**Changing Labor Force and Economic Growth in Post-Industrial Taiwan: The Importance of Incorporating a Gender Perspective**

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## Introduction

Unpacking the determinants for economic growth has long been a topic of interest among social scientists. Since its inception in 1956, the Solow growth model has dominated this field of study. In this model, factors of economic growth are decomposed based on a neoclassical production function, where the population structure and saving rates of an economy are set as exogenous. Although researchers have confirmed that the model can function with consistency even with variations in country-level contexts (Mankiw, Romer, and Weil 1992), it fails to capture the relation between population dynamics and the economic development of a country. A country typically experiences educational expansion, gender empowerment, and population aging on its way to development. These features of demographic transition have dramatically changed the composition of a country's labor force, which is the foundation of economic production. Recent studies have successfully incorporated demographic factors into economic analyses, where the importance of "demographic dividend" resulted from changing age structures is reported (e.g. Bloom et al. 2010). However, relatively few studies focus on the diverging patterns of labor force participation between men and women. In addition, educational expansion restructures the composition of economically active population as well as shifts people's labor force participation preferences. The interrelation of age, gender, and educational composition of a population contributes to the unique context for economic development in each country. To demonstrate the dynamic influences of demographic transition, incorporating multiple demographic indicators to analyze economic trend is imperative.

The current study aims to contribute to demographic research in a few ways. First, the study will enrich our understanding of the nexus between human capital accumulation and economic growth by integrating a gender perspective (the sex-specific labor force participation rates) into the macro level analysis. By disentangling the interrelation between educational expansion and increasing female employment, our findings will address empirical issues in theories linking gender equity and development (Boserup et al. 2007). Second, our findings will supplement the existing literature on economic growth of the Asian Tigers (i.e. Hong Kong, Singapore, South Korea and Taiwan) in the post-industrial era. With its growing human capital and aging population, re-examining the growth formula in Taiwan will deepen our knowledge about the complex connection between demographic transition and economic development. Third, this study adopts an alternative decomposition method other than Solow's growth model or its refinements to tackle the determinants of economic growth. The advantage of the standardized decomposition approach is its integration of multi-dimensional cross-classified indicators into a formula. This advantage makes the method especially suitable for studying demographic transition, which can be understood a long-term trend of population development driven by changes in various demographic indicators.

## The Taiwanese context

As one of the pillars of the "Asian Miracle," Taiwan's successful industrialization was a story widely explored in several influential studies (Young 1994, 1995; Tallman & Wang 1994). In addition to its miraculous economic growth, Taiwan experienced a significant demographic transition from 1970 to 1990, when its population dependency ratio (population aged 15- & 65+ divided by population aged 15-64) dropped from 0.74 to 0.49. The rapid expansion of secondary education was also remarkable, with the proportion of 15+ population with at least secondary education rose from 20% to almost 40% for men and from 10% to 33% of women. Empirical results have shown that the massive upsurge in labor force and the sustaining growth in human capital accumulation both played crucial roles in Taiwan's economic growth prior to the 1990s.

However, starting from Japan's economic recession in the early 1990s, and following by the 1997 Asian financial crisis, the script of the Asian Miracle was shadowed by a pessimistic growth prospect in East Asia and had thus lost its attention from development economists. In a sharp contrast to their stalling economy, rapid demographic transitions continued in the post-industrialized period among these countries.

During the analytical period of in this study (1993-2016), Taiwan has experienced a 66.5% decrease in its total fertility rate (from 1.76 to 1.17); and life expectancy at birth prolonged for 5.72 years (from 74.28 to 80). In addition, a second phase of educational expansion took place in the early 1990s. With this policy reform, more citizens received tertiary education, leading to a fundamental change in the quality of labor force. At the same time, gender differences in labor force participation were decreasing due to the general advancement of female education and the changing demand for labor force in the knowledge economy. For these reasons, it will be valuable to re-examine economic development in Taiwan over the recent two decades, a period when the society experienced a modest growth in its economy but a dramatic change in its demographic compositions.

