
Haodong Qi/Andy Kin*

August 14, 2013

Abstract

This paper examines the life-cycle dynamics of real wages and labor supply in Sweden. The descriptive results lend support to the intertemporal substitution hypothesis (ISH), as the age patterns of both real wages and labor force participation (LFP) are hump-shaped. However, the age-wage profiles increasingly shift towards older ages over time, whereas the age-LFP profiles do not. This leads to an accentuated difference-in-differences of the two variables over the ages 45-64, and, in turn, casts doubt on the explanatory power of ISH for the senior labor supply at the extensive margin. My econometric investigation of old-age LFP further implies that, at least at the aggregate level, the backward-bending supply curve may better reflect the retirement transition rather than intra- and/or inter-temporal substitution. Based on the estimated age-specific elasticities, I found spectacular life-cycle variation in the responses of labor supply to wage change. This suggests that an array of life-cycle parameters (rather than a constant elasticity for all ages) is needed in calibrating the Overlapping Generation Model (OLG).

Keywords: Population Ageing, Life-cycle Labor Supply, Inter-temporal Substitution Hypothesis, Overlapping Generation Model
1 Introduction

At the frontier of the best-practice life expectancy, Sweden is likely to reach a life expectancy at birth of one hundred in about six decades (Oppen and Vaupel, 2002). Coupled with the low fertility over recent decades, the share of the age 65+ population is expected to grow. Holding the mean age at retirement constant, this process implies the per worker cost of providing a given age-vector of per capita benefits will increase (Lee and Edwards, 2001). The costs of the elderly in Sweden is largely based on tax revenues. Therefore to finance such growing cost requires either expanding the tax base or increasing tax rate. The taxation level in Sweden has already gone far beyond the international average, thereby broadening the tax base seems a more feasible solution. Demographic measures might be useful to enlarge tax base. However they are likely to introduce additional problems, one way or another. For instance, poor integration of immigrant workers to the Swedish labor market might induce additional burden on the society. Rising fertility, on the other hand, would take at least 25-30 years to start exerting positive effect on the size of working population (Bengtsson and Scott, 2011). Hence, a more realistic alternative seems to increase the labour force participation (hereafter LFP) of those who are “able to work”.

Recent trends toward better health in the age of 60s and 70s point to the option of prolonging working life so as to expand the tax base. However, during the first decade of this century, LFP for 65+ remained constantly as low as around 10 percent in Sweden. Youth labor, on the other hand, exhibits a downward trend in participation, which is particularly profound during the great recession after the year of 2008\(^1\). Such evidence implies that policy measures that encourage early entry and late exit to the labor market are needed for the expansion of the tax base. This is perhaps also the most effective way because both the youth and the elderly form a large share of the total population as well as a considerable amount of exploitable human resource. More importantly, if they remain out of the workforce, an additional burden would emerge leading to a multiplicative threat to the welfare state.

To assess the long-term impact of population ageing, one has to consider various scenarios of LFP. A thorough understanding of the underlying process in such labor supply decision at extensive margin, as well as potential behavioral modifications, is a sine qua non for formulating meaningful scenarios so as to evaluate viable solutions. For this, the present study has significance at policy level as it contributes to the understanding of the macro behavior of labor supply. From a scientific perspective, labor supply has attracted enormous attention in macroeconomics since the introduction of intertemporal substitution hypothesis (hereafter ISH) by Lucas and Rapping (1969). However it has eluded economists to agree upon the magnitude of this elasticity. Labor economists typically obtain the estimates are small at individual level, while macro-economists provide mixed evidence. This paper adds some new insights to this issue as well as other so called ”Puzzles”.

Moreover, It has been a long tradition to introduce age into macro economic modelling. Overlapping generational model with computable general equilibrium (OLG-CGE) is one

---

\(^1\)Data source used for discussion here refers to Labor Force Statistics in OECD Countries. Detailed information on compiling statistics from different countries can be found at: www.oecd.org/els/employmentpoliciesanddata/LFSNOTES.
of such pioneered by Samuelson (1958) and Diamond (1965), and pursued by number of followers on various applications, e.g. Auerbach and Kotlikoff (1987), Miles (1999), and Borsch-Supan (2003). Nonetheless, all of these models assumes constant elasticity of substitution over the life-cycle for each representative agents, which are mostly taken from aggregate time-series analysis without take into account the age-differentials. This leads to inconsistency between the setting where empirical evidence is obtained and the setting where estimated elasticities are applied to. Aggregate estimates of time-series data, in fact, correspond to a model of single infinitely lived representative agent, which is literally different than OLG environment, where multiple agents live with finite lives. Such estimated elasticity does not necessarily reflect actual behavior of the agents over the life-cycle, as which could potentially eliminate the disproportional responses to macro-economic change at different ages. To this end, I use the National Transfer Accounts (NTA) for Sweden with time-varying age profiles of economic activity for the period 1985-2003 to estimate a life-cycle labor supply function. The estimation is theoretically consistent with the overlapping generation framework. It also allows me to envisage a more realistic life-cycle model with age-separable elasticities of labor supply with respect to wage. This can serve as a new basis for future application of OLG models.

The remainder of the paper is organized as following. It first gives a brief background of the Swedish economy and the labor market over 1985-2003, followed by some theoretical consideration of the life-cycle real wage and labor supply. Various data sources and the empirical models are stated in the section of data and method. And results are then reported and discussed in the succeeding section. Finally some key findings are summarized in the conclusion.

The Swedish Economy and its Labor Market 1985-2003

Up until the 1980s, the Swedish labor market was characterized by high level of job protection, low level of unemployment, and compressed wage distribution. All these are mainly attributable to two factors: the centralized bargaining between labor organization and employers’ association, and active labor market policies formulated by the government aiming for full employment (Edin and Topel, 1997). This, as a result, feeds the reputation of the highest standards of living and most egalitarian income distribution for the Swedish model in the global economy.

Things however had changed during the crisis in the early 90s, which dragged the employment rate down to around 90 percent by the year 1993 (See the 3rd panel in Figure 1). An important feature of the crises is that young workers were hit particularly hard, soaring to 18 percent being unemployed by the year of 1993 (Edin and Topel, 1997). Although the crisis lasted for three years, the adverse effects on labor force were prolonged, employment rate remains as low as 90 percent until year 1997.

In addition, labor supply appeared extremely responsive to the recession. As shown in the bottom panel of Figure 1, labor force participation rate (the registered labor force as a fraction of population aged 16-64) dropped from 84 percent by 1990 to 77 percent by 1994. Nonetheless, unlike the employment rate, which nearly returned to its pre-crisis
level in the late 1990s, participation rate remained low through early 2000s.

It is evident that the sharp drop in both employment and participation rates can be, at least partly, explained by the shrinking labor demand over the crisis. As seen from the middle panel of Figure 1, real gross domestic output was stagnating over year 1990-93. If this could be interpreted as a demand shift in the labor market, then the puzzle is why participation rate remained as low as the crisis level, while the real output was growing during the post-crisis era.

On contrast, the real wage, shown on the top panel of figure 1, revealed a long-run upward trend over time. Despite of a slight decline between year 1989 and 1990, it was growing slightly throughout the crisis. This aggregate variable exhibits a typical pattern of wage rigidity. Given the centralized bargaining was largely abandoned during the 1980s, and wage inequality and the returns to skill have since risen (Edin and Topel, 1997), the key question in this regard is whether such wage growth pattern is identical to all social economic and demographic groups in the labor market. Hence, this paper shall address the issue of wage dispersion over the late 1980s through early 2000s with a specific focus on the age differentials in wage settings. On top of this, the differences in real wage and labor supply relation with respect to the age dimension are also examined.

