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Essays on Heterogeneous-agent Macroeconomics and Public Policies

비동질적 경제주체를 가정한 거시경제모형과 공공정책에 관한 연구

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Essays on Heterogeneous-agent Macroeconomics and Public Policies

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Abstract

The Earned Income Tax Credit (EITC) is a means-tested income support program, but it differs from other welfare programs in that it requires earned income as a qualification. Therefore, the EITC provides labor supply incentives as well as cash transfers to low-income households. Pioneered by Eissa and Liebman (1996), many empirical studies have investigated its labor supply effect and found that tax credit programs increase the target individual's labor market participation. However, as noted by Eissa and Liebman (1996), the labor supply effect is a piece that shapes the picture of the overall welfare consequence of the EITC. In their conclusion, they stated: *"A full evaluation of [...] the EITC requires more than just an estimate of the [...] impact [...] on the labor supply of transfer recipients. It also requires information on the value of the additional income received by program beneficiaries as well as the change in the amount of leisure that they consume."* Nevertheless, there have been only a few studies on its impact on income (Hoynes and Patel, 2018) and welfare, or the long-term impact over the life cycle (Athreya et al., 2014; Blundell et al., 2016). This dissertation mainly aims to fill this gap by expanding our understanding of the EITC's impacts in these dimensions. Specifically, I develop a heterogeneous-agent life-cycle model in the tradition of Huggett (1993) and Aiyagari (1994), one of the workhorse models in modern macroeconomics, to answer the following questions: How are the EITC's long-term impacts over the life cycle affected by the public pension system in terms of (i) labor supply and lifetime income and (ii) savings, consumption, and welfare? In addition, through the lens of the sophisticated model, I investigate (iii) why

some EITC expansions in Korea were less effective in inducing labor market participation as found in the empirical literature (Park and Lee, 2018).

In the first and second chapters of the dissertation, I explore the role of the public pension tax-benefit link in the benefits of the EITC program. In the public pension systems of many countries, contributions before retirement and benefits after retirement are linked. In other words, an increase in lifetime earnings and pension contributions through more labor supply during the working age increases pension benefits after retirement. Therefore, the labor supply response to the EITC during the working age of the life cycle increases pension income in retirement through the tax-benefit link of public pensions. This mechanism amplifies the income-increasing effect of the EITC by raising pension income. Moreover, salience literature on public pensions (Liebman and Luttmer, 2015) suggests that informational intervention about the dynamic incentive for work through the tax-benefit link could intensify the labor supply and earnings responses to the EITC. This channel also magnifies the EITC's welfare consequence by enabling the target household to reduce retirement savings and enjoy more consumption. I quantitatively analyze the EITC's long-term impacts on income and welfare over the life cycle and highlight the role of the pension tax-benefit link. To this end, I construct a heterogeneous-agent life-cycle model with consumption-savings and extensive margin labor supply choices, as well as a public pension system. The model is calibrated to the Korean economy running a sizable EITC program. I examine the EITC's effect on newborn individuals who will face unfavorable labor productivity histories over their lives, making their lifetime income low, to focus on the direct incentive effect of the program. By comparing the impacts of the

EITC with versus without the dynamic labor supply return through the pension tax-benefit link, I find that the role of the tax-benefit link is quantitatively significant. For newborns with low lifetime income, the pension tax-benefit link explains more than half (a quarter) of the increase in lifetime income (welfare) due to the EITC.

