In this paper, we apply the segmented linear regression in econometrics with setting the degree of industry cluster in different geographic areas as the threshold variable and

there exist a(or some) breakpoint(s)(or threshold) (or the similar concept: critical mass) to segment the observations into different groups, hence, the independence variables in different data clusters might have different influences on the dependence variable. The modification why we employ this econometric model is related to the industrial agglomeration externalities. agglomeration externalities means that firms locate in the same region (cluster) to receive information spilling over from other firms, to reduce transport costs of inter firm trade, and to enhance the diversity of firms and local products available, and hence increase their own productivities.

Harrison and Rodriguzs-Clare(2009) show that there exists multiple equilibria of economic developments under the phenomenon of Marshallian externalities. If the market size of an economy is too small to surpass the critical mass, thus it will be difficult for its industry to generate positive Marshallian externalities and, hence, be impossible to change its comparative advantage in the international trade. As discussing the relationship between the Marshallian externalities and economy development, Carillo and Pugno(2004) assumes that Marshallian externalities depend positively on the number of active firms in the economy. They model a non-linearity structure of Marshallian externalities function by a suggestion in the literature on economic development: an economy will accelerate its overall efficiency when it has reached a minimal size.¹ In other words, until the number of firms in an economy has reached a minimal critical threshold value, the Marshallian externalities increase and become positively related to the number of firms.

Accordingly, we argue that, as considering the Marshallian externalities in an industry cluster area, the agglomeration externalities will be accelerated as long as the degree of agglomeration surpass a critical mass (or the breakpoint) and thus enforce the region to arrive a good equilibrium. Thus, we apply the segmented regression model as our empirical method. Segmented regression analysis are threshold models because some decision must be made concerning what is the appropriate threshold at which to split the sample. Hansen(2000) pointed out that the threshold models have a wide variety of applications in economics, such as separating and multiple equilibria and sample splitting in cross section topics and the threshold autoregressive model in the nonlinear time series literatures. Krugman(1991) and Arthur(1996) proved that there will be at least two development equilibria in a region with Marshallian externalities. Therefore, it's adequate to apply segmented regression model to estimate the effects of agglomeration degree on the wage rate differentiation between the employee inside and outside an industrial cluster area.

Generally speaking, to investigate the relationship between the wage rate of an employee and the agglomeration degree in the area his/her firm locates, this paper estimates the following equation,

$$w_i = \beta AD_i + \gamma' X_i + \varepsilon, \quad (1)$$

where w_i is the wage rate of employee i , AD_i measure the level of the agglomeration degree of where his/her firm's locates. X_i is a vector contains other control variables that

¹ The importance of multiple equilibria and critical mass has been mentioned in Arthur(1994) and other researches which are focusing on the network effects.

can affect wage rate; ε_i is the error term. β and γ are the parameters we are going to estimate.

From our theoretical model, we know that different levels of regional agglomeration degree might result in different level of wage rate because of agglomeration externalities (Marshallian externalities). To capture this effect, we can extend equation (1) into a non-linear two regimes threshold model,

$$w_i = (\beta_1 AD_i + \gamma_1 X_i) L(AD_i \leq \tau) + (\beta_2 AD_i + \gamma_2 X_i) L(AD_i > \tau), \quad (2)$$

where $L(\cdot)$ is the indicator function and τ is the threshold parameter. This model permits the regression parameters (β_1 , γ_1 , β_2 and γ_2) to switch between regimes depending on whether AD_i is smaller or larger than the unknown threshold value τ . We apply the endogenous threshold regression approach proposed by Hansen (2000) to estimate equation (2). Hansen (2000) provides an algorithm that searches over value of τ using conditional ordinary least square (OLS) regressions base on a sequential searching procedure. It also provides estimates of regression parameters in the searching process. Another important hypothesis which we care about is that there indeed exists the effect of threshold. Another important hypothesis which we care about is that there indeed exists the effect of threshold. The null hypothesis, for example, can be expressed as,

$$H_0 : \beta_1 = \beta_2 \quad (3)$$

We employ the heteroskedasticity-consistent Lagrange Multiplier (LM) test which is proposed by Hansen (1996) to examine hypothesis (3). If the hypothesis in (3) is rejected, it is adequate to split the sample into two different regimes.