2 A General Theory of Real Wage and Labor Supply - A Lifecycle Perspective

2.1 Age-Wage Differential

The changing pattern of life-cycle earnings has barely been examined for Sweden so far. This is mainly because yearly age-profiles of such variable are mostly unavailable. To the best of my knowledge, the only systematic investigation of the annual variation in the shape of the life-cycle earning profiles being conducted thus far is for the U.S. using Current Population Survey 1962-2003. One of the major findings is that there was a consistent upward trend for the earnings of older men, relative to the younger men, which is attributable to the fact that young workers no longer possess educational advantage over old workers. By looking within education groups, it was found that age effects still dominate education attainment (Lee et al., 2011). Moreover, wage differentials between young and old workers might also be a result of wage-productivity discrepancy, in which young workers are underpaid and old workers are overpaid relative to their productivity (Skirbekk, 2003).

A few theories are worth to mention here, which attempt to explain the existence of wage-productivity discrepancy and age-wage differentials. The efficiency wage hypothesis argues that firms will be unconstrained by labor market conditions in pursuing its optimal policy on recruiting as long as labor supply exceeds demand, and real wage offer is higher than reservation wage(Yellen, 1984). One extension of this hypothesis seeks to explain why firms are willing to pay the wage rate above market clearing, namely the shirking model. It applies to the condition that piece rate is an inaccurate measure of
Figure 1: Log Real Wage, Log Real Gross Domestic Output, Labor Force Participation and Employment Rates, Sweden 1985-2003
productivity, and the over pay with respect to productivity provides incentives for workers not to shirk (Calvo, 1979). This is one of the explanations of wage-productivity discrepancy. In addition, one might wonder why firms prefer to pay workers less when they are young and higher when they are old with respect to marginal product. This is further argued as a result of the nature of the optimal wage profile. Such contracted pay schedule would lead to Pareto Efficient with mandatory retirement (Lazear, 1981). Furthermore, the age-wage differentials can be induced by time spend in the labor market. Senior workers earn more on average, even if perceived productivity is held constant. This is because they have had more time to bid up their wage, and their ability can be more precisely assessed (Harris and Bengt, 1982). Finally, the age distribution of labor earnings might also be influenced by the trade union. If unions attach greater weight to the wishes of old workers than young workers, and wages and employment are determined by efficient collective bargaining, the wage outcome of older workers are then always higher than the younger ones regardless of productivity and labor supply (Pissarides, 1989).

In short, literature regarding the age-wage profile mostly predict the pattern that workers at younger ages tend to be underpaid relative to at older ages. Although various theories suggest different explanations for the age-wage differentials, I have no attempt, in this paper, to examine which causal link is valid or, to what extent, more important than the others. My main purpose for the present study is to verify whether the age-profiles of labor income is in line with theoretical predictions, and how it has evolved overtime.

2.2 The Substitution and Income Effects on Labor Supply

The theory of labor supply responses to work compensation has been well established in neoclassical economics. With the standard assumption of treating leisure as a normal good, an increase in real wage would have two possible impacts on labor supply, i.e. the substitution and income effects of a change in the real wage rate. The former effect is positive, whereas the latter is negative. The intuitive reasoning for the substitution effect is that leisure become increasingly expensive when real wage goes up, and therefore, by holding utility constant, individuals tend to supply more hours to market work so as to substitute consumption for leisure. Such function is also named compensated labor supply function. In contrast, an increase of real wage also shifts the budget constraint outward parallel and facilitates the purchasing power, more leisure will then be demanded. Due to the time constrain, an increase in leisure time will result in a reduction of working hours supplied to the market. Such negative association is the income effect, or uncompensated labor supply function.

Based on the two opposite effects, micro-economists further envisaged two possible shapes of individual labor supply curve, i.e. a strictly positive supply curve and a backward-bending supply curve. In a two-dimensional coordinate with real wage on the vertical axis and hours of work on the horizontal axis, the individual labor supply curve would exhibit a strictly positive slope if the substitution effects of higher real wage rate always outweigh the income effects. On the contrary, the backward-bending curve implies that the substitution effects initially dominate up until a point where both wage and working hours reach a relatively high level, and then income effects kick in and outweigh substitution effects. That is to say that any further increase after a certain high level of real wage and hours of work would induce individual to reduce labor supply in order to consume
more leisure.

The two competing theoretical predictions lead to an important question: which curve better depicts the individual labor supply. Empirical evidence, thus far, provides mixture of these two. Although cross-sectional evidence that mainly measures the short-run labor supply curve suggests the substitution effects dominate, at least for married women (Cain, 1966; Mincer, 1962), secular trends consistently lend support for the backward-bending supply curve, particularly in the long-run.

2.3 The Inter-temporal Substitution Hypothesis

It is noteworthy that the former discussion on substitution and income effects has been restricted to the static analysis. For a comprehensive life-cycle analysis of labor supply, it is necessary to distinguish between the intra-temporal effect (i.e. which discussed in the static analysis) and the inter-temporal effect. That is to isolate the labor supply response to an unanticipated wage shift in a life-cycle wage profile from an anticipated evolutionary wage growth\(^2\). There are substantial differences between the two sorts of responses. The unanticipated wage shift can yield not only substitution effects, but also income effects, as just discussed in the one-period analysis. The evolutionary wage growth, on the other hand, can only generate substitution effect because, given the life-cycle wage profile is foreseeable, people would concentrate their labor supply over the ages with highest wages, whereas demand more leisure when wages are low (MaCurdy, 1981). This implies that the labor supply and wage rate should be positively correlated over the life-cycle, i.e. inter-temporal substitution hypothesis (hereafter, ISH).

Empirical literature in this regard, however, provides controversial evidence. Mankiw et al. (1985) used the aggregate U.S. data to estimate the elasticity of substitution between current and future consumption, current and future leisure, and current consumption and leisure, and found no statistical evidence supporting ISH, while Alogoskoufis (1987) found substantially higher estimates of intertemporal real wage and interest rate elasticities than others. Such controversy is mainly due to the measurement of labor supply. Mankiw et al. (1985) used the aggregate man-hours, which is criticized as the least important component by Heckman (1993). Alogoskoufis (1987), on the other hand, used various measures of labor supply and found strong inter-temporal elasticity when using number of employees and employment rates, yet weak estimates when using total employee hours. This is not surprising, as hours are not as flexible as what theory assumes in daily working life. The pattern of hours worked over the life-cycle typically appear sticky, at least for male workers over the prime working ages. As a result, the labor supply (measured by worked hours) responsiveness to wage changes tends to be weak and insignificant. In aggregate, most of the variations in total manhours comes from the employment variation, not hours per head (Coleman, 1984). In addition, Heckman (1993) asserted that the strongest empirical effects of wages and nonlabor income on labor supply are at the extensive margin, where the elasticity are definitely not zero.

A final note on the measurement of the labor supply relates to some policy implication. While hours appear sticky, labor force participation is found to decrease dramatically over the years approaching retirement. That is a motion of early retirement commonly

\(^2\)A fuller discussion on this distinction is given in MaCurdy (1981).
observable in countries where pension benefits are generous. Thus, if one needs to evaluate the effects of labor market policy as well as social insurance programme on old-age labor supply, measuring the participation as a decision at extensive margin might better reflect the behavior of exiting labor market than solely counting for hours. For this, my current paper exclusively stresses on the labor supply decision upon to work or not to work over the life-cycle as a response to wage variation.

