Gender Earnings Differentials in Taiwan: A Stochastic Frontier Approach

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February, 2007

Abstract

We examine Taiwan's male-female earnings gaps over the past three decades in order to assess the progress in assimilating women into the labor market. Two alternative methods of evaluating earnings gaps are employed in this paper: the traditional Oaxaca-Blinder decomposition method and the less well-known method of evaluating labor market efficiency. Men and women's earnings are converging during this period (1978-2003) while at the same time there is little change in the level of gender discrimination measured by the standard Oaxaca-Blinder method. Using the labor market efficiency (stochastic frontier) model we find increases in labor market efficiency over time for both males and females; however, females enjoy a much faster rate of increase in efficiency. We conclude that the relative increase in female efficiency represents a decline in discrimination against females.

JEL Codes: J6, O15

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I. Introduction

It is well known that Taiwan has made remarkable economic progress since the 1950s, and has served the world as a model of expert-led development. In addition, Taiwan attained a relatively equitable distribution of income in the midst of rapid economic growth during the 1970s, which jointly formed Taiwan's "economic miracle." Taiwan's ability to achieve "growth with equity" is often considered as a unique case study in economic development.

This paper examines Taiwan's claim of "growth with equity' from a different perspective; that is, from the perspective of gender equity. We propose to measure and evaluate the male-female wage gap across time in order to assess Taiwan's progress in assimilating women into the labor market. Taiwan is an interesting case study in gender equity as it has experienced both a rapid increase in female labor force participation and a gradual liberalization of both the economy and the political system.

Gender discrimination in Taiwan has not gone unnoticed in the literature. Vere (2005) reports the disparity between men's and women's wages narrowed slightly between 1979 and 1998. He argues that Taiwan's explicit policy of science and technology developed benefited older, more educated male workers but "contributed almost nothing to increases in the demand for [female] skilled labor" (p.178). Berik, Rodgers and Zveglich (2004) conclude that "competition from foreign trade … is positively associated with wage discrimination against female workers" (p. 249). Alternatively, Tam (1996) and Kao, Polachek, and Wunnava (1994) argue that the gender gap is not due to labor market discrimination but due to differences in labor market experience. Tam suggests that a reduction in the gender gap will require a "more equal sharing of family responsibilities" (p. 831). Kao et al, in a similar vein, suggest that females are expected to participate in the labor market less than males and "females on average

earn less than males because they invest less" (p.369). Zveglich and Rodgers (2004) investigate to what extent occupational segregation explains Taiwan's gender gap. They conclude that "changes in occupational segregation matter very little in explaining the trend in the wage gap" (p. 867). They suggest that until the early 1990's women suffered growing wage discrimination.

Typically, discrimination in the labor market is defined as different treatment of workers based on their demographic characteristics not related to their job performance (race, gender, etc.). Thus, in order to distinguish between skill-related differences and the predispositions for certain jobs for different groups, the discriminating personal characteristics must be unrelated to the job market performance. As a result one seeks to find any differences in earnings between non-market relevant characteristics that may occur, holding everything else constant (market-relevant characteristics, or productive characteristics).

To accomplish this task we employ two alternative methods of evaluating earnings gaps, the traditional Oaxaca-Blinder decomposition method and the less well-known method of evaluating labor market efficiency. While the details of these two methods must necessarily wait until the body of the paper, we do note that these two approaches take a somewhat different view as to how the labor market functions. In the traditional approach, it is assumed that there are two separate labor markets, one for males and one for females, with different returns to human capital (schooling and experience, in particular). Our labor market efficiency approach assumes the returns to one's human capital characteristics do not vary by gender; men and women with the same levels of schooling and experience are assumed to be equality productive and differences in gender are reflected in relative abilities to capture the returns to their human capital attributes (i.e, their relative efficiencies). Equally endowed women suffer

lower earnings than men as job opportunities are not made available due to labor market discrimination or due to lack of job mobility.

These differences in how the labor market is modeled are reflected in the differences in how the discrimination is measured. In the Oaxaca approach only differences in the returns to observable characteristics, human capital (schooling and experience) as well as non-human capital observables (marital status, children, and occupation) contribute to the measurement of discrimination. The frontier model, on the other hand, allows both observed and unobserved non-human capital and to contribute to discrimination; the unobserved non-human capital includes idiosyncratic employee or consumer preferences. If the additional sources of discrimination are time-variant then the Oaxaca method may result in a systematic bias in the estimated trend in discrimination.