3. Data

To estimate the empirical equation (2), we have to incorporate two surveyed databases in Taiwan. The first one is the "Industry, Commerce and Service Census Survey" held in every 5 years by the Directorate General of Budget, Accounting and Statistics (DGBAS) by Taiwan's Executive Yuan in 2001. In this dataset, we calculate the agglomeration degree(AD) of every two digital industries in every town in Taiwan². Then we integrate this variable into the "Manpower Utilization Survey" dataset, another survey held by DGBAS in 2008 and offered the variable of wage rate of each employee, by its industry and location codes. In equation (2), in addition to AD, we also include other explanatory variables according to previous literatures related to wage differentiation, such as gender, age(or work experience), education level, marital status, work attribute (professional or not), and the firm size(numbers of employees) in where he/she works.

As for the calculation of AD of firm i in town j , we employ the method proposed by Chan et al.(2004),

$$AD_j^i = \sum_{i \in j} w_j^i AS_j^i \quad (4)$$

where w_j^i is the employment ratio of firm i in town j , which is calculated by

² Town is the third level of geographic administrative region in Taiwan.

$$w_j^i = \frac{\text{employment}_i}{\sum_{k \in j} \text{employment}_k}, \quad i, k \in j \quad (5)$$

and AS_j^i is the total employment of firms in town j except firm i and the total employment of firms in the same industry located in the neighbor town connected to town j . That is

$$AS_j^i = \sum_{\sim i \in j} \text{employment}_{\sim i} + \sum_{S \in N_j} \sum_{r \in S} \text{employment}_r \quad (6)$$

where employment_r is the employment of firm r in the neighbor town S of town j and N_j is the set of all neighbor towns. Equation (4) combines equation (5) and (6) as considering that the agglomeration degree of a town should not only include the employment of itself but also its neighbor towns because of the possible spillover effects resulted from the movements of labors between these regions. We calculate this index of every industry in every region they located in. According to the discussion before, the predicted sign of AD should be positive, no matter the segment regime upper or lower the threshold.

As for other variables, the gender wage gap has, however, persistently been an important issue in modern labor economics, and several studies have tried to explain the wage gap between males and females by controlling for demographic and productivity-related factors. Altonji and Blank(1999) pointed out that the gender is an important factor influencing the wage discrimination because of employer's preference, the comparative advantage, and the pre-work investment in human capital. Ham et al.(1995) concluded that women in Communist Czechoslovakia earned on average about 70 percent of men's wages in 1988. Schafgans(2000) concluded that 'discrimination' favoring men in Malaysia is still quite prevalent. Kunze(2005) also argued that sex segregation explains a large portion of wage differences and leads to a permanent wage disadvantage for women. Accordingly, we consider that the gender will influence the wage rate significantly. In this paper, we set a worker's gender to be 1 if male and to be 0 if female. Hence, the sign of gender would be positive.

In addition, the age and work experience are considered as important factors which affect the wage rate significantly even they might be highly correlated and the former often be the proxy variable of the latter. In usual, the elders who work for more years than the younger and earn higher wage rate because of his/her higher productivity resulted from his/her work experience. Williams(2009) found that for all male workers, tenure plays a modest role, increasing wages by about 1% each year over the first 10 years on the job. General labor market experience has a larger role, and after 30 years wages have increased by about 60%. Munasinghe et al (2008) found that the overall wage return on an extra year of labor market experience is lower for women than men. After their decomposition analysis, they pointed out that the wage return to job tenure is substantially lower for women than men, and that the wage returns to experience is higher for women than men. Therefore, the predict sign of the age(or work experience) variable is positive.

As considering about the influence of education level on wage rate, a person with higher education level might result in a higher productivity and then earn a higher return.

Thus, the wage disparity between workers might be affected by their difference of education level. Cortez(2001) argued that the relative wage return resulted from the higher education level would increase the income inequality in Mexico. Gindling and Sun(2002) proved that the relative supply of workers with higher education is the main factor raising the relative wages of Taiwanese workers with higher education between 1978 and 1995. Neuman and Ziderman(2003) found that the vocational education could raise the wage levels of immigrants in Israel. Gonzalez(2003) also conclude that the immigrants with more US schooling will earn more if the returns to US schooling are greater than the returns to foreign schooling, holding total education constant. Accordingly, we might predict that the sign of estimated parameter of education level should also be positive.