2.4 Labor Supply Elasticity in An Overlapping Generation Setting

Labor supply elasticities, on one hand, are important for understanding human behavior, such as why people concentrate labor supply over certain period of lifetime and why there is gender differences in LFP rates. On the other hand, it matters for addressing broad societal issues, e.g. for designing effective social and economic policies, evaluating the financial sustainability of public systems, and experimenting with welfare consequences of institutional reforms, etc. For the latter purpose, one of the most common methods is to calibrate the estimated elasticities into an overlapping generation model with computable general equilibrium (OLG-CGE), e.g. Auerbach and Kotlikoff (1987); Borsch-Supan (2003); Miles (1999), etc. Nonetheless, two major issues arise when conducting this type of analysis. First of all, what parameter values one should use, as the estimated elasticities vary with respect to different sources and little consensus has been reached in terms of their magnitude and representativeness. Prescott and Wallenius (2011) summarized that aggregate elasticities are typically found larger than individual elasticities, and labor economists estimated elasticities are small, whereas macro economists estimated elasticities are considerably large. Therefore, the argument is that one should not estimate parameters in one setting and apply them to another. In this regard, OLG-CGE, as an abstracted macro model, should be calibrated by elasticities estimated at aggregate level.

Nevertheless, as a second issue, aggregate estimates of time-series data, in fact, correspond to a single agent model with infinite life, which is not necessarily equivalent to the OLG setting, where multiple agents live with a finite life span. Such estimated elasticities could potentially eliminate the disproportional impacts of macro-economic change on various agents who are co-existing in the stylised environment given a point in time. For example, empirical evidence, as formerly discussed, show that youth were hit particularly hard during the recent recession (OECD, 2011). Such unevenly distributed responses to business cycles can not be reflected into OLG simulations if one assumes elasticities are constant over ages and calibrate on the basis of estimates by aggregate data in the national accounts.

To the best knowledge of mine, none of the OLG models, so far, has incorporated age-specific parameters governing inter- and intra-temporal decisions in the calibration. Furthermore, there has been very few macro-economic studies empirically estimate age-specific elasticities. The only one that I can think of is Fair (1971) who examined the relation between wage, money illusion and labor force participation by using quarterly data for the U.S. 1956-1970. The data are both separable with respect to age and gender. This purely empirical paper did not find consistent labor supply response to wage by different demographic groups, nor the wage and money effects are substantively dis-
tistinguishable. The statistical results also suffer from collinearity problem, and therefore prevent any definitive conclusion from being drawn. An additional drawback of Fair’s analysis is lack of theoretical foundation, both in terms of variables chosen, model specification and the length of distributed lags. For this, I feel it is necessary to estimate an empirical model that is consistent with theory as well as applicable to the environment that what theory envisages. For the case of estimating the labor supply function that is compatible with which in the OLG model, one shall stress on the age differences in estimated elasticities on one hand, and specify the model in line with the theoretical framework on the other hand. In another word, it is to explicitly address the question whether people at different stage over the life-cycle could have different intertemporal and intratemporal response to wage change.

2.5 The Life-cycle Labor Supply Function

A new classical model of the dynamic household’s labor supply and firm’s marginal productivity condition for labor was first introduced by Lucas and Rapping (hence after, L-R model) and applied to the U.S. labor market. This is also the milestone of introducing labor supply into macroeconomic analysis, as, prior to that, labor supply decision was regarded as virtually irrelevant for this level of analysis since aggregate labor supply was not seen as determined by factors driving individual labor supply (Prescott and Wallenius, 2011). In what follows, I give a brief presentation of a multi-period life-cycle model. Although a more realistic model should comprise multi-sectors: i.e. households, firms, government, and, perhaps, banking, I shall limit my theoretical consideration to household only, since the main purpose here is to give a basis for deriving an empirically testable labor supply function for the current analysis that will be discussed in the next section. The model presented here shares certain characteristics as L-R model, yet not exactly the same.

In an overlapping generation setting, each representative household lives up to a certain age X. In each calendar year t, the household who has reached age X dies out and a newborn comes in. The households derive their utility from consumption and leisure, which can be traded not only within period, but also across periods. The implicit lifetime utility function can be expressed as

\[ U = \sum_{x=0}^{X} u_x(c_x, l_x) \]  

where, let \( x \) be age, and \( c \) and \( l \) denote consumption and leisure, respectively. The right hand side of (1) represents the time-separable utility function for each age.

Assuming there is no income and payroll tax, nor any kind of social benefits, each household maximize their lifetime utility subject to a lifetime budget constraint. At each age, household solve for a dynamic optimization problem, and derive their consumption and leisure. The economy is closed, thus no international trade, capital flows and migration. Both labor market and capital market are perfectly competitive. In addition, household is assumed to have no bequest motive. The Hamiltonian for each representative household

---

3For simplicity, let us consider the age as the only time variable, thus drop calendar time "t" for now.
can, therefore, be expressed,

\[ H_x = \frac{1}{(1+\delta)^x} \frac{1}{1-1/\gamma} (c_x^{1-1/\rho} + \alpha l_x^{1-1/\rho})^{1-1/\gamma} \frac{1}{1-1/\rho} + \lambda_x [a_x r_x + w_x (1-l_x) - c_x] \]  

(2)

where, let \( \delta, \alpha, \gamma, \rho \) be the parameters of time preference, intensity for leisure, inter-temporal elasticity and intra-temporal elasticity, respectively. Subscripts \( x \) denote age. Let \( c, l, r \) and \( a \) be consumption, leisure, interest rate and assets, respectively. \( \lambda \) is the costate variable can be interpreted as marginal value of the unit change in budget constraint. \( w \) is the aggregate wage rate. Note: for simplicity, the value of \( l \) is assumed to be \( l \in [0, 1] \), it reflects the age-specific labor supply. In general, for an inactive labor, \( l = 1 \), whereas for a full time labor, \( l = 0 \), and any value between 0 and 1 reflects partial labor supply.

Maximize (2) with respect to \( c_x \) and \( l_x \), respectively, yield the following two first-order conditions,

\[ \lambda_x = (1+\delta)^x (c_x^{1-1/\rho} + \alpha l_x^{1-1/\rho}) \frac{1}{1-1/\rho} c_x^{-1/\rho} \]  

(3)

\[ \lambda_x w_x = (1+\delta)^x (c_x^{1-1/\rho} + \alpha l_x^{1-1/\rho}) \frac{1}{1-1/\rho} \alpha l_x^{-1/\rho} \]  

(4)

And combining of the two first-order conditions yield (5), an expression for intratem- poral effect of wage change on consumption and leisure or labor supply. The sign of the parameter \( \rho \) is hard to say a priori due to the ambiguous effects of wage increase on labor supply that has been discussed in the proceeding section. If \( \rho \) is positive, an increase in wage would lower the leisure-consumption ratio and, therefore, imply an increase in labor supply - that is the substitution effect dominates. Conversely, a negative sign of \( \rho \) implies a positive relation between the changes in wage rate and leisure-consumption ratio, thus reduces labor supply - i.e. income effect dominates.

\[ l_x = \left( \frac{w_x}{\alpha} \right)^{\rho} c_x \]  

(5)

The change of the shadow value, \( \lambda_x \), with respect to age is

\[ \frac{\partial \lambda_x}{\partial x} = -\frac{\partial H_x}{\partial a_x} = -\lambda_x r_x \implies \frac{\lambda_x}{\lambda_{x-1}} = \frac{1}{1 + r_x} \]  

(6)

Substitute (5) into (3), we get an expression for the shadow price \( \lambda_x \) represented by consumption and divided by \( \lambda_{x-1} \), we get,

\[ \frac{\lambda_x}{\lambda_{x-1}} = (1+\delta)^{-1} \left( \frac{c_x}{c_{x-1}} \right)^{-1/\gamma} \left( \frac{1 + \alpha^\rho w_x^{1-\rho}}{1 + \alpha^\rho w_{x-1}^{1-\rho}} \right)^{1/\gamma} \]  

(7)