II. Overview of Taiwan's Labor Market

Table 1 presents aggregate statistics on Taiwan's economic performance with emphasis on the labor market outcomes for several years, 1976-2003[1]. Column 1 provides the GDP growth rates; Taiwan's high growth rates of the 1970's are well-known and the 1980's and 1990's provided solid growth as well. Taiwan's high growth rates are clearly reflected in per capita incomes (US$, column 3) which increased almost 10-fold between 1976 and 1992. However, our period of study also includes the recession of 2001 with a 2.2 percent decline in GDP and a corresponding drop in per capita income. The Consumer Price index (column 2) shows a low rate of inflation after 1992 and a small degree of deflation in 2003.

Columns 4-9 provide macro level labor statistics. Labor force participation among women is rising over time while fewer men are in the labor force. Unemployment rates for

[1] The data source for Table 1 is Social Indicators—The Republic of China, 2003.

both men and women are below three percent until 1995—unemployment increased for both men and women during the 2001 recession. Furthermore, while GDP grew in 2003 it was accompanied by an increase in the unemployment rate. In contrast, labor productivity (column 8) continued to rise through and beyond the recession of 2001. Finally, Column 9 provides an index of Labor Force Adequate Utilization. Reasons for inadequate utilization include unemployment, employer-employee mismatch, inadequate hours or low income for the education level. We note the decline in this index after 1995.

Columns 10-13 provide real monthly earnings (1000's NT$) and average monthly hours worked. Real monthly earnings increased rapidly in the 1980's and 1990's but stagnated after 1999. Columns 11-12 show that flat male earnings account for the overall earnings stagnation; female earnings continue to grow after the 2001 recession. The last column of the table provides average monthly hours worked, which decline steadily until after the 2001 recession.

III. Methodologies

Oaxaca-Blinder Decomposition

One of the most common methodologies for determining earnings differentials by gender was developed by Oaxaca (1973) and Blinder (1973). This method distinguishes between the unequal treatments of females outside the labor market (differentials in variables) from the unequal treatment inside the labor market (differentials in coefficients). The average unadjusted logarithmic differential in gender earnings may be decomposed into an "explained" portion and an "unexplained" portion, which represents the same characteristics being rewarded differently:

$$\overline{\ln Y_m} - \overline{\ln Y_f} = (\overline{X_m} - \overline{X_f})\hat{\beta}_m + (\hat{\beta}_m - \hat{\beta}_f)\overline{X_f}\ , \qquad (1)$$

or

$$\overline{\ln Y_m} - \overline{\ln Y_f} = (\overline{X_m} - \overline{X_f})\hat{\beta}_f + (\hat{\beta}_m - \hat{\beta}_f)\overline{X_m}, \quad (2)$$

where *m* stands for the male worker, *f* stands for the female worker, *X* is a vector of the characteristics of the workers, and $\hat{\beta}$ is a vector of the estimated coefficients. The first term on the right-hand side stands for the earnings differential explained by the characteristics differential, while the second term is usually interpreted as discrimination because it represents different returns for the same characteristics.[2] The decomposition is performed based on the assumption that the "discriminated" group should be paid the same as another group, which means that males and females with the same characteristics, such as education, experience, occupation, etc., should earn the same. Equation (1) assumes that the returns to characteristics for males should be the "true" coefficient given certain characteristics, while equation (2) assumes returns to characteristics for females are the true betas. We choose the average X's for the entire sample (males and females) for our decomposition.

Labor Market Efficiency

We employ a stochastic frontier method (Aigner, Lovell, and Schmidt, 1977) to obtain a latent efficiency measure. Stochastic frontier analysis has been employed by labor economists to study incomplete worker information (Hofler and Polachek, 1985, among others), discrimination (Robinson and Wunnava, 1989; Slottje, Hirschberg, and Hayes, 1994; Ogloblin and Brock, 2005), immigrant's relative earnings performance (Daneshvary et al, 1992; Lang, 2005), and labor market liberalization in China (Bishop, Grodner, and Liu, 2006). Lovell (1995) provides a useful policy oriented review of efficiency analysis.

