Does an Aging Population Affect Real Wage

An Overlapping Generation Approach in United States, China and Japan

Research Proposal

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1 Introduction

In the 21st century, aging problem will become a significant important issue around the world, particularly in most developed economies. According to the current estimation of United Nations, the median age in 2050 will rise from 29.0 to 37.3 comparing to current level. The proportion of people above sixty will double at that time. The changing population structure leads to several critial influence on the labor market. Among them the effect on the real wage rate is what we concern in this paper. Japan, for instance, suffers the most significant influence from aging problem in the past decade and the situation of aging population will become even worse in the next 30 years if the fertility rate could not be raised in the near future. The real wage rate is not raised significantly in the past 20 years in Japan (MD Hurd, N Yashiro, 2007) while in the US the real wage rate is increased significantly.

In this paper we will build an Overlapping Generation Model to depict the dynamic impact on the real after-tax wage in the three biggest economies around the world: the United States, China and Japan. The population structure and aging problems are quite different in these three countries. The US population structure is the most healthest among these three economies since US has an approximate homogeneous population density among all ages and the immigrant policy could adjust dynamically to guarantee such homogeneity in the long run. On the other hand, the population structure of Japan is an inverted pyramid in the long run. The future labor supply will decrease significantly while the tax rate shall increase to maintain the ongoing booming pension and social security system. China, which enjoys the lowest dependency ratio in the past 30 years, will suffer a sharp increase in the dependency ratio and experience the most significant aging problem in the next 30 years. This is a direct result of the famous *One Child Policy* in the past three decades that intentionally restrict the fertility rate at a very low level.

From examining the change of real wage rate on this three countries, we can figure out whether aging problem exert a significant impact on the real wage rate across the countries. Also, these three countries are the three most important economies around the world. Our conclusion shall contribute to the wage trend forecasting for the future research. There is no current literature to make such forecasting of the ageing effect on the wage rate on this three major economies. This paper could

supply the first prediction on this important topic comprehensively. The paper will begin with a review of current literature. Then we build a two-period overlapping generation model to explain how aging problem will affect the real before-tax and after-tax wage rate dynamically in the long run. After a theoretical framework, we will conduct an empirical approach to examine the efficiency of our conclusion in the United States, China and Japan. Finally a final conclusion will be made and it will be discussed in detailed to explain the empirical results.

2 Literature Review

There are quite amount of past and current research discussing the effect of aging on the wage rate. AJ Auerbach, LJ Kotlikoff, RP Hagemann, G Nicoletti (1989) discuss such affect in OECD countries and find will the aging problem has a major impact on real wage rate. The domestic wage rate will increase because there will be a decrease in the labor supply under an inverted pyramid population structure. On the other hand, some scholars suggest a change in population distribution will shift the labor demand curve. A BrschSupan (2003) believes an aging society will require a substantial increase in labor mobility in order to accommodate these structural changes. The consequent wage effect is not clear in his research paper. Jame Liang (2011) discusses the disappointed labor market in Japan. He provides an alternative explanation for stagnant wage in Japan. He finds in an aging society, not only there are fewer young people, but even fewer young people with the high human capital necessary for being successful entrepreneurs to keep economics at a high growth rate to support an increasing wage.

W Groot, M Verberne (1997) points out that age and tenure are negatively correlated with job mobility. The oppotunity cost for an aging society to relocate to hunt for a higher compensation is relatively high comparing to a younger society. Therefore, the wage rate could not adjust to the economics development in an aging population. This phenomenon is particularly observed in Japan. In 1985 M Hashimoto, J Raisian(1985) publishes a famous AER paper comparing the tenure system in Japan. They conclude the earnings of Japanese men rise more rapidly in both small and large firms than the United States, giving the situation that at that time Japan is still experiencing the benefit of baby boom after the the Second World

War. However, when the fertility rate in Japan decreases sharply and those baby boomers retire at the beginning of 21st century, D Kawaguchi, Y Ueno (2013) concludes the wage and tenure benefits of young workers are getting worse comparing to their parents. It is a direct result of heavy pension expenditure and less incentive for higher compensation for young workers under an aging and stagnant economy.