Equate (6) and (7), we get the Euler equations for both consumption and leisure. Let \( N_x \)
be labor supply at each age, and given that \( l_x = 1 - N_x \), the dynamic change of leisure can be written in the form,

\[
\frac{1 - N_x}{1 - N_{x-1}} = \left(1 + r_x \right)^\gamma \left(1 + \alpha^\rho w_x^{1-\rho} \right)^\frac{1-\rho}{\rho} \left( \frac{w_x}{w_{x-1}} \right)^{-\rho}
\]  

(8)

By imposing zero discount rate (i.e., pure rate of time preference \( \delta = 0 \)), taking the logarithm of (8), and using the first-order Taylor approximation for \( \ln(1 - N_x) \) and \( \ln(1 + \alpha^\rho w_x^{1-\rho}) \), an empirical labor supply function can be expressed,

\[
\ln (N_x) = \ln (N_{x-1}) - \frac{1 - \bar{N}}{N} \gamma \ln(1 + r_x) + \frac{1 - \bar{N}}{N} \gamma \left( \frac{\rho + \alpha^\rho \gamma}{\gamma + \alpha^\rho \gamma} \right) \ln \left( \frac{w_x}{w_{x-1}} \right)
\]  

(9)

where, \( \bar{N} \) is the parameter in the Taylor approximation for \( \ln(1 - N_x) \), which can be interpreted as a constant value of labor supply in steady state.

Adjust the interest rate \( r \) and wage rate \( w \) in (9) for inflation, i.e., take the value in real terms, then the model is similar to L-R model. The only difference is that Lucas and Rapping deleted the interest rate, and therefore explicitly examine the effects of inflation on labor supply, whereas I implicitly assumes that both interest and price will have the same effect of non-labor income on labor supply, governed by one parameter. For the model estimation, which will be discussed in more detail in the next section, \( r \) is deflated by the annual percentage change in price index and \( w \) is adjusted at a constant price level.

The advantage of estimating a labor supply function in the form as (9) is that it allows for distinguishing the intertemporal and intratemporal response to wage change. As formerly discussed, such distinction is important for a life-cycle labor supply analysis, as a wage change can come from two sources, an anticipated movement along the evolutionary wage path and an unanticipated wage shifts. If one simply regress the measured labor supply on wage rates, the estimated parameter would confound the two types of response. To make this point more explicitly, let \( \beta_1 \) be the term \( \frac{1 - \bar{N}}{N} \gamma \left( \frac{\rho + \alpha^\rho \gamma}{\gamma + \alpha^\rho \gamma} \right) \), (9) can therefore be rewritten as,

\[
\ln (N_x) = \ln (N_{x-1}) - \beta_1 \ln(1 + r_x) + \beta_2 \ln \left( \frac{w_x}{w_{x-1}} \right)
\]  

(10)

If we merely estimate the model with only wage, not interest rate, the single parameter \( \beta_2 \) contains information on both intertemporal and intratemporal responses, which, however, cannot be separated. Nevertheless, when both interest and wage are included as explanatory variable, as in the form of (10), the two elasticities, \( \beta_1 \) and \( \beta_2 \), can be used to identify the relative importance of the two kinds of responses. That allows for addressing the question whether labor supply is more responsive to the evolutionary wage change than temporal wage shift or the other way around, although the absolute magnitude of the two responses cannot be recovered.
To date, the proceeding theoretical discussion on the real wage and labor supply gives two main predictions: a) the sign of the intratemporal elasticity of labor supply w.r.t wage can be either positive or negative due to the ambiguous theoretical prediction: i.e. it depends on whether income or substitution effect dominates. b) the sign of the intertemporal elasticity of labor supply w.r.t wage can only be positive as this is the labor supply response to evolutionary wage rate, which is known to the household.

There has been no theoretical prediction on the relative magnitude of intertemporal and intratemporal elasticities, and empirical literature generally suggests the former is nearly negligible comparing to the latter. Hence, statistical inference on the two parameter estimates will be the main focus in the reminder of this paper. Note: in order to quantify the relative magnitude of inter-temporal and intra-temporal response, an additional assumption is needed. That is to assume $\alpha = 1$, i.e. household’s utility weight on leisure is equal to which on consumption\(^4\). And therefore, the relative magnitude can be written as $\xi = \frac{2\beta_2}{\beta_1} - 1$. Given this, the following hypothesis are proposed, among which, four of them test not only the relative importance of inter- and intra-temporal effect, but also whether income or substitution effect dominates the within-period response. The final hypothesis testing relates to a special case, where the inter-temporal and intra-temporal elasticities are equal. This is the same hypothesis as what was tested by Alogoskoufis (1987).

\textit{Hypothesis 1:} If $\frac{\beta_2}{\beta_1} > 1$, substitution effect dominates within period, and intratemporal elasticity outweighs intertemporal elasticity of labor supply w.r.t wage increase, i.e $\xi > 1$.

\textit{Hypothesis 2:} If $\frac{1}{2} < \frac{\beta_2}{\beta_1} < 1$, substitution effect dominates within period, but intratemporal elasticity is outweighed by intertemporal elasticity of labor supply w.r.t wage increase, i.e $0 < \xi < 1$.

\textit{Hypothesis 3:} If $0 < \frac{\beta_2}{\beta_1} < \frac{1}{2}$, income effect dominates within period, but intratemporal elasticity is outweighed by intertemporal elasticity of labor supply w.r.t wage increase, i.e $-1 < \xi < 0$.

\textit{Hypothesis 4:} If $\frac{\beta_2}{\beta_1} < 0$, income effect dominates within period, and intratemporal elasticity outweighs intertemporal elasticity of labor supply w.r.t wage increase, i.e $\xi < -1$.

\textit{Hypothesis 5:} If $\frac{\beta_2}{\beta_1} = 1$, i.e.$\beta_2 = \beta_1$, intratemporal elasticity equals intertemporal elasticity of labor supply w.r.t wage increase, i.e $\xi = 1$.

\(^4\)The $\alpha$ parameter represents the weight of household’s utility attached to leisure relative to consumption. Were $\alpha$ greater than one, household prefer leisure to consumption, thus supply less labor. Conversely, if $\alpha$ is smaller than one, but greater than zero, household prefer consumption to leisure, and therefore supply more labor. Two special cases are when $\alpha$ equals zero and one. The former refers to the fix labor supply assumption, in which, household would choose no leisure, thus it reduces to a constant relative risk aversion utility function (CRRA). The latter refers to the assumption of equal utility weight on leisure and consumption, that is household would be indifferent by consuming one unit of good or leisure, \textit{ceteris paribus}. As can be seen in (5), were $\alpha$ equals one, the leisure-consumption choice is only influenced by the wage rates and governed by the parameter of intra-temporal elasticity.
3 Data and Methods

3.1 National Transfer Accounts Sweden 1985-2003

The age profile of labor income in NTA is a comprehensive measure of the age differentials in market value of total labor supply weighted by all members of a population in a particular age group (Lee and Ogawa, 2011). It is noteworthy that, by definition, NTA labor income includes employees’ labor earnings, self-employed labor income, fringe benefits, and payroll tax contributed by employers. The NTA time-series for Sweden comprises repeated cross-sectional age profiles over the period 1985-2003. For each year, the relationship between the aggregate and age-specific labor income, and its essential components can be expressed as.

$$Y_t = \sum_x Y_{x,t} = \sum_x y_{x,t}^E \times E_{x,t}$$  (11)

where, $x$ and $t$ denote age and time, respectively. Let $Y$ be the aggregate annual labor income, $E$ be the number of employed person, and $y^E$ be the effective annual wage rate per employed.