[2] We use the term "discrimination" interchangeably with the term "unexplained wage gap."

Due to the inefficiency originating from both labor demand and supply, we expect to see a sizable gap between realized earnings and earnings frontiers, which in Taiwan's case is likely to diminish over time due to globalization.

Using a standard labor market efficiency model:

$$L_{jk}^{D} = \theta_1^{D} + \theta_2^{D} X_{jk} + \theta_3^{D} w_{jk} - u_{jk}^{D}, u_{jk}^{D} \geq 0, \quad (1)$$

and

$$L_{ji}^{S} = \theta_1^{S} + \theta_2^{S} X_{ji} + \theta_3^{S} w_{ji} - u_{ji}^{S}, u_{ji}^{S} \geq 0, \quad (2)$$

where L_{jk}^{D} is quantity of labor demanded for employer *k* in local labor market *j* and L_{ji}^{S} is individual *i*'s labor supply choice. The deterministic parts of equations (1) and (2) are local labor demand and supply frontiers. The term u_{jk}^{D} reflects the inefficiency for employer *j* to identify the potential pool of qualified workers in locale *j*, u_{ji}^{S} captures the inability of individual *i* to identify the full range of potential employers, or to realize the full potential of worker's human capital, as well as the immobility caused by the local employers' monopsony.[3]

In the market with K_j employers and N_j potential workers in locale j, with the local labor market clearing condition applied, we have

$$\sum_{k=1}^{K_j} L_{jk}^{D} = \sum_{i=1}^{N_j} L_{ji}^{S}. \quad (3)$$

We can derive the following reduced-form wage equation:

$$\ln(w_i) = \alpha + \beta X_i + v_i - u_i, \quad (4)$$

[3] Polachek and Robst (1998) address the assumption that efficiency can be measured as a residual. Using independent information they find that "stochastic frontier estimates provide a reasonable measure of a worker's incomplete wage information"p.231).

where $\ln(w_i)$ is log earnings, X_i is a vector of human capital measures, $v_i \sim N(0,\sigma_v^2)$ is normal error, and $u_i \geq 0$ is earning inefficiency due to the joint effects of u^D and u^S. The predicted wage efficiency is then given by

$$E[\exp(-u_i) \mid \ln(w_i) - (\alpha + \beta X_i)]. \qquad (5)$$

We assume that a worker's human capital endowment is measured solely by one's education and experience (c.f., Polachek and Xiang, 2005). Other factors such as gender, occupation, industry, and marital status affect earnings indirectly by influencing how *efficiently* one is able to convert their human capital into earnings. This assumption, along with our theoretical model, suggests that we can model (log) earnings as a function of experience, experience squared, and years of schooling. Finally, it is necessary to assume a structure for the efficiency portion of the combined error term. We follow the literature and impose an exponential form on the error term as the most robust alternative.

We postulate a similar model for the Oaxaca decompositions; the only difference being that we run separate equations for males and females. We note that alternative models including occupational indicators improve model fit but do not influence the trend in the unexplained portion of earnings over time.

A Comparison of the Two Approaches

The Oaxaca approach is based on the assumption that all the characteristics that affect the wage are controlled for, and thus any differences in reward to productive characteristics must be due to non-market related factors, like discrimination. There are three potential problems with the approach. First, as mentioned above, it is unclear which coefficients are to be used as "non-discriminatory." Second, because of the assumption of full control for all earnings-

related characteristics, Oaxaca decomposition implies that we can measure discrimination only as differences in observed characteristics - be it human capital characteristics or other relevant demographic characteristics. Any unobservables that are in the error term and that contribute to discrimination are not included. The third problem is that we cannot distinguish between the differences in the returns to schooling due to discrimination and due to omitted variable bias. For example, suppose that females participating in the labor market have unobservable preferences for engaging in the labor market because they believe that they will be less discriminated against relative to all the females. Thus, these motivated females have higher returns to schooling than all the females and it may even be the case that their education may be more rewarded than males. As a result we may observe negative discrimination.