Some scholars have built models to test the influence of aging on the tax ratio and after-tax real income. Assaf Razin, Efraim Sadka, Phillip Swagel (2001) use data in the United States and countries in Western Europe to figure out a negative correlation between the dependency ratio and labor tax rates and the generosity of social transfers. The real effect of aging could be ambiguous since the tax rate could be increased in an aging economy while the real after-tax income decreases. It is observed in Japan in the recent decades since the authority has to pay more attention and expenditure on the pension system and transfers more from younger generation to the older one. Edgar Vogel, Alexander Ludwig, Axel Brsch-Supan (2013) shows an aging society will tend to extend the retirement age to relieve the stress of pension system. It could exert significantly influence on young worker' labor market since the demand for new workers will decrease when old people dominate the job market. They conclude the maximum welfare losses of demographic change for households alive in 2010 are reduced by about 3 percentage points.

3 Theoretical Framework: an Overlapping Generation Approach

In this section, we attempt to build a two period overlapping generation model to depict the dynamic after-tax wage process. In this model, we make a general assumption that each individual lives for two period: a younger period and an older period. Everyone has the same life expectancy and wants to maximize his/her utility level. A government exists in this model to collect tax from younger generation and then tranfers the tax revenue to the older generation to support the pension and social welfare system. That is to say, the pension system is a Pay-as-You-Go(PAYG) system, which is exactly what China and Japan implement nowadays. Also, United States currently is partly running the PAYG system and with the aging problem

becomes more severe, the fully-funded system might be thoroughly abandoned in future. In order to be accommodate to the reality of these three countries, we select an PAYG approach in this OLG model.

Under the general assumption a representative individual chooses to maximize his lifetime utility.

$$\max Z = U(c_{1,t}) + \beta U(c_{2,t+1}) \tag{3.1}$$

where $U(c_{1,t})$ is the utility of consumption in the first period while $U(c_{2,t+1})$ denotes the consumption in the second period.

We suppose a person only works in the first period when he/she is young and relies on the saving in the first period and government pension system in the second period.

$$c_{1,t} + s_t = w_t^b - x_t \tag{3.2}$$

$$c_{2,t+1} = R_{t+1}s_t + z_{t+1} \tag{3.3}$$

where s_t denotes the first period savings; R_{t+1} represents the interest rate in the $(t+1)^{th}$ period. w_t^b is the before tax wage rate(nominal wage) and x_t denotes the government collection to support the pension system at time t. z_{t+1} is the pension expenditure per person in period $t+1$.

Suppose the population of young people in time t is N_t, the following condition must be satisfied to balance the pension inflows and outflows.

$$N_t z_{t+1} = N_{t+1} x_{t+1} \tag{3.4}$$

And we suppose the younger population growth rate is n. That is to say it is assumed $N_{t+1} = (1+n)N_t$. If $n > 0$, it means the younger proportion could become larger in the second period. On the other hand, if $n < 0$, it could be indicator to represent an aging economy. The more negative n is, the more aging problem this economy will face. Hence we get the following relationship between z_{t+1} and x_{t+1}.

$$z_{t+1} = (1+n)x_{t+1} \tag{3.5}$$

Here we use a simple utility function $U(c) = \ln c$ to continue our discussion. This ulitity function is generally used in economics theory. It follows $U'(c) = 1/c > 0$

while $U''(c) = -1/c^2 < 0$. Consequently, our problem becomes the following.

$$\max Z = \ln[w_t^b - s_t - x_t] + \beta \ln[R_{t+1}s_t + (1+n)x_{t+1}] \tag{3.6}$$

Therefore, we calculate the first order condition with respect to x and evaluate it in the equilibrium point.

$$F.O.C. \quad \frac{1}{w_e^b - s_e - x_e} = \frac{\beta(1+n)}{R_e s_e + (1+n)x_e} \tag{3.7}$$

where w_e^b, s_e, x_e, R_e denotes the equilibrium level of $\{w_t^b\}_{t=1}^{\infty}$, $\{s_t\}_{t=1}^{\infty}$, $\{x_t\}_{t=1}^{\infty}$, $\{R_t\}_{t=1}^{\infty}$. Consequently we have

$$x_e = \frac{\beta}{1+\beta} w_e^b - \frac{\beta}{1+\beta} s_e - \frac{R_e s_e}{(1+\beta)(1+n)} \tag{3.8}$$

From the expression of x_e we can conclude the following Theorem.

Theorem. The taxation collected in a Pay-as-You-Go system will increase with an increase of younger generation pupulation growth rate.