Equation (11) implies that the aggregate age-specific labor income is a product of the effective annual wage rate per employed and number of employed persons in the same age group. That is,

$$Y_{x,t} = y_{x,t}^E \times E_{x,t} = y_{x,t}^E \times \frac{E_{x,t}}{L_{x,t}} \times L_{x,t}$$  (12)

where, $L_{x,t}$ represents the number of labor market participants.

It is evident from (12) that the aggregate age-specific labor income confounds the effects of market wage rate and the labor supply and demand, i.e. $E_{x,t}$ and $L_{x,t}$. Dividing through (12) by age-specific population on both sides yields,

$$y_{x,t} = y_{x,t}^E \times \frac{E_{x,t}}{L_{x,t}} \times \frac{L_{x,t}}{P_{x,t}} = y_{x,t}^E \times e_{x,t} \times p_{x,t}$$  (13)

where, $P$ denotes the population size, $e$ is the employment rate, and $p$ is the labor force participation rate.

From (13), it can be shown that per capita labor income for each age and period in NTA is the product of three components: effective wage rate, employment and labor force participation rates. Therefore, the difference between the NTA labor income and the conventional wage rate is by the factors of labor force participation and employment rate. In another word, both would be equivalent, if, and only if, the condition of full employment and labor force participation is satisfied. That is the equilibrium wage rate at market clearing level of no voluntary and involuntary unemployment. In this regard, NTA provides a consistent framework with general equilibrium theory by linking population structure and aggregate national income. The empirical data, however, suggests that unemployment always exists, as does fraction of population draw themselves out of labor force. Hence, NTA labor income shall not be analysed solely, rather looking at decomposed components would be certainly beneficial for better understanding the complexity in the labor market. To this end, my analysis stresses on the age-specific
variation in these decomposed components, mainly the effective market wage rate and the LFP rate as a measure of households’ labor supply decision at extensive margin.

The NTA time-series for Sweden provides information on per capita age-specific labor income for each year between 1985 and 2003, i.e. $y_{x,t}$ in (13). The effective wage rate per employed person, $y_{x,t}^E$, is then derived by dividing $y_{x,t}$ by employment rate, $e_{x,t}$, and labor force participation rates $p_{x,t}$ for each age and time. Unfortunately, the employment and labor force participation rates provided by Statistics Sweden are aggregated by following age groups: 16-19, 20-24, 25-34, 35-44, 45-54, 55-59, and 60-64, hence the derived wage rates are computed in accordance with these classification. All wage rates are adjusted to the price level in year 1985. The price information are obtained from Statistic Sweden. Furthermore, I use a series of short-run annual yield as a proxy for asset return $r$ in (10), which are extracted from the Annual Swedish stock prices and returns and bond yields 1856-2006 by Swedish Riksbank.

3.2 Fitting the Age-Wage Profiles over Time

To examine the age differences in work compensation overtime, the data are fitted by Lee-Carter method (Lee and Carter, 1992). By doing so, not only allows for capturing the changing shape of life-cycle wage rates, but also investigate the age-specific responses to aggregate wage change over time.

In addition, there has been substantive social and economic changes over the investigation period. The economic crisis through year 1993, new legislation of the pension system in the year 1994 (moving towards a notional defined contribution model), and its implementation in the early 2000s. For this, the time-varying age profiles are fit for four sub-periods, which are 1985-89, 1990-93, 1994-99 and 2000-03, so as to account for the differences in age-wage differentials as responses to the changing macroeconomic and institutional condition.

3.3 Estimating the Labor Supply Function

Equation (9) and (10) serve the basis for the estimation of the labor Supply function. Nonetheless, certain adjustments need to be made so as to make the model and the data compatible. NTA time series is not like longitudinal data, which can capture the realistic dynamics of the life-cycle labor supply for each individual. Nor does it like aggregate time-series, which only provides year to year variations in the system of national accounts. It is in the form of repeated cross-sections, which involves variation along both time and age dimensions. Ideally, it would be desirable to estimate the data with either age-specific cohort or cohort-specific period perspective so that they would better reflect the life-cycle dynamics and be possible to compare the inter-generational differences. However, given the limited time span of the data, such analysis is too expensive to be conducted. The only affordable option for now is to pursue the analysis in an age-specific period setting. Although such strategy is inferior to longitudinal and co-
hort analysis, it is certainly superior to aggregate time-series modelling. This is because the estimated elasticities can be separable across age groups, which may provide better insights on how labor supply responses to wage changes might differ at various life stages.

Let $x$ be age and $t$ be calendar time, by imposing no restrictions on any parameters, the estimation equation can be written as following,

$$\ln (N_{x,t}) = \theta_{x,0} + \theta_{x,1} \ln (N_{x,t-1}) - \theta_{x,2} \ln (1 + r_t) + \theta_{x,3} \ln (w_{x,t}) - \theta_{x,4} \ln (w_{x,t-1}) + \epsilon_{x,t} \quad (14)$$

Equation (14) is an unrestricted model (the benchmark model in the analysis), which is seemingly identical to many other models applied to aggregate time-series data (Lucas and Rapping, 1969; Alogoskoufis, 1987; Altonji, 1982). The variable $N$ refers to the number of labor market participants deflated by the population index $M$ at the level of the base year (1985). $r$ is adjusted by annual inflation and $w$ is deflated by the constant price index (1985=100). $\epsilon$ is a white-noise error term.

The price and interest rate are assumed to be exogenous to household in this model, only labor supply and wage rates are endogenous. Two-stage Least Square regression is used to estimate the labor supply function. The wage expectation is formed at the first stage least square estimation, that is regressing observed wage rate on all exogenous variables and instruments\(^5\).

It is important to stress the difference between the definition of labor supply in my model and in L-R Model. Lucas and Rapping relate labor supply to total man-hours supplied annually to the market work, whereas I count the number of persons registered in the labor force as a proxy for labor supply. In fact, the two measures of labor supply is only different by a scale factor, average working hours. This is because the total man-hours in L-R data is the product of number of employed persons and annual hours worked per full-time employee. It implicitly assumes that all persons engaged in production works on the full-time basis with the same amount of hours, which is equivalent to counting the number of labor market participants by assuming each of them supplies one unit of full-time equivalent labor.

Moreover, the measured labor supply in L-R Model is conditioning on population who are effectively employed, thus their labor supply function might be better viewed as the determinants of employment (Rees, 1970). For this, the number of labor force participants is chosen instead of employed persons so as to explicitly model the households’ labor supply decision.

Finally, the population deflator used in L-R Model, $M_t$, is a very strong assumption. This is because they measure the hours supplied by those who are employed, which is supposed to be deflated by the relative increase in actual labor force participants with

\(^5\)The instrument variables used for estimated expected wage rates are the same as L-R model, except the labor quality measure is excluded due to data constraint. The three instruments are: 1. Annual Gross Domestic Output (GDO) from the Historical national accounts for Sweden 1800-2000 established by Rodney Edvinsson. The series is deflated by the population index $M$ and price index (base year 1985). 2. Marginal productivity condition for labor is derived by dividing number of labor force participants by real GDO. 3. The annual total output is measured by the yearly percentage change in real gross domestic output.
respect to the base year so as to rule out the effects of the labor force growth on number of persons being employed. However their deflator merely captures the relative increase in population size *per se*, as the labor force participation rates are held constant overtime, thus the effect of labor growth on employment still exists. This will not be a problem for the estimation in this paper, as labor supply is explicitly measured by labor force participants rather than employees, and the $M$ index is an explicit measure of the relative change in population size with respect to the base year: 1985. That is to say that the change in the size of the labor force, or equivalently the labor supply, is substantively isolated from population change.