## Research Design

### *Analytical strategy*

In the first section of this article, general trends in Taiwan's economic growth over the past two decades and the structural change in its population and labor force will be demonstrated. Next, I will utilize Das Gupta's (1993) method to decompose the changes in labor force participation rates (LFPR) into two terms: one of which is the contribution of changes in educational composition, and the other is interpreted as the contribution of differences in education-specific labor force participation rates. To illustrate the variance by gender and age, I will decompose male and female LFPR over four age groups (15-24, 25-34, 35-54, 55-64), each of which represents a specific phase of an individual's working life span.

After analyzing the proportional contribution of gender, age, and education to the changing labor force, I will incorporate these results into the Shapley decomposition formula to examine the role of rising female labor force participation in propelling Taiwan's economic development over the period of 1993-2016. Following World Bank's (2010) analytical framework, changes in the aggregate productivity of a country (GDP) can be understood as an outcome of a series of interrelated changes in labor productivity, labor force participation rate, population age structure, and the size of a population. The productivity equation can be expressed as:

$$Y = \frac{Y}{E} * \frac{E}{A} * \frac{A}{N} * N \qquad (1)$$

*Or* $$Y = w * e * a * N \qquad (2)$$

Where $Y$ refers to the total values added, the GDP; $E$ refers to economically active population; $A$ is the total population of working ages, which is defined as population aged 15-64; and $N$ is the total population of a country. In equation (2), $w = Y/E$ refers to labor productivity; the $e = E/A$ denotes labor force participation rates; $a = A/N$ represents the proportion of population in working age. Equation (2) implies that the GDP of a country is a product of four factors; and its proportional change in values, the GDP growth rate, can thus be decomposed into four elements: change in labor productivity ($\triangle w$), change in labor force participation rates ($\triangle e$), change in age structure ($\triangle a$), and change in population size ($\triangle N$). I will utilize Shapley approach to decompose the contribution of each component to economic growth rates in Taiwan in the period of 1993-2016. This approach has been used in previous research to study the causes of economic growth in different countries (e.g. Pirciog and Lincaru 2016 for Romania; Chen et al. 2018 for China). Detailed discussions about the approach can be found in the Appendix of this article.

*Data*

To address issues outlined above, annual data on GDP (from national accounts), employment by age, sex, and education (from labor force survey), and population by age, sex, and education (from vital statistics) are required. Given that Taiwan is not a member country of the United Nation and the World Bank, I compile the data needed from different sources of government publications. Real GDP data (deflated on 2011's price index) are available from the National Accounts Database managed by the Directorate-General of Budget, Accounting and Statistical; labor force data are assembled from the Labor Statistics Database directed by the Ministry of Labor; and data on population by age, sex, and education come from the Statistical Yearbook of Taiwan, which is published annually by the Ministry of Interior. Our decomposition analyses will cover changes over 23 years from 1993 to 2016, since data for the cross-classified rates and population counts in each age-sex-education category are not available before 1993.

To make the educational levels comparable to those of other countries, I group the population into three educational categories: those with less than secondary education (equivalent to ISCED 0/1/2), those with secondary education (ISCED 3), and those with tertiary education (ISCED 5/6). In addition, to measure the economic contribution of changes in age structure (percentage of population in working age), the economically active population is defined as population aged 15-64.

**Preliminary Findings and Planned Analyses**

Economic and demographic trends over the past two decades are presented in Table 1. From 1993 to 2016, Taiwan's real GDP experienced a relatively stable annual growth of 4.32% (from 6,007 to 15,876 billion NTD). During the same period, the population structure began to age, with the percentage of child population decreasing from 25.2% to 13.6%. However, because a large number of adults born after the 1970 economic boom started to enter the labor market, the net impact of population aging on dependency ratio was negative during this period. A larger proportion of population in prime working age translated into the "demographic dividend," which has been proved to be an important source of growth among the Asian Tigers (Bloom et al. 2003). Paralleled with the economic and population trends, educational attainments, especially among women, underwent a remarkable advancement. In 2016, the percentages of 15+ population receiving at least a secondary degree were 69.4% for men and 64.4% for women, which were more than 25% increase for both sex from their 1993 level. The population with tertiary education has expanded at an even faster pace, accounting for more than one third of the total adult population in 2016.