As for the relation between the marital status and the wage rate, the situation is more complex. First, Becker(1991) mentioned that marriage makes men more productive because the married men have greater opportunities to specialize in labor market activities when their wives specialize in home production. Thus, the marriage wage premium reflects a productivity gap between married and never-married men. Second, Nakosteen and Zimmer (1987, 1997) argued that married men are more productive not because they become more productive after marriage, but because they were more productive before marriage. Chun and Lee(2001) concluded that the selection of high-ability men into marriage is the cause of the marriage wage premium. As for women, Greenberg Quinlan Rosner(2007) mentioned that the unmarried women and men have lower mean personal earnings than the married ones respectively. This means that the marriage wage premium exists no matter what your gender is. In this research, we set a worker who is married is 1 and 0 for whom is not get married in our data. We think that if the marital status of a worker is married, then he/she will earn a higher wage rate and the predict sign of this variable should be positive.

Finally, as for the influence of firm size on the wage rate differentiation, Krueger and Summers (1988), Brown and Medoff (1989), Oi and Idson (1999) and Bertola and Garibaldi(2001) had argued that the larger firms or plants pay higher wages. Besides, Meagher and Wilson(2004) also concluded that the plant size effect for supervisors is at least double that of non-supervisors. In this paper, we use the employment size as the firm size of a worker's firm and divide the firm size into two classes: large and small. According to the definition of a small and medium enterprises (SMEs) on the number of regular employees defined by Small and Medium Enterprises Administration(SMEA) in Ministry of Economic Affairs in Taiwan, the number of regular employees must be less than 200 in the manufacturing industry. And in the "Manpower Utilization Survey", it categorize the total employment of a worker's firm into 8 level. Firms' total employment in 1~199 workers are categorized into the first six classes. Therefore, we redefine the firm size of an employee as a dummy variable with value 1 if his answer is the 7th and 8th category of firm size. Thus, we also predict the firm side effects would be positive. In addition, the work attribute (for example, professional or not) of a worker should positively influence his/her wage rate. An expert or a professional work would earn a higher wage rate because of his/her higher productivity resulted from his specialization. In this study, we define a worker who is a professional worker as 1 and others to be 0 and thus it's intuitive to predict its sign of estimated parameter positive. In addition, to figure out if the agglomeration externality in high-tech industry is significant in high-tech industries, we also define a dummy as High-Tech for a employee who works in

“Computer, Communications, and Audio and Video Electronic Products Manufacturing” and “Electronic Parts and Components Manufacturing”.

In table 1, we list the basic statistic summary of explanatory variables in whole manufacturing industry in Taiwan. We also offer the statistic summaries of AD of two-digit manufacturing industries in Taiwan in appendix. Table 2 is the correlation coefficients for all explanatory variables. In this table, we find the correlation coefficient is very high between the high-tech industry dummy and the AD, which reflects the clustering of high tech industries in Taiwan.

Table 1 Statistic Summaries of Explanatory Variables

Variables	Mean	Maximum	Minimum	Variance	Observation
Wage Rate(NT\$)	29860.75	200000	1000	13944.6	7377
Sex(Dummy)	0.593602	1	0	0.491194	7377
AD	13088.39	72370.98	1	15238.76	7377
Firm Size(Dummy)	0.226515	1	0	0.418604	7377
High-Tech(Dummy)	0.245628	1	0	0.430488	7377
Marriage(Dummy)	0.617731	1	0	0.485975	7377
Education(yrs)	11.27369	23	0	3.215515	7377
Experience(yrs)	6.251796	40	0.083333	6.177798	7377
Professional(Dummy)	0.235462	1	0	0.424316	7377

Table 2 Correlation Coefficients between Explanatory Variables

	Wage Rate	Sex	AD	Firm Size	High_Tech	Marriage	Edu cation	Expe rience	Profes sional
Wage Rate	1								
Sex	0.402	1							
AD	0.1566	-0.0236	1						
Firm Size	0.2175	-0.0079	0.2156	1					
High-Tech	0.0959	-0.1107	0.5645	0.336	1				
Marriage	0.1415	-0.0699	-0.1087	0.0125	-0.1279	1			
Education	0.3909	0.1812	0.2449	0.2633	0.3129	-0.2154	1		
Experience	0.2596	0.0576	-0.095	0.0959	-0.185	0.3361	-0.1924	1	
Professional	0.4895	0.1795	0.1912	0.1767	0.211	-0.0112	0.4994	0.0521	1

4. Empirical Results

We list our estimated results of whole manufacturing industry in table 3. In this table, we report the results of ordinary least square(OLS) estimation of whole samples without considering the threshold effect in the first part. As for the second and third part, the OLS regression results of observations under and upper the threshold value are list separately with the estimated threshold value of AD at 5691.798. From the results of heteroskedasticity-consistent Lagrange Multiplier (LM) test, it rejects of null hypothesis in equation(3). There are two implications of this result. In the one hand, it firstly represents that the estimated parameters of AD under and upper the threshold are not equal to each other. Besides, it also tells us that such a segmented regression analysis is adequate to discuss the critical mass concept in the theories of agglomeration externality.