Apart from the benchmark model (14), two additional nested models were estimated so as to test the proposed hypotheses. The first restricted model imposes the restriction on $\theta_{x,3} = \theta_{x,4}$. This model tests the hypothesis 1-4. And the second restricted model imposes restriction on $\theta_{x,2} = \theta_{x,3} = \theta_{x,4}$, which is used for testing hypothesis 5. The estimated results are reported and discussed in the following section.

4 Results and Discussion

4.1 Some Descriptive Results

Figure 2 illustrates the average age-profiles of real wage and labor force participation rates over the entire period and sub-periods. In general, wage rate is persistently higher for old workers than young workers, which is in line with predictions by the theories reviewed in the proceeding section. However the pattern appears a shifting towards old age over time.

Up until 2000s, the age-earning profiles are characterized by a steep increase from labor market entry age through a peak around age 45-54, and gradually decline thereafter. Such pattern is in line with what Skirbekk (2003) summarized based on OECD evidence. That is wage peaks for the age group 45-54 in 17 out of the 19 OECD countries\(^6\). However, this pattern was altered over 2000-2003. As the dark solid line in the bottom right panel in Figure 2 illustrates, the peaking age shifted from age 45-54 to 55-59, and earnings remained high through age 64. This is somewhat similar to what been found by Lee et al. (2011) for the U.S. where the earnings of older men are consistently upward trended relative to the younger men. One of the explanations could be, as given by Lee et al. (2011), that young workers are no longer possessing educational advantage over the old workers. On the other hand, this can be also attributable to the factors, as discussed in the proceeding section, e.g. the existence of wage-productivity discrepancy, efficiency wage hypothesis, the shirking model, the nature of the optimal wage profile, working experience, and the trade union preference given to old workers. All such can contribute to higher work compensation for senior relative to junior workers.

The age-profiles of LFP appears slightly more stable than of wage. The overall pattern reveals a downward shift overtime. However, the dash line in Figure 3 evidently

---

\(^6\)These countries are Australia, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Mexico, The Netherlands, New Zealand, Norway, Portugal, Sweden, Switzerland and the U.S.
shows that young workers, aged 16-19 and 20-24, are much more sensitive to the overall change in LFP relative to their older counterparts. This implies that those aged up to 24 seem to contribute more to the great decline in LFP throughout the crisis in the early 90s and remained constantly lower than pre-crisis level, as shown in figure 1. At least two factors are worth to mention in this regard. Firstly extensive schooling might explain such pattern, as pursuing a bachelor education would delay labor market entry, thus if university enrolment rate increases, LFP rate would decline for this particular group. Secondly, the theory of labor supply over the business cycle predicts that there could be discouraged worker effect. That is once the labor market is tightening throughout the economic downturn, unemployment could generate disincentives for non-workers to keep searching for new jobs. Nonetheless, this theory does not seem to explain the LFP during the post-crisis recovery, as shown in Figure 1 that LFP and GDO reveal somewhat counter-cyclical trend. Unfortunately, these two factors can not be empirically examined at this stage.

By looking at both age profiles simultaneously, wage and LFP over the life-cycle appear coincidentally hump shaped. This is in line with ISH prediction that wage and labor supply should be positively correlated. Nevertheless, the rate of change for the two life-cycle series do vary at different ages. From age 16 to 34, LFP grows faster than wage. Nonetheless, between age 34 and 54, the LFP curve flatten out, while wage curve continuously upward trended. The most striking feature is the divergence between LFP and wage after age 54. The decline of the LFP is too steep to be explained by the decreasing wage. And this divergence tend to amplify over time, particularly for the most recent period (2000-03), in which, LFP drops considerably while wage rates flatten out between age 54 and 64. All of this implies that ISH might only explain the labor supply over part of the life-cycle. It is obviously insufficient to account for the sharp decline in LFP after age 54. Health, taste for work, disincentives by social insurance programme, working condition for elderly, as well as many other factors might force down the labor supply curve over old ages. This certainly reserves further investigation. Speculatively speaking, health should not be the main force draw people out of the labor force, especially for Sweden. Simply because this is a country has been at the frontier of the best-practice life expectancy for a century long, and is likely to reach a life expectancy at birth of a hundred in about six decades (Oppen and Vaupel, 2002). Recent trends also show an improved health condition in the age of 60s and 70s.

Figure 3 shows the age-specific change in wage and LFP over the period 1985-2003. If we look at the youngest and the oldest in this figure, it is evident that the relation between the wage response and labor supply response appears negative. For those aged 16-19, wage growth is nearly zero with respect to one unit change in aggregate wage rate, whereas LFP changed by over 50 percent for each unit change in aggregate LFP rate. On the other extreme, those aged 60-64 would gain by over 20 percent for each unit change of overall wage, which is more than doubled of their LFP response.

The key message from figure 2 and figure 3 is that the old age population appears reluctant to supply labor, despite the most accelerated wage growth for this group. If this persists over the coming decades, it would certainly threat the ageing welfare state. This is because the services provided by the welfare state are labor intensive, and population ageing would increase the per worker cost of providing a given age-vector of per capita
benefits (Lee and Edwards, 2001). Elderly can be substantial assets for reducing this per worker cost if they work, whereas it would become a burden if they do not. On the other hand, if the wage shift towards old age really reflects the cohort differences in the marginal product of labor induced by human capital development, then the persistent low LFP among old aged implies a large share of human capital remain unexploited. This will further become a concern for the long term economic growth.

4.2 Estimated Elasticities of Labor Supply w.r.t Real Wage

Table 1 through Table 3 report the coefficient estimates for the benchmark unrestricted model - i.e. Equation (4) - as well as two restricted model, which are used to test the hypothesis 1-4 and hypothesis 5, respectively.

With respect to the level of analysis, only the estimates for all age groups, shown in the first column of each table, are comparable to other aggregate time series analysis, e.g. L-R model and Alogoskoufis (1987). Nonetheless, my results in table 1 are in sharp contrast to previous empirical studies in terms of the size of the coefficients, but rather consistent regarding the signs and the statistical significance of the parameters. The elasticities of labor supply with respect to real wage estimated by Lucas and Rapping (1969) and Alogoskoufis (1987) are all far greater than unity (1.4 and 1.9, respectively), whereas mine is merely 0.58. Although minor differences in model specification, and the choice of instruments and exogenous variables, can lead to variations in these point estimates, country and period differences should contribute more in this regard. On the other hand, despite the proxy for non-labor income in my model is different than L-R, but similar to Alogoskoufis (1987), the real interest elasticities are strikingly close to each other. My elasticity of labor supply w.r.t real interest rate is 0.66 that is approximately the same as the estimates in Alogoskoufis (1987), while 0.74 in Lucas and Rapping (1969) w.r.t annual inflation. Nonetheless, the implication of these elasticities are saliently different. In particular, Alogoskoufis (1987) conclude that intertemporal real wage and interest rate elasticities are substantially higher than previous estimates (e.g. (Mankiw et al., 1985)), whereas much lower than the static substitution elasticity. My results show that intertemporal and intratemporal elasticities are very close to each other (see both table 1 and table 2). Furthermore, the F-test in the first column of Table 3 suggests no statistical evidence to reject the equality restrictions on both types of elasticity, implying that intertemporal and intratemporal elasticities are with the same magnitude. This is also the test performed for hypothesis 5.

For the age-specific estimates, elasticities do vary considerably. With respect to the relative magnitude of the inter- and intra-temporal elasticities (See the last row in Table 2), only the age group 25-34 is in line with the aggregate estimates, which confirm the hypothesis 1. That is substitution effect dominates within period, which further outweighs the intertemporal elasticity of substitution. For those aged up to 24, hypothesis 3 is confirmed that income effect dominates within period, which, however, is outweighed by intertemporal elasticity. The age group 35-44 reveals that there is only substitution effect dominates, both within and across period, and intertemporal elasticity outweighs intratemporal elasticity of substitution, i.e. hypothesis 2. Hypothesis 4 is confirmed by
Figure 2: Comparison of Estimated Age Profiles of Real Wage and Labor Force Participation Rate over Time
Figure 3: Comparison of Estimated Age-specific Responsiveness in Real Wage and Labor Force Participation 1985-2003
those age 45+ that income effect dominates within period, and which outweighs the intertemporal elasticity of substitution.