With improvements in women's educational levels, a surge in female labor force participation rates from 50.9% in 1993 to 61.2% in 2016 has been observed. On the other hand, men's higher educational attainments did not necessarily bring them higher labor force participation rates. As shown in Figure 1, the age patterns of LFPR for men and women are converging over time. In 2016, there is no significant difference between young men and women regarding their LFPR before age 30. Although the gender gap in the LFPR has been shrinking, women are still more likely to exit the labor market at a later life stage. Decrease in the LFPR implies that the idea of sacrificing their career at a certain stage for the sack of family formation might still be prevalent among Taiwanese women. However, we do find a postponement in women's exit from the labor force, and the magnitude of this effect is decreasing as well. These findings are somewhat different from those observed among women in South Korea, where women's labor force participation behaviour has changed little over time (Ma 2016). Advancement of education among women is likely to close the gender gap in labor force participation in Taiwan.

Results from the decomposition analyses reveal the impact of structural change in education on female and male LFPR over the past 23 years. Graph (a) in Figure 2 shows the absolute contributions of educational composition and education-specific LFPR to changes in LFPR for women, while Graph (a) in Figure 3 presents the results for men from the same calculation. Moreover, in the following two graphs (Graph (b) & (c)), the absolute contributions of the two factors (i.e. educational composition and education-specific LFPR) derived from different educational categories are presented. According to Graph (a) in Figure 2, educational expansion contributes positively to female LFPR. Due to the higher baseline employment rates among tertiary-educated women, a universal rise in the proportion of tertiary-educated women accounts for a major part of the increase in female LFPR (Graph (b)). A more remarkable finding is that controlling for the compositional change, there is a general upsurge in LFPR for women aged 25-64 across all types of educations (Graph (c)). What should be noticed is that non-tertiary educated women, who were more likely to quit working under the traditional gender division of labor, are becoming more active in labor market now.

For men, stories are different. Results in Figure 3 show that men, especially older men, are more likely to drop out of labor market in year 2016 than before. Graphs (a) and (c) in Figure 3 report that declines in male LFPR among middle-age and old-age workers were driven by a decrease in LFPR across all educational groups. In a sharp contrast to their female counterparts, middle- and old-age men who did not receive tertiary education become more likely to cease employment. We should be aware of the emerging trend in old-age unemployment among less-educated men, which could be a sign of expanding social inequality in Taiwan society.

In the next step, this study will perform a three-way decomposition of total LFPR with two compositional factors (i.e. sex and education). Results from the three-way decomposition will be integrated into the Shapley approach in order to measure the contributions of structural change in LFPR to economic growth (details of the approach is available in the Appendix). With an emphasis on gender perspective, this study aim to illustrate that a successful incorporation of women into labor force is crucial for a country's long-term economic development.

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## Table 1. Economic and Population trend in Taiwan, 1993-2016

| | Year | | | |
|---|---|---|---|---|
| | **1993** | **2000** | **2008** | **2016** |
| Real GDP (billion NTD) | 6,007 | 9,170 | 12,661 | 15,876 |
| Population size (thousands) | 20,996 | 22,276 | 23,037 | 23,493 |
| Population age structure (% pop.) | | | | |
| 0-14 | 25.15 | 21.11 | 16.95 | 13.57 |
| 15-64 | 67.75 | 70.26 | 72.62 | 73.92 |
| 65+ | 7.10 | 8.63 | 10.43 | 12.51 |
| Dependency ratio | 47.60 | 42.32 | 37.70 | 35.28 |
| Secondary+ education (%) | | | | |
| 15+ Men | 43.88 | 53.48 | 62.18 | 69.40 |
| 15+ Women | 37.86 | 48.35 | 57.48 | 64.44 |
| Tertiary education (%) | | | | |
| 15+ Men | 14.02 | 21.77 | 29.54 | 36.96 |
| 15+ Women | 9.88 | 18.05 | 26.94 | 34.71 |
| Labor force participation rates (%) | | | | |
| 15-64 Men | 83.16 | 80.75 | 77.72 | 78.51 |
| 15-64 Women | 50.86 | 52.87 | 57.42 | 61.23 |