Proof and Discussion. It could be directly obtained by calculation.

$$\frac{dx_e}{dn} = \frac{R_e s_e}{(1+\beta)(1+n)^2} > 0 \tag{3.9}$$

□

It is rational to pay more tax to support the pension system for us if we expect there are more people in next generation to pay us even more. On the hand, when $n < 0$ which denotes an aging population structure, more people tend to refuse to attend the pension system and choose to fund themselves when they become older. This is what we observed in Japan today. Under an inverted population pyramid, the younger generation begins to refuse to attend the social security system since they expect the system could go to bankrupcy in the next period. We thus prove an increasing population is beneficial and pivotal to the stability of pension and social welfare system. Any social welfare system with fewer next generation could not survive in the long run.

We define the after-tax real income as $w^a = w^b - x$. In this way, if the before-tax income keeps at a constant level and the tax payments increases with a larger

population growth rate, we can conclude the real after-tax wage increases because younger people tend to pay less tax.

In the following step, we alter our assumption and discuss the dynamic pattern of before-tax income w^b more generally. In this part, we assume the before-tax wage rate is positively correlated with the consumption of younger generation(M Friedman 1957, L Calmfors, A Forslund 1991). Under this general assumption we examine the changing of population growth rate n on the before-tax income rate.

We figure out the F.O.C. with respect to s and evaluate it at the equilibrium point.

$$F.O.C. \quad \frac{1}{w_e^b - s_e - x_e} = \frac{\beta R_e}{R_e s_e + (1+n)x_e} \tag{3.10}$$

So we have

$$s_e = \frac{\beta}{1-\beta}(w_e^b - x_e) - \frac{1+n}{R_e(1+\beta)}x_e \tag{3.11}$$

So we could have the consumption of the younger generation c_1^e. Then we can calculate $\frac{dc_e}{dn}$.

$$\begin{aligned}
\frac{dc}{dn} &= -\frac{ds}{dn} - \frac{dx}{dn} \\
&= \frac{\beta}{1-\beta}\frac{dx}{dn} + \frac{1+n}{R_e(1+\beta)}\frac{dx}{dn} - \frac{dx}{dn} \\
&= \frac{dx}{dn}[\frac{\beta}{1-\beta} + \frac{1+n}{R_e(1+\beta)} - 1] \\
&= \frac{R_e(2\beta-1)(1+\beta)+(1+n)(1-\beta)}{(1-\beta^2)R_e}\frac{R_e s_e}{(1+\beta)(1+n)^2}
\end{aligned}$$

So the necessity and sufficient condition for $\frac{dc}{dn} > 0$ is $R_e(2\beta-1)(1+\beta)+(1+n)(1-\beta) > 0$. Notice here $\beta > \frac{1}{2}$ is sufficient for $\frac{dc}{dn} > 0$.

Under the assumption that before-tax wage rate is positively correlated with the consumption of younger generation, the effect of population growth rate n on the before-tax wage rate in ambiguous. In most cases when $\beta > \frac{1}{2}$, we know the effect of an increasing population on the before-tax wage is positive. On the contrary, if a country is experiencing population decline, the before-tax wage will also decrease from our two-period OLG model.

We can see clearly from this section in an aging economy when the population of younger generation is declining, the nominal before-tax wage decreases while the tax payment willingness is also declining. If the before-tax wage effect dominates

the tax payment decline, we can conclude people earn less in an aging society. Vice Versa.

4 Data Description

In this section, the wage and population data in the United States, China and Japan are used to test how wage rate evolves in these three countries. All the data are gained from GTA database (http://www.gtarsc.com/), which is a private database in China. We just obtain the historial wage per capita, inflation rate, younger population level (the population in age 20-60), elder people proportion(population above 60 over total population) , tax ratio and other control variables such as average education level, etc from the year 1980 to 2010 in the United States, China and Japan. Before 1980 China was experiencing unprecedented Cultural Revolution and the wage data was inaccuate and incomplete. As a result, the data from 1980 to 2010 is used to conduct the regression analysis.