Considering the difficulties using Oaxaca decomposition, we use the differences in efficiency measures obtained from the frontier model to measure the discrimination. In the frontier model we assume that the potential earnings are only determined by human capital characteristics, like schooling and experience, whereas actual earnings also are determined by the level of individual efficiency. Here labor market efficiency measures how other observable and unobservable characteristics contribute to the (in)ability of each worker to reach his or her earnings potential. Some workers may realize their full potential, and some may not be able to exploit their full potential, and the differences will be represented in the differences in earnings.

Assuming that the workers on average reach the same level of efficiency across various demographic groups, we should see no differences in labor market performance, as represented by earnings. Any differences in efficiency between various groups will not be the result of underutilization of personal potential, but the result of other non-market factors like

discrimination, that artificially decrease the earnings.[4] In other words, given that human capital characteristics are rewarded the same way for every group, and that each group reaches the same level of efficiency in the economy, any differences in the revealed efficiency must be the result of observed and unobserved non-human capital related factors that we can call discrimination.

III. Empirical Results

Data

Our analysis is based upon the sample of workers in the "Household Income and Expenditure Survey", a series of country-wide surveys conducted by the Directorate-General of Budget, Accounting and Statistics, Executive Yuan, R.O.C. (DGBAS). Interviews and account keeping are used to collect data in the survey. Households to be interviewed are drawn from the population by a stratified random sampling method.

The DGBAS annually provides detailed income information for individuals in a large number of representative households. Microdata are available since 1976. The sample rate of households was 0.3% for 1975-1977 and 0.4% for 1978-1983; however, it was fixed to 16,434 households for 1984-1994 and then reduced to 14,706 after 1994. The present analysis focuses on individuals with positive annual earnings, ages 18 to 59, for 1978, 1985, 1992, 1995, 1999, 2001 and 2003.

Table 2 provides summary statistics for male and females for the seven years considered. Females make up a growing proportion of workers, rising from just over a quarter of the workforce in 1978 to nearly 40 percent by 1999. Similarly, the unadjusted earnings ratio is shrinking over time. Women earned only one-half of what men earned in 1978 (54.2

[4] Among these other factors includes unequal sharing of family responsibilities, see Tam (1996).

percent); by 2003 women's earnings are 70 percent of male earnings. Men and women are nearly equal in educational achievement, but male workers are older on average than female workers.

Estimation Results

Table 3 provides the regression estimates for males and females. The dependent variable is the log of earnings. Somewhat surprisingly, the female R^2 values are higher than those for males. Females appear to earn higher returns to education and lower returns to experience than males. Returns to education among males are generally rising over time, from approximately 8 percent in 1978 to approximately 10 percent in 2003. In contrast, female returns to schooling fall from nearly 14 percent to approximately 12 percent over this same time period. Male returns to experience show no trend over time, beginning and ending the period at about the same rate. Female returns to experience appear to have increased over time; for example, a female worker with 10 years of potential experience earned 28 percent more than a new entrant (with the same education) in 1978 but 37 percent more in 2003.

Table 4 provides the earnings gaps and decomposition results. As in Table 2 we observe a sharp decline in the unadjusted earnings gaps over time (column 4). But this is clearly not due to gender convergence in the education and experience coefficients. Like Zveglich and Rodgers (2004) we find a slight worsening of the status of females between 1978 and 1995, with some improvement after 1995. This said, given the steep decline in the unadjusted earnings gap, there appears to be little decline in gender discrimination as measured by the Oaxaca method.

This somewhat confounding result that earnings are converging while at the same time there is little change in the level of gender discrimination suggests that an alternative model of

labor market behavior may be necessary. Returning to Table 3, we find that returns to education are higher for females than males. Why is this the case? Does an additional year of schooling given to a female really provide a larger increase in output? Or is it merely the case that higher educated women suffer less discrimination than lower educated women.[5] Using the same data source as this paper, Bishop and Chiou (2004) find that the adjusted gap between men and women's earnings declines with education. Therefore, we next present the results of the frontier model estimation.

Recall that the labor market efficiency (frontier) model assumes that a worker's human capital endowment is measured solely by one's education and experience whereas other factors (e.g., gender) affect earnings indirectly by influencing how *efficiently* one is able to convert their human capital into earnings. Table 5 presents the results of the frontier model. As expected the returns to the education and experience in this single model lie between those found for males and females. Note that *lambda*, the ratio of the two error terms, is close to one in each case. This tells us the random error term and the (in)efficiency error term are of the same magnitude.