## Figure 1. Male and female labor force participation rates by age group, Taiwan, 1993-2016

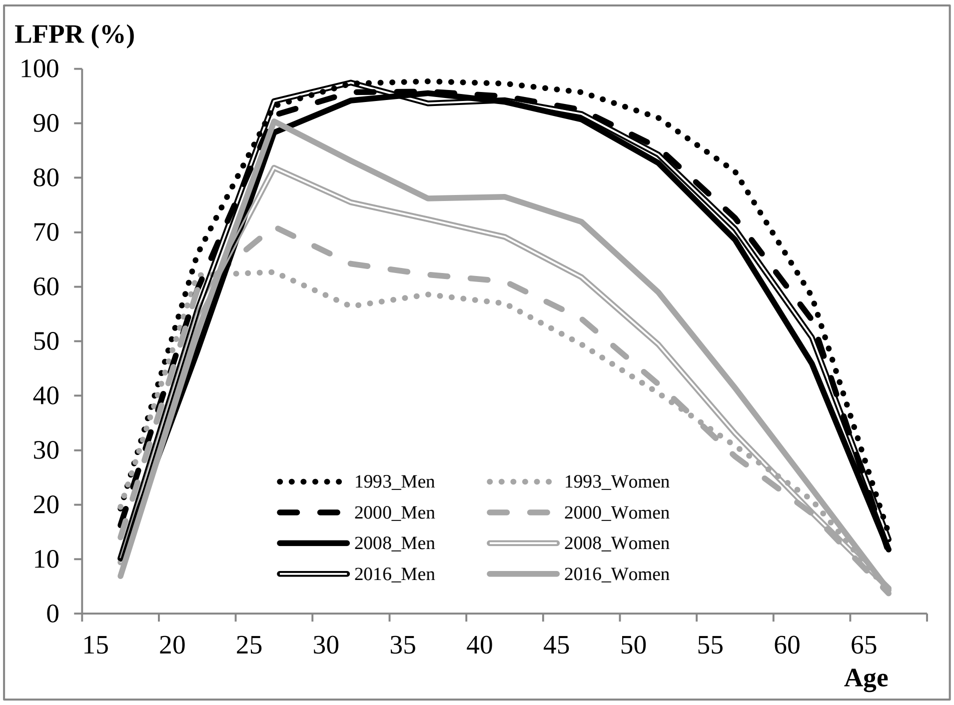
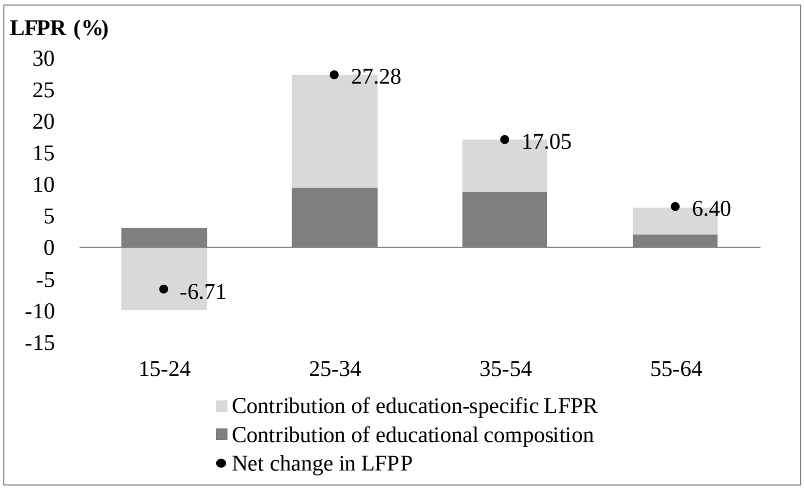
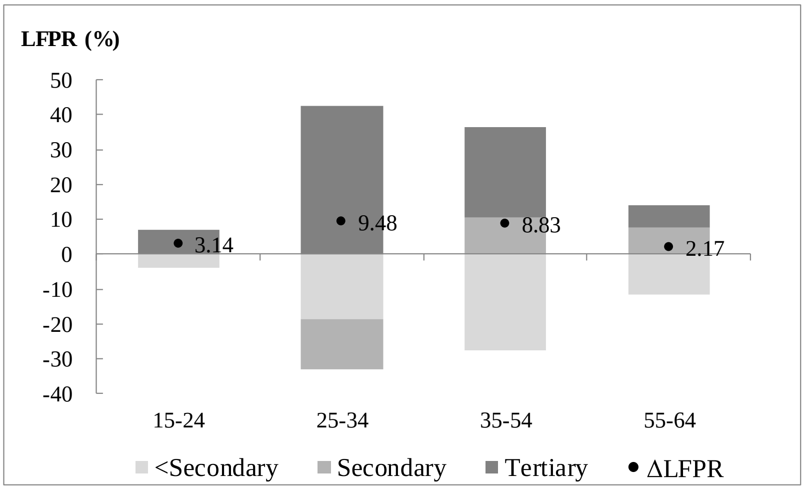