5 Empirical Strategy

In this section we use general regression method to test how wage evolves under different social pattern. We are particularly interested in how wage adjusts in an aging economy. All the wage rate are inflation adjusted so that it represents the real before-tax and after-tax wage. In the following content, $i = 1$ represents the United States; $i = 2$ denotes China and $i = 3$ represents Japan. We implement two regressions in the empirical approach.

$$w_{it}^b = \alpha_i^b + \beta_{1i}^b N_{it} + \beta_{2i}^b O_{it} + L_i^b X_{it} + \epsilon_{it}^b, \qquad i = 1, 2, 3, t = 1980, ..., 2010 \tag{5.1}$$

$$w_{it}^a = \alpha_i^a + \beta_{1i}^a N_{it} + \beta_{2i}^a O_{it} + L_i^a X_{it} + \epsilon_{it}^a, \qquad i = 1, 2, 3, t = 1980, ..., 2010 \tag{5.2}$$

where *dependent variables* are:

w_{it}^b: inflation adjusted before-tax wage in country i in the year t.

w_{it}^a: inflation adjusted after-tax wage in country i in the year t.

and the main *regressors* are:

N_{it}: population of younger generation (age 20 to 60) in country i in the year t.

O_{it}: population proportion over 60 years old in country i in the year t.

other controls X_{it} are :

X_{it}^1: average education years in country i in the year t.

X_{it}^2: average life expectanct in country i in the year t.

What we concern are coefficients β_{1i}^b, β_{2i}^b, β_{1i}^a, β_{2i}^a for $i = 1, 2, 3.$ and whether they are significant or not.

β_{1i}^b: the impact of younger population amount on the before-tax wage for country i.

β_{2i}^b: the impact of elder population proportion on the before-tax wage for country i.

β_{1i}^a: the impact of younger population amount on the after-tax wage for country i.

β_{2i}^a: the impact of elder population proportion on the after-tax wage for country i.

To solve the endogeneity problem, we add a set of controls such as average education years and average life expectancy into the regression. They affect the wage level in some extent and exclude possible omitted variable bias. Also, the average life expectancy is added into the regression since the definition of "old generation" could vary from 1980 to 2010. For example, a person who is 55 years old could be treated as "older generation" in the year 1980 while he/she could be considered to belong "young generation" according to the criteria in 2010. Also the definition of "old" could also be different among these three countries. For instance, a person who is 60 years old could be regarded as young in Japan thanks to the longevity factor(average life expectancy is 83.10 in Japan in 2010) while he/she is considered to be old in China Since the life expectancy in China is only 75.20 (2010 statistics).

However, since we cannot get gender specific statistics in some years, an important factor (ie. gender) is ignored in the regression and could result in possible estimation bias. The retirement pattern and wage compensation differ significantly among male and female. Under limited data restriction, we could not run gender-specific regression to test the aging influence on wage for men and women. But this problem is minor since the main purpose in this paper is to test the aging effect but not the gender effect.

6 Possible Results and Implication

The possible results (results prediction) could be shown in the following tables.

USA	β_{11}^b	β_{21}^b	β_{11}^a	β_{21}^a
Results Prediction	+	+	+	-

Table 1: USA result (predicted)

China	β_{12}^b	β_{22}^b	β_{12}^a	β_{22}^a
Results Prediction	+	+	+	+

Table 2: China result (predicted)

Japan	β_{13}^b	β_{23}^b	β_{13}^a	β_{23}^a
Results Prediction	+	-	+	-

Table 3: Japan result (predicted)

It is expected that an increasing number in younger generation population will increase the wage (both before-tax and after-tax) significantly in all three countries. For China and USA, the effect of aging proportion on before-tax wage is positive (predicted). But we predict the impact of aging proportion on after-tax wage for the USA is negative since US expands its tax revenue in recent decades rapidly to maintain its pension, social security system and the considerable military expenditure. For Japan, the story is truly sad that Japan suffers the most negative effect of aging problem. The total population even begins to decrease from the year 2007. If the current low fertility rate could not be raised significantly in the future, scholars even predict Japanese will finally become extinct on the earth. The decreasing population not only ruins the labor supply but also hurts the labor demand in a greater level so that the real wage rate goes down in Japan. Even a negative interest rate policy by Bank of Japan can not rescue Japan from a even worse future. From the predicted estimation result, it could be concluded that an increasing younger population is crucial to economic growth and a better life. If Japan could not raise the fertility rate (currently it is 1.25) significantly or open its immigration policy, the real wage rate will continue to decrease and even worse Japanese could disappear from the earth in the year 2200. China, on the other hand, should stop its absurd *One Child Policy* and encourage giving birth to more offsprings to maintain steady economic growth rate. Otherwise, the population structure for China is even worse

than Japan 20 years later. And for the United States, the country should maintain its steady economics growth by immigrating more high-skilled young generations.

7 Reference

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