Table 5 also provides the efficiency estimates for all workers, by gender. As expected the overall labor market efficiency in Taiwan is growing over time, from 0.677 in 1978 to 0.734 in 1999. Labor market efficiency declines during the deep recession of 2001 but rebounds by 2003. This growth in efficiency is experienced by both males and females; however, females enjoy a much faster rate of increase in efficiency. Furthermore, females do not suffer a decline in efficiency during the 2001 recession. The last row of Table 5 provides the ratio of male to female efficiency, which increases from 0.775 to 0.906. Therefore, we

[5] Alternatively, the returns to male educations are "too low" as the male earnings premium due to positive discrimination declines with education.

conclude that *the relative increase in female labor market efficiency represents a decline in discrimination against females.*

The apparent difference between Oaxaca results, which indicate no change in gender discrimination over time, and the decline in discrimination suggested by the stochastic frontier model, stems from the competing interpretations of the labor market by the two methods. The former measures relative compensation for the observed determinants of earnings, whereas the latter allows the change in how both observed and unobserved factors affect female earnings. Given the dramatic structural changes in the Taiwan economy during the last there decades, we believe that the frontier model is better suited to correctly capture trends in relative (male/female) earnings because it is able to reflect the changing economic environment.

IV. Conclusion

This paper examines Taiwan's claim of "income growth with equity" from the perspective of gender earnings differences. We evaluate the male-female wage gaps over time in order to examine Taiwan's progress in assimilating women into the labor market. Taiwan is an interesting case study in gender equity as it has experienced both a rapid increase in female labor force participation (rising from just over a quarter of the workforce in 1978 to over 40 percent in 2003), and a gradual liberalization of both the economy and the political system.

Two alternative methods of evaluating earnings gaps are employed in this paper: the traditional Oaxaca decomposition method and the less well-known method of evaluating labor market efficiency. These two approaches take a somewhat different view as to how the labor market functions. In the traditional Oaxaca approach, it is assumed that there are two separate labor markets, one for males and one for females, with different returns to human capital

(schooling and experience, in particular). The labor market efficiency approach assumes the returns to one's human capital characteristics do not vary by gender; men and women with the same levels of schooling and experience are assumed to be equally productive. Thus, the differences in earnings by gender are reflected in relative efficiencies. Equally endowed women suffer lower earnings than men as job opportunities are not made available to them due to the labor market discrimination, family responsibilities, or lack of job mobility.

Using the standard Oaxaca-Blinder decomposition method we find little trend in the ratio of "unexplained to total earnings gap" over time. It is a somewhat confounding result given the growth of the Taiwanese economy and the dramatic changes in the composition of the labor force, where females make up a growing proportion of workers and the unadjusted wage ratio is shrinking over time.

The result that earnings are converging while at the same time there is little change in the level of gender discrimination motivates the use of an alternative model of labor market behavior, the labor market efficiency (stochastic frontier) model. Using this model we find increases in labor market efficiency over time for both males and females; however, females enjoy a much faster rate of increase in efficiency. We conclude that the relative increase in female labor market efficiency represents a decline in discrimination against females.

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TABLE 1. Taiwan's Labor Market Statistics 1976 - 2003

Year	Growth Rate	CPI	Per Capita GDP $US	Labor Force Participation		Unemployment Rate		Labor Productivity	Adequate Utilization	Real Monthly Earnings (1000's NT$			Average Monthly Hours Worked
				Male	Female	Male	Female			All	Male	Female	
1976	13.9	38.8	1,132	77.1	37.6	1.59	2.19	--	--	12.0	-	-	219
1985	5.0	69.6	3,297	76.1	43.3	2.90	2.92	40.8	75.3	20.1	-	-	204
1992	7.5	83.9	10,502	73.8	44.8	1.47	1.57	63.9	78.6	35.2	-	-	196
1995	6.4	93.2	12,686	72.0	45.3	1.79	1.80	74.6	83.1	38.0	-	-	194
1999	5.4	98.8	13,235	69.9	46.0	3.23	2.46	92.0	81.2	41.4	46.8	34.4	190
2001	-2.2	100.0	12,876	68.5	46.1	5.16	3.71	100.0	78.2	42.0	47.1	35.7	180
2003	3.2	99.5	13,157	67.7	47.1	5.51	4.25	106.7	75.9	42.5	47.1	36.7	181