**Figure 2. Decomposition analysis of changes in female labor force participation rates by age and education in Taiwan, 1993-2016**



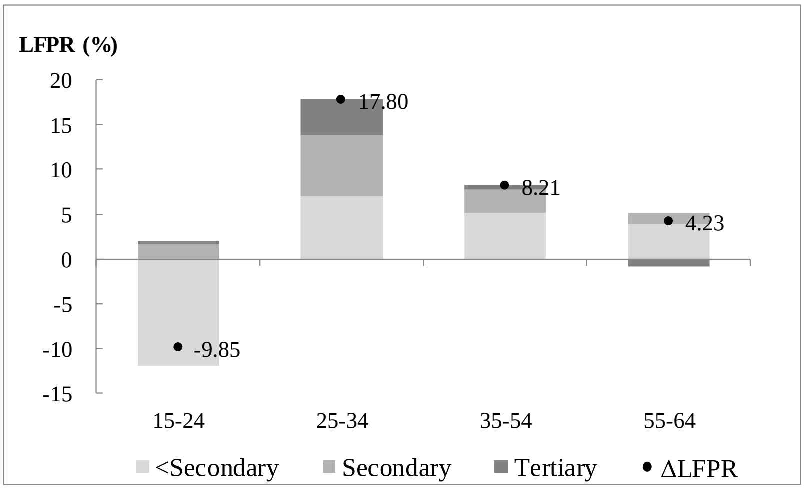

(a)

Demoposition of changes in Female LFPR




(b)

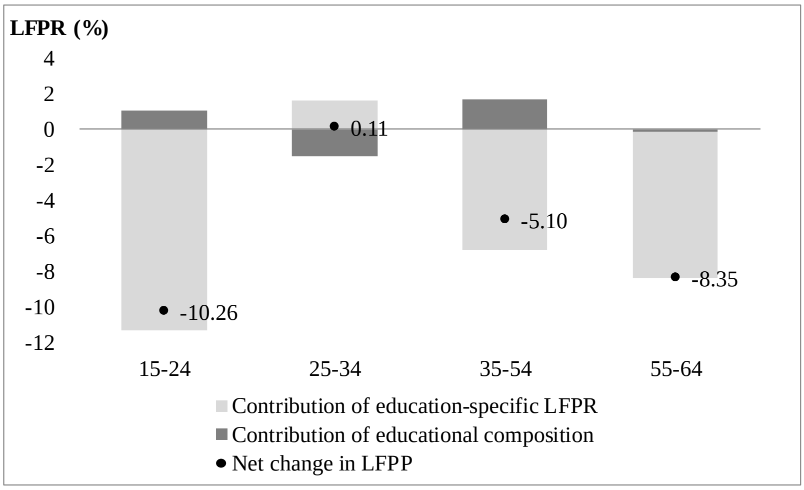
Contribution of changes in educational composition