Besides, the R-squared values are 0.460 and 0.512 in the individual regression model, which means that they are acceptable too.

Table 3 Parameter Estimation for the Whole Manufacturing Industry in Taiwan

Model	Without Threshold		With Threshold AD<5691.798		With Threshold AD>5691.798	
Variable	Parameter	t-value	Parameter	t-value	Parameter	t-value
Constant	9.108**	288.417	9.100**	195.314	9.158**	215.019
Sex	0.314**	41.250	0.353**	29.460	0.278**	29.202
Marriage	0.054**	6.146	0.041*	2.987	0.064**	5.914
Education	0.040**	23.409	0.039**	15.320	0.041**	17.726
Experience	0.027**	13.428	0.027**	8.027	0.028**	11.620
Experience^2	-0.001**	-7.727	-0.001**	-4.773	-0.001**	-6.621
Professional	0.213**	22.779	0.211**	14.311	0.217**	17.839
High-Tech	-0.004	-0.436	0.004	0.236	0.001	0.089
Firm Size	0.090**	11.343	0.111**	9.117	0.072**	6.773
AD	3.36E-06**	8.740	7.85E-06*	2.086*	1.08E-06*	2.259
Observations	7377		3384		3993	
R-squared	0.494		0.460		0.512	
Heteroskedasticity Test (P-Value)			7.33E-18***			

Note: *: at 5% significance level; **: at 1% significance level.

As for the individual variables, most explanatory variables of wage rate determination are significant with consistent signs we predicted before, except the one of high-tech industry dummy. The insignificance of this estimated parameter is pretty surprising and counterintuitive because Taiwan is famous on its production of ICT products in global high-tech market and is attributed to the rise of employees' wage rate in Taiwan. The reason for this insignificance might due to its low correlation with wage rate or the high correlation with AD in table 2. Besides, the marginal effects of AD on wage rate inside and outside the cluster is different. The marginal effect of AD on wage rate outside the cluster is higher than the one inside the cluster in Taiwan's manufacturing industry. This might happen because the AD outside the cluster is relative low which results in a higher marginal effect on wage rate due to the higher marginal productivity of AD, or the diminishing returns on wage rate of AD, or the less crowding out effect which might be much serious inside the cluster resulted from the negative influence of space congestion in manufacturing industry.

The effect of sex variable on wage rate outside the cluster is larger than the one inside the cluster, which means that the level of wage differentiation in average between males and females outside the cluster is higher than one inside the cluster. The former might reflects the natural difference of mental structure between the males and females. The lower wage differentiation in average between the males and females employees inside the cluster might happen because the potentials of females might be stimulated by the agglomeration externality and shorten the range of wage differentiation. In addition, the estimated results of marriage variable of employees who work inside the cluster is higher than the one outside the cluster, which mean that, from the view that persons who get married are more productive and thus earn higher money, with the agglomeration externality, the firms inside the cluster are more possible to offer a higher wage rate for the married persons. Finally, the quadratic form estimated result of work experience on wage rate is also worthy emphasized. The negative significance of squared experience

implies a diminishing marginal return for work experience on employees' wage rate in manufacturing industry in Taiwan.

We have mentioned that the dummy variable of high-tech industry in the whole manufacturing industry is not significant in table 3. Therefore, we further subgroup the samples who works in the ICT industry and estimate the parameters in equation(2) independently. The estimated results are list in table 4. The test results of heteroskedasticity-consistent Lagrange Multiplier (LM) rejects of null hypothesis in equation(3) too, which means that the threshold regression is also suitable for estimation the data in ICT industries. The R-squared values are also acceptable with values at 0.582 and 0.592. As for the threshold point, it is 22688.85, a value much higher than the counterpart in the whole manufacturing industry.