Source: Social Indicators: Republic of China (Taiwan), 2003

Table 2. Summary Statistics

	1978	1982	1992	1995	1999	2001	2003
Male							
Age	38.7	38.4	38.4	38.8	39.3	39.6	40
Percent	73.4	67.9	64.7	63.2	60.8	60.4	59.5
Education	10.5	10.9	11.7	11.9	12.5	12.7	12.9
Real Earnings	242163	319990	553992	584416	630384	610795	611756
Sample Size	14913	16363	15364	11832	10661	10848	10661
Female							
Age	32.7	33.6	35.0	36.0	36.5	36.8	37.5
Percent	26.6	32.1	35.3	36.8	39.2	39.6	40.5
Education	10.5	10.8	11.6	11.9	12.6	12.9	13
Real Earnings	131172	179300	330426	360930	417987	411935	428512
Sample Size	5391	7739	8394	6879	7299	7105	7250
Earnings Ratio	54.2	56.0	59.6	61.8	66.3	67.4	70.0

TABLE 3

Regression Estimates

Variables	1978		1985		1992		1995		1999		2001		2003	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Experience	.0678 (.0018)	.0361 (.0032)	.0798 (.0016)	.0394 (.0023)	.0820 (.0015)	.0467 (.0020)	.0751 (.0017)	.0446 (.0020)	.0672 (.0017)	.0397 (.0018)	.0685 (.0019)	.0498 (.0019)	.0623 (.0018)	.0443 (.0018)
Exp²	-.0014 (.0000)	-.0008 (.0001)	-.0016 (.0000)	-.0008 (.0001)	-.0016 (.0000)	-.0009 (.0006)	-.0015 (.0000)	-.0083 (.0000)	-.0012 (.0006)	-.0007 (.0000)	-.0012 (.0000)	-.0009 (.0000)	-.0010 (.0000)	-.0007 (.0000)
School Years	.0794 (.0016)	.1393 (.0039)	.0907 (.0016)	.1337 (.0030)	.0850 (.0016)	.1337 (.0026)	.0791 (.0019)	.1285 (.0027)	.0912 (.0019)	.1200 (.0025)	.1037 (.0021)	.1202 (.0027)	.0998 (.0021)	.1236 (.0026)
R^2	0.176	0.229	0.239	0.246	0.277	0.303	0.245	0.303	0.259	0.288	0.261	0.288	0.249	0.291

TABLE 4. Earnings Gaps and Decompositions

(1) Year	(2) log_earnings_Male	(3) log_earnings_Female	(4) Unadjusted Earnings Gap	(5) ”Unexplained” X'(ßmßf)	(6) X'(ßmßf)/Earnings Gap
1978	12.25	11.569	.681	.599	.880
1985	12.517	11.897	.619	.536	.865
1992	13.509	12.509	.554	.486	.878
1995	13.136	12.634	.502	.449	.896
1999	13.206	12.798	.408	.355	.870
2001	13.139	12.760	.379	.318	.839
2003	13.153	12.801	.352	.300	.853

Table 5. Frontier Regression Results

	1978	1985	1992	1995	1999	2001	2003
Experience	0.0647 (.0001)	0.0717	0.0687	0.0643	0.0582	0.0611	.0539
Exp^2	-0.0012	-0.0013	-0.0012	-0.0011	-0.0009	-0.0010	-0.0008
Schooling	0.0878	0.1022	0.0992	0.0948	0.1026	0.1136	0.1142
N	20304	24102	23758	18711	18627	17953	17911
Lambda	1.26	1.25	1.25	1.08	1.02	0.97	0.96
Overall Efficiency	0.6767 (.0012)	0.687 (.0011)	0.7006 (.0011)	0.7187 (.0011)	0.7339 (.0011)	0.7317 (.0011)	0.7367 (.0010)
Male Efficiency	0.720	0.732	0.749	0.762	0.769	.761	.766
Female Efficiency	0.558	0.589	0.612	0.644	0.679	.687	.694
M/F Ratio	0.775	0.805	0.817	0.845	0.883	.903	.906