(c)

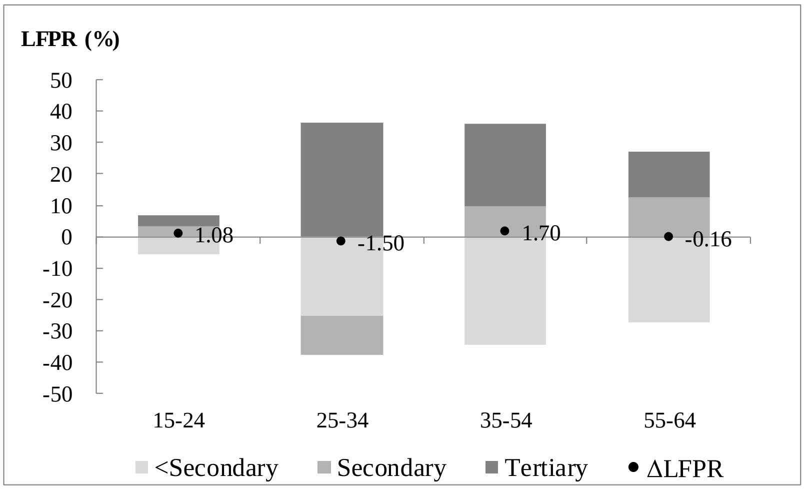
Contribution of changes in education-specific LFPR

**Figure 3. Decomposition analysis of changes in male labor force participation rates by age and education in Taiwan, 1993-2016**



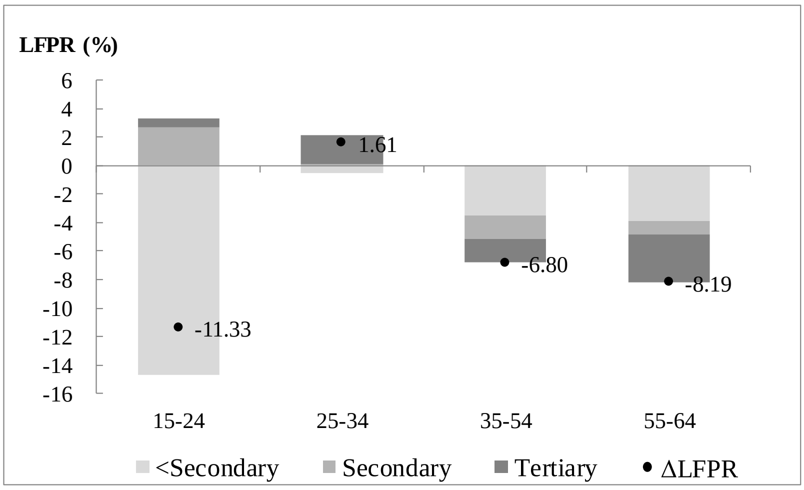

(a)

Demoposition of changes in Male LFPR




(b)

Contribution of changes in educational composition




(c)

Contribution of changes in education-specific LFPR

# Appendix

## 1. Decomposing labor force participation rates by gender, age, and education

Das Gupta's standardization method is applied to decompose the contribution of changes in each cross-classified demographic indicator to the differences in labor force participation rate (LFPR). I first decompose the LFPR by one cross-classified indicator—the age specific educational composition. The algorithm used in this decomposition analysis is:

$\Delta$LFPR = $\Delta e$ = $e$(t) - $e$(t-1)

$$=\Sigma\,[C(t)-C(t-1)] * \left[\frac{R(t)+R(t-1)}{2}\right] + \Sigma\,[R(t)-R(t-1)] * \left[\frac{C(t)+C(t-1)}{2}\right]$$

= [Difference in educational composition]*[Standardized by education-specific LFPR]
+ [Difference in education-specific LFPR]*[Standardized by educational composition]

= Contribution of education composition differences to $\Delta$ (C)
+ Contribution of education-specific rate differences to $\Delta$ (R);

In this stage, calculations based on the educational composition and the corresponded educational-specific LFPR are performed over four major age groups (15-24, 25-34, 35-54, 55-64). With this method, we can analyze the proportional contribution of educational factors to the changing male and female LFPR in each phase of an individual's working life trajectory.