Table 4 Parameter Estimation for the High-Tech Industry in Taiwan

Model	Without Threshold		With Threshold AD<22688.85		With Threshold AD>22688.85	
Variable	Parameter	t-value	Parameter	t-value	Parameter	t-value
Constant	8.960**	133.718	8.902**	95.007	8.912**	90.189
Sex	0.213**	15.486	0.233**	11.987	0.200**	10.511
Marriage	0.060**	4.404	0.039*	2.086	0.074**	3.786
Education	0.057**	15.205	0.056**	9.784	0.058**	11.974
Experience	0.024**	5.453	0.018*	3.006	0.029**	4.994
Experience^2	3.31E-6	-1.452	6.57E-7	-0.206	-0.001	-1.784
Professional	0.200**	11.769	0.200**	8.897	0.191**	7.776
Firm Size	2.45E-07	5.66E-01	-2.16E-07	-0.164	3.80E-07	0.755
AD	1.55E-06*	2.800	6.93E-06**	5.373	2.42E-06*	2.444
Observations	1812		900		912	
R-squared	0.583		0.582		0.592	
Heteroskedasticity Test (P-Value)			3.42E-06***			

Note: *: at 5% significance level; **: at 1% significance level.

We find that estimated parameters of most variables are significant and are consistent with the predicted signs we discussed before, except the variable of experience square and the firm size. The insignificance of parameter of experience square, which is different from the estimated result in table 3, means that work experience in high-tech industry doesn't result in diminishing marginal returns on wage rate. Besides, the insignificant estimated resulted of firm size in table 4 is also different from the one in table 3, which is also different from the results in previous studies. The reason here might attribute to that the firms our sampled employees work in are large one in high-tech industries in Taiwan, which could not influence the wage rate effective, no matter they located inside or outside the cluster. The higher level of wage differentiation in average between males and females outside the cluster is also hold here, but the difference is much shortened. Finally, in table 4, both of the marginal effects of AD on wage rate inside and outside the cluster are significant, but the one in the outsider of cluster area is still higher than the one in the insider. The reasons for this phenomenon are similar to the arguments mentioned above in explaining the in manufacturing industry. As comparing their difference with the counterpart in table 3, the range of these two parameters in high-tech industries is smaller than the one in manufacturing industry. The lower marginal

effects of AD outside the cluster in high-tech industries, as comparing with the effects in manufacturing industry, might due to the lower marginal productivity of AD because of higher diminishing marginal returns. And the higher marginal effects of AD in the high-tech cluster than the one in the manufacturing industry cluster might come from the stronger agglomeration externality and the less crowding-out effects in high-tech cluster.

Finally, we compare the average wage rate of employees who work inside and outside the cluster with the threshold criterion estimated in table 3 and 4. We list the results in table 5. In manufacturing industry, we find that the average wage rate of employees inside the cluster is higher than the one in outside with the magnitude of NT\$ 3903.978. The t-value and p-value of test results support our argument before. The situation is similar to the high-tech industry. The average wage rate inside the cluster is also significantly higher than the one of outsider according to the significance of t-value and p-value, even through the magnitude is smaller than in manufacturing industry. Thus, we conclude that the agglomeration externality resulted from the industry agglomeration in regions(areas) could consequently results in the wage differentiation between employees who works inside and outside the cluster, according to the empirical results here. Furthermore, the threshold values, which represent the concept of critical mass, should be considered in the analysis model of agglomeration.

Table 5 The Average Rate in the Subsamples Under and Upper the Threshold Value

Group	Manufacturing Industry			High-Tech Industry		
	Observations	Mean	Std. Err.	Observations	Mean	Std. Err.
Total	7377	29860.75	162.355	1912	32204.14	370.228
AD<5691.798	3130	27613.20	221.408			
AD>5691.798	4247	31517.18	226.694			
AD<22688.85				900	30822.54	500.598
AD>22688.85				912	33567.55	541.505
Difference		3903.978**	325.360		2745.01*	737.861
t-value	t = 11.999			t = 3.7202		
Ho: Difference = 0	Pr(T > t) = 0.0000			Pr(T > t) = 0.0002		

Note: *: at 5% significance level; **: at 1% significance level.