However, in terms of the statistical equality between inter- and intra-temporal elasticities, shown in the last row of Table 3, hypothesis 5 is confirmed by all age groups, except the oldest \(^7\). Combining hypothesis 4 and 5 for the age group 60-64, it somewhat gives the explanation, at least partially, of the divergence between wage and LFP over the late period of the life-cycle, as shown in Figure 2. Both F-test and the \(\frac{\rho}{\gamma}\) ratio imply that intertemporal substitution hypothesis is not adequate to explain the labor supply over old age, as it is outweighed by intra-temporal response, which is further dominated by income effect rather than substitution effect. A more intuitive interpretation is that people exit labor market and entering into retirement is, to a less extent, as a response to evolutionary wage change, which is known to them, but rather more to unanticipated short-run wage shifts. And those who are approaching the retirement age seem strongly prefer leisure to consumption, and therefore the income effect of a wage increase on labor supply dominates.

One explanation for such behavior is that the individual life-cycle labor supply curve might be backward-bending. That is when individuals grow old, their decision-making become more myopic rather than forward-looking because of fewer years of remaining life expectancy. This implies that the work-leisure choice problem would become more static instead of dynamic. On top of that, the work compensation at old age is higher relative to at young age, and the wage rate has been shifting towards old age over time, as formerly discussed. Therefore, based on what backward-bending labor supply curve predicts, any further wage increase at high level of income would yield the income effect, which, in turn, reduces the intensity for work at this stage of the life-cycle.

The last, but not the least, note in this section is regarding the instruments that I used to estimate the labor supply function (14) by 2SLS regression. The last row of Table 1 gives the p-value for Basmann over-identification test. In most of the cases, I cast no doubt on the appropriateness of the instruments, except the two models, for age groups 16-19 and 55-59, that I do not reject the null hypothesis that all the instruments are uncorrelated with the error term. This implies that some of the instrument variables do not satisfy the condition of orthogonal error process. Nevertheless, since this problem do not appear in most of the models and to ensure the comparability of the estimates across all the age groups and with the aggregate model, I choose to use (14) as a standardized estimation equation for all.

\(^7\)F-test for the age group 60-64 indicates that the null hypothesis that the restriction on both parameters being equal is rejected at 10 percent confidence interval.
Table 1: Estimation of Equation (14) by 2SLS (Unrestricted Benchmark)

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>All Age</th>
<th>16-19</th>
<th>20-24</th>
<th>25-34</th>
<th>35-44</th>
<th>45-54</th>
<th>55-59</th>
<th>60-64</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln ( (N_{x,t}) )</td>
<td>0.305</td>
<td>0.700</td>
<td>0.00184</td>
<td>-2.572</td>
<td>0.920</td>
<td>11.06***</td>
<td>5.715**</td>
<td>4.330</td>
</tr>
<tr>
<td>ln ( (N_{x,t-1}) )</td>
<td>1.017***</td>
<td>0.968***</td>
<td>1.022***</td>
<td>1.179***</td>
<td>0.967**</td>
<td>0.241</td>
<td>0.593***</td>
<td>0.576**</td>
</tr>
<tr>
<td>ln ( (w_{x,t}) )</td>
<td>0.581**</td>
<td>0.257</td>
<td>0.327*</td>
<td>0.409***</td>
<td>0.155</td>
<td>-0.0806</td>
<td>-0.147</td>
<td>-1.113**</td>
</tr>
<tr>
<td>ln ( (w_{x,t-1}) )</td>
<td>-0.626**</td>
<td>-0.282*</td>
<td>-0.351**</td>
<td>-0.401***</td>
<td>-0.193</td>
<td>0.0191</td>
<td>0.106</td>
<td>1.192**</td>
</tr>
<tr>
<td>ln ( (1 + r_t) )</td>
<td>-0.656***</td>
<td>-1.615*</td>
<td>-0.793***</td>
<td>-0.330**</td>
<td>-0.296**</td>
<td>-0.0366</td>
<td>-0.264**</td>
<td>0.752</td>
</tr>
<tr>
<td>Constant</td>
<td>0.305</td>
<td>0.700</td>
<td>0.00184</td>
<td>-2.572</td>
<td>0.920</td>
<td>11.06***</td>
<td>5.715**</td>
<td>4.330</td>
</tr>
</tbody>
</table>

| Observations    | 18      | 18     | 18     | 18     | 18     | 18     | 18     | 18     |
| R-squared       | 0.913   | 0.928  | 0.963  | 0.892  | 0.919  | 0.882  | 0.827  | 0.702  |
| Overid (p-value) | 0.511   | 0.0212 | 0.185  | 0.461  | 0.272  | 0.311  | 0.00693| 0.714  |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Overid refers to Basmann over-identification test.
Table 2: Estimation of Equation (14) by 2SLS (with Restriction: $\theta_{x,3} = \theta_{x,4}$)

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>All Age</th>
<th>16-19</th>
<th>20-24</th>
<th>25-34</th>
<th>35-44</th>
<th>45-54</th>
<th>55-59</th>
<th>60-64</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln \left( \frac{w_{x,t}}{w_{x,t-1}} \right)$</td>
<td>0.667***</td>
<td>0.283*</td>
<td>0.350*</td>
<td>0.401***</td>
<td>0.310</td>
<td>-0.0313</td>
<td>-0.0541</td>
<td>-0.937*</td>
</tr>
<tr>
<td></td>
<td>(0.171)</td>
<td>(0.154)</td>
<td>(0.183)</td>
<td>(0.0971)</td>
<td>(0.234)</td>
<td>(0.0847)</td>
<td>(0.250)</td>
<td>(0.474)</td>
</tr>
<tr>
<td>$\ln (1 + r_t)$</td>
<td>-0.592***</td>
<td>-1.515*</td>
<td>-0.734***</td>
<td>-0.352***</td>
<td>-0.312*</td>
<td>-0.0315</td>
<td>-0.177</td>
<td>0.282</td>
</tr>
<tr>
<td></td>
<td>(0.106)</td>
<td>(0.712)</td>
<td>(0.211)</td>
<td>(0.0756)</td>
<td>(0.149)</td>
<td>(0.0608)</td>
<td>(0.158)</td>
<td>(0.641)</td>
</tr>
<tr>
<td>$\ln (N_{x,t-1})$</td>
<td>1.183***</td>
<td>0.955***</td>
<td>1.033***</td>
<td>1.154***</td>
<td>1.162***</td>
<td>0.915***</td>
<td>0.848***</td>
<td>0.496*</td>
</tr>
<tr>
<td></td>
<td>(0.0713)</td>
<td>(0.0648)</td>
<td>(0.0574)</td>
<td>(0.0751)</td>
<td>(0.132)</td>
<td>(0.157)</td>
<td>(0.157)</td>
<td>(0.256)</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.785**</td>
<td>0.583</td>
<td>-0.409</td>
<td>-2.127*</td>
<td>-2.253</td>
<td>1.160</td>
<td>1.958</td>
<td>6.288*</td>
</tr>
<tr>
<td></td>
<td>(1.087)</td>
<td>(0.780)</td>
<td>(0.743)</td>
<td>(1.037)</td>
<td>(1.845)</td>
<td>(2.127)</td>
<td>(2.010)</td>
<td>(3.176)</td>
</tr>
</tbody>
</table>