Next, I will perform a three-way decomposition of total LFPR with two compositional factors (sex and education). Cross-classified rates and population counts for each sex-education category are required for this task. The difference between the total LFPR of two specific years in Taiwan will be decomposed as a sum of a rate effect and the two compositional effects. The equation is:

$$T_{..} - t_{..} = R\text{-effect} + I\text{-effect} + J\text{-effect} \quad (1)$$

Where t.. and T.. represent the total LFPR in the initial and the later years. I and J identify the composition effects for sex and educational structure respectively, and R is the rate effect that applies equally to both variables.

$$\Delta e = T_{..} - t_{..} = [R(\bar{T})-R(\bar{t})] + [I(\bar{A})-I(\bar{a})] + [J(\bar{B})-J(\bar{b})] \quad (2)$$

Effects in function (1) are derivatives from differences of components in function (2). On the left-hand side of equation (2), the total LFPR are written as:

$$T_{..} = \sum_{i,j} \frac{T_{ij}N_{ij}}{N_{..}}\ ,\ t_{..} = \sum_{i,j} \frac{t_{ij}n_{ij}}{n_{..}} \quad (3)$$

Where Nij and $T_{ij}$ are the number of persons and the rate for the (i,j) category in population 1; Ni. and $T_{i.}$ are the number of persons and the rate for the $i^{th}$ category of I, and $N_{.j}$ and $T_{.j}$ are the corresponding number of persons and the rate for the $j^{th}$ category of J.

On the right hand side of equation (2), the first set of vector components, the total LFPR ($R(\bar{T})$), are weighted by the proportion of population in each of the sex-education cell.

$$R(\bar{T}) = \sum_{i,j} \frac{\frac{n_{ij}}{n_{..}}+\frac{N_{ij}}{N_{..}}}{2} T_{ij} \tag{4}$$

The ratio of each sex-education cell to a population can be further written as:

$$\frac{N_{ij}}{N_{..}} = \sqrt{\left(\frac{N_{ij}}{N_{.j}} * \frac{N_{i.}}{N_{..}}\right)} * \sqrt{\left(\frac{N_{ij}}{N_{i.}} * \frac{N_{.j}}{N_{..}}\right)} = A_{ij}B_{ij} ,$$
$$\frac{n_{ij}}{n_{..}} = \sqrt{\left(\frac{n_{ij}}{n_{.j}} * \frac{n_{i.}}{n_{..}}\right)} * \sqrt{\left(\frac{n_{ij}}{n_{i.}} * \frac{n_{.j}}{n_{..}}\right)} = a_{ij}b_{ij} \tag{5}$$

In equation (5), the $\bar{A};\bar{a}$ and the $\bar{B};\bar{b}$ are two sets of vector-factors weighted in average between two population groups (population in two different observation years) to generate the standardized coefficients for each of the compositional variables. After standardizing the population composition, the two ratios in $\bar{A}$ and $\bar{a}$ represent only the *I*-effect, and the two ratios in $\bar{B}$ and $\bar{b}$ represent only the *J*-effect. Equations of standardized rates for each compositional variable are:

$$I(\bar{A}) = \sum_{i,j} \frac{t_{ij}+T_{ij}}{2} \frac{b_{ij}+B_{ij}}{2} A_{ij} \tag{6}$$

$$J(\bar{B}) = \sum_{i,j} \frac{t_{ij}+T_{ij}}{2} \frac{a_{ij}+A_{ij}}{2} B_{ij} \tag{7}$$