5. Conclusions and Suggestions

In this paper, we apply the segmented regression analysis to investigate the relationship between the geographically industry AD and the wage rate differentiations of employees in Taiwan’s manufacturing industry and high-tech industries in Taiwan. We get the regional AD of every Taiwan’s employee in the two-digit manufacturing industries by calculating the geographic AD of each town in every individual industry from the “Industry, Commerce and Service Census” firstly, and then involve these data in the “Manpower Utilization Survey” with the data of each employee by matching the two-digit industries and location in which an employee’s firm belong to.

According to our empirical results, the factors resulting in the wage differentiation include the gender, education level, marriage status, work experience, the firm size and the AD of an employee. Our results also confirm LaFountain (2005)’s theory that the geographic agglomeration of an industry could increase firms’ productivity in the cluster and thus increase the wage rate of the their employees. Furthermore, we confirm that the

wage rate of employees in the cluster might be higher than the ones who are employed outside the cluster. The existence of the threshold values from the estimated results in segmented regression model implies the importance of considering the critical mass in a model with agglomeration externality. In addition, our estimated results that marginal effects of AD on wage rate outside the cluster are higher than the ones inside the cluster are counterintuitive, but we think such results might be reasonable as considering the principle of diminishing marginal return.

One shortage in this research is that the lag period of AD the “Industry, Commerce and Service Census” from the “Manpower Utilization Survey”. For further researches, it would be better to use the new survey of “Industry, Commerce and Service Census” held by DGBAS in Taiwan in 2006. Besides, in this paper, we concern about the localization externalities only as the definition of AD, but the concept of urbanization externalities in an industry cluster is also important in the literatures of geographic agglomeration. Thus, the researches in the future could take it into consideration and discuss its influence on the wage rate. Finally, the congestion effects resulted from the agglomeration of industries might dominate the positive externality triggered by agglomeration. Thus, how to involve this concept in practice is also worthy for further discussing.

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**Appendix: The Statistic Summaries of Agglomeration Degree in
Two-Digit Manufacturing Industries in Taiwan in 2001**

Industry	Observations	Mean	Minimum	Maximum	Variance
Food and Beverage Manufacturing	381	3657.463	94	9598.262	5754625
Textiles Mills	346	9484.238	1.333333	28527.74	4.68E+07
Apparel, Clothing Accessories and Other Textile Product Manufacturing	401	5310.356	3.897436	18021.79	2.80E+07
Leather, Fur and Allied Product Manufacturing	148	2198.76	7.266667	6133.863	2528050
Wood and Bamboo Products Manufacturing	61	813.72	6	3200.492	505786.4
Furniture and Fixtures Manufacturing	162	1569.848	45.78313	5468.391	1850974
Pulp, Paper and Paper Products Manufacturing	164	2021.77	2.4	8293.889	3085211
Printing and Related Support Activities	135	10336.98	47	25715.57	9.24E+07
Chemical Material Manufacturing	199	3205.361	91.69768	10535.7	7911105
Chemical Products Manufacturing	195	3355.728	222.2963	8875.604	7606306
Petroleum and Coal Products Manufacturing	34	280.9037	7.5	3243.372	578421
Rubber Products Manufacturing	75	1962.692	25	5222.143	2275109
Plastic Products Manufacturing	409	9023.209	44	26825.66	4.97E+07
Non-metallic Mineral Products Manufacturing	217	3661.117	41.875	8626.531	9100640
Basic Metal Industries	228	7362.4	49.05263	17044.63	3.82E+07
Fabricated Metal Products Manufacturing	807	11877.44	24.7	33071.86	8.14E+07
Machinery and Equipment Manufacturing and Repairing	635	19826.98	106.5373	50605.98	2.44E+08
Computer, Communications, and Audio and Video Electronic Products Manufacturing	646	23874.45	2	72370.98	4.59E+08
Electronic Parts and Components Manufacturing	1166	30536.53	2	52513.25	3.17E+08
Electrical Machinery, Supplies and Equipment Manufacturing and Repairing	319	8995.396	1	28197.72	5.85E+07
Transport Equipment Manufacturing and Repairing	356	7638.698	111.6	14941.64	2.12E+07
Precision, Optical, Medical Equipment, Watches and Clocks Manufacturing	103	2833.594	42.66667	9810.6	6603492
Other Industrial Products Manufacturing	190	3658.091	41	11443.29	7880157
Total	7377	13088.39	1	72370.98	2.32E+08

Note: According to the 7th modification of Standard Industrial Classification of Taiwan in 2001.