Observations: 18 18 18 18 18 18 18 18
R-squared: 0.967 0.941 0.965 0.962 0.934 0.777 0.787 0.768
F-test (p-value): 0.0995 0.864 0.752 0.674 0.650 0.0226 0.108 0.300
$\frac{\xi}{\gamma}$: 1.254 (0.369) -0.627 (0.327) -0.0476 (0.588) 1.277 (0.532) 0.989 (0.923) -2.986 (7.646) -1.611 (3.264) -7.648 (12.31)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
F-test refers to the test: $H_0$: the restricted model ($\theta_{x,3} = \theta_{x,4}$) is nested to the unrestricted model
$\xi/\gamma$ refers to the relative magnitude of intra- to inter-temporal elasticity.
Table 3: Estimation of Equation (14) by 2SLS (with Restriction: $\theta_{x,2} = \theta_{x,3} = \theta_{x,4}$)

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>All Age</th>
<th>16-19</th>
<th>20-24</th>
<th>25-34</th>
<th>35-44</th>
<th>45-54</th>
<th>55-59</th>
<th>60-64</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln \left( \frac{(1 + r_t)w_{x,t-1}}{w_{x,t}} \right)$</td>
<td>-0.575***</td>
<td>-0.432***</td>
<td>-0.516***</td>
<td>-0.366***</td>
<td>-0.313**</td>
<td>-0.0153</td>
<td>-0.228</td>
<td>1.175**</td>
</tr>
<tr>
<td></td>
<td>(0.102)</td>
<td>(0.125)</td>
<td>(0.137)</td>
<td>(0.0699)</td>
<td>(0.138)</td>
<td>(0.0559)</td>
<td>(0.159)</td>
<td>(0.502)</td>
</tr>
<tr>
<td>$\ln (N_{x,t})$</td>
<td>1.160***</td>
<td>0.960***</td>
<td>1.047***</td>
<td>1.138***</td>
<td>1.162***</td>
<td>0.842***</td>
<td>0.947***</td>
<td>0.293</td>
</tr>
<tr>
<td></td>
<td>(0.0615)</td>
<td>(0.0676)</td>
<td>(0.0577)</td>
<td>(0.0672)</td>
<td>(0.108)</td>
<td>(0.120)</td>
<td>(0.146)</td>
<td>(0.258)</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.434**</td>
<td>0.472</td>
<td>-0.609</td>
<td>-1.901*</td>
<td>-2.264</td>
<td>2.145</td>
<td>0.679</td>
<td>8.775**</td>
</tr>
<tr>
<td></td>
<td>(0.938)</td>
<td>(0.812)</td>
<td>(0.745)</td>
<td>(0.927)</td>
<td>(1.511)</td>
<td>(1.635)</td>
<td>(1.863)</td>
<td>(3.200)</td>
</tr>
<tr>
<td>Observations</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.966</td>
<td>0.931</td>
<td>0.960</td>
<td>0.961</td>
<td>0.934</td>
<td>0.768</td>
<td>0.756</td>
<td>0.702</td>
</tr>
<tr>
<td>F-test (p-value)</td>
<td>0.511</td>
<td>0.145</td>
<td>0.206</td>
<td>0.595</td>
<td>0.990</td>
<td>0.471</td>
<td>0.174</td>
<td>0.0656</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

F-test refers to the test: $H_0$: the restricted model ($\theta_{x,2} = \theta_{x,3} = \theta_{x,4}$) is nested to the restricted model ($\theta_{x,3} = \theta_{x,4}$)
5 Conclusion

This paper examines the macro behavior of real wage and labor supply in the Swedish labor market over the period 1985-2003. The descriptive analysis show that LFP does not correspond thoroughly to labor-related income over the later working life. LFP drops too steep to be explained by wage change over old ages. Moreover, the age-wage profiles reveal a profound shift towards old age overtime, whereas the age-LFP profiles do not. These cast doubt on the explanatory power of ISH, at least for the later part of the life-cycle.

Combining the time-varying NTA age-profiles with other macro-economic variables allows me to estimate a life-cycle labor supply function that is theoretically consistent with the overlapping generation framework. Unlike traditional macroeconomic analysis relying on National Accounts to estimate a single elasticity for all social and demographic groups, the NTA setting enables me to envisage a more realistic life-cycle model of labor supply. That is not only to test the intertemporal substitution hypothesis, but also allows for estimating age-separable elasticities of labor supply w.r.t wage. This can serve as a new basis for calibrating the overlapping generation models with age-specific elasticities. Some key findings in my econometric analysis are summarized as following.

1) In the aggregate model, the estimated intertemporal elasticity of substitution is similar to that in Alogoskoufis (1987) and Lucas and Rapping (1969) in terms of the coefficient sign and statistical significance, yet much smaller in magnitude. As a result, both types of substitution effect are found to play the same role in governing the household’s labor supply decision. Statistical test on the parameter restriction further confirms the equal magnitude of inter- and intra-temporal elasticities of substitution.

2) The age-specific estimates, however, show considerable life-cycle variation in the relative magnitude of inter- and intra-temporal elasticities as well as in the household’s within period response to real wage change. Intertemporal elasticity of substitution dominates for the youth and those aged 35-44 over the period 1985-2003, while it is outweighed by intratemporal elasticity for the age groups 25-34 and 45+. It is noteworthy that only the age group 25-34 is in line with the aggregate estimates implying that estimated elasticities in traditional macroeconomic studies, e.g. Alogoskoufis (1987) and Lucas and Rapping (1969), are only representative for a certain demographic group, i.e. those aged 25-34 in this case.

3) In stark contrast to previous studies, I find income effect dominates within period response to wage changes for several age groups, which is particularly profound for age 45+. As a result the net response to wage change for those groups are negative.

4) With respect to parameter restriction test, the inter- and intra-temporal elasticities are in the same magnitude for all age groups, except the oldest group 60-64, for which income effect dominates within period and outweighs the intertemporal elasticity of substitution. This implies that the old age labor supply can not be fully explained by ISH, but seemingly by backward-bending supply curve instead. In another word, the retirement transition do not seem to be mainly driven by evolutionary wage change, but rather by short-run wage shifts, and people tend to prefer leisure to consumption at this stage of the life-cycle.
I would like to conclude this paper by mentioning some limitations that one might think of throughout reading it and potential extension for future research. First of all, the patterns showed in terms of real wage and labor supply as well as the relation between the two are in an age-specific period setting. Therefore they shall be more literally interpreted as the working behavior in a quasi life-cycle framework. To better reflect the real life-cycle behavior, cohort estimates are certainly preferable. This, however, is not readily implementable given the current state of the NTA time-series for Sweden. Data expansion over a longer time horizon is therefore desirable. This should be placed at one of the core tasks for the future development of the NTA project.

At the second, the differences in the life-cycle profiles of real wage and labor supply with respect to other observable dimensions, such as education, gender, ethnic as well as migration, are not examined in this study. This, however, can be accomplished in the very near future once the National Time Transfer Accounts (NTTA) has been established.

Finally, the estimated elasticities in this study are very likely to be different than which from longitudinal analysis of individual data. I shall stress that the choice of the level of the analysis as well as the type of data depends on the research question and the aim of the study. For the interest in more detailed heterogeneity among individuals, such as the differentials over other dimensions that I have just mentioned, micro-level analysis would be certainly preferred. Nevertheless, if one needs to apply the individual elasticities to macro models, such as OLG-CGE, he has to ensure the equivalence of the parameters in the two environments implied by the aggregation theory (Browning et al., 1999; Prescott and Wallenius, 2011). For one of the purposes in this paper, that is providing some additional insights to the calibration of OLG models, my estimates are appropriate as they correspond to the average of each representative generation.

References