Combining equation (4), (6), and (7) into equation (2), we generate the decomposition formula for the change in total LFPR, which considers the contribution of ratio and compositional change in working age population across sex and education lines:

$$\Delta e = \left[\sum_{i,j} \frac{\frac{n_{ij}}{n_{..}}+\frac{N_{ij}}{N_{..}}}{2} Tij - \sum_{i,j} \frac{\frac{n_{ij}}{n_{..}}+\frac{N_{ij}}{N_{..}}}{2} tij\right] + \left[\sum_{i,j} \frac{t_{ij}+T_{ij}}{2} \frac{b_{ij}+B_{ij}}{2} Aij - \sum_{i,j} \frac{t_{ij}+T_{ij}}{2} \frac{b_{ij}+B_{ij}}{2} Aij\right]$$

$$+ \left[\sum_{i,j} \frac{t_{ij}+T_{ij}}{2} \frac{a_{ij}+A_{ij}}{2} Bij - \sum_{i,j} \frac{t_{ij}+T_{ij}}{2} \frac{a_{ij}+A_{ij}}{2} bij\right] \tag{8}$$

## 2. Decomposing the GDP growth rate ($\frac{\Delta Y}{Y_0}$)

Based on the marginal effect on the value of each indicator, the Shapley decomposition approach firstly eliminates each of the contributory factors in a sequence, and then re-assign to each factor the average of its marginal contribution in all possible elimination sequences (World Bank 2010: Appendix). The specific decomposition equation for GDP growth rate is:

$$\frac{\Delta Y}{Y_0} = \frac{Y_1 - Y_0}{Y_0} = \frac{\Delta w}{Y_0}\left[\frac{e_1 a_1 N_1}{4} + \frac{e_1 a_1 N_0}{4} + \frac{e_0 a_0 N_1}{12} + \frac{e_0 a_0 N_0}{12} + \frac{e_1 a_0 N_1}{12} + \frac{e_1 a_0 N_0}{12} + \frac{e_0 a_1 N_1}{12} + \frac{e_0 a_1 N_0}{12}\right]$$

$$+ \frac{\Delta e}{Y_0}\left[\frac{w_1 a_1 N_1}{4} + \frac{w_1 a_1 N_0}{4} + \frac{w_0 a_0 N_1}{12} + \frac{w_0 a_0 N_0}{12} + \frac{w_1 a_0 N_1}{12} + \frac{w_1 a_0 N_0}{12} + \frac{w_0 a_1 N_1}{12} + \frac{w_0 a_1 N_0}{12}\right]$$

$$+ \frac{\Delta a}{Y_0}\left[\frac{w_1 e_1 N_1}{4} + \frac{w_1 e_1 N_0}{4} + \frac{w_0 e_0 N_1}{12} + \frac{w_0 e_0 N_0}{12} + \frac{w_1 e_0 N_1}{12} + \frac{w_1 e_0 N_0}{12} + \frac{w_0 e_1 N_1}{12} + \frac{w_0 e_1 N_0}{12}\right]$$

$$+ \frac{\Delta N}{Y_0}\left[\frac{w_1 e_1 a_1}{4} + \frac{w_1 e_1 a_0}{4} + \frac{w_0 e_0 a_1}{12} + \frac{w_0 e_0 a_0}{12} + \frac{w_1 e_0 a_1}{12} + \frac{w_1 e_0 a_0}{12} + \frac{w_0 e_1 a_1}{12} + \frac{w_0 e_1 a_0}{12}\right] \quad (9)$$

The last step is to measure the contributions of structural change in LFPR to economic growth. The way to break down the proportional contribution of each elements (sex, education, and ratio change) is to multiply the two sides of equation (8) by the weight used in standardizing $\Delta e$ in equation (9):

$$\frac{1}{\Delta Y}\left[\frac{w_1 a_1 N_1}{4} + \frac{w_1 a_1 N_0}{4} + \frac{w_0 a_0 N_1}{12} + \frac{w_0 a_0 N_0}{12} + \frac{w_1 a_0 N_1}{12} + \frac{w_1 a_0 N_0}{12} + \frac{w_0 a_1 N_1}{12} + \frac{w_0 a_1 N_0}{12}\right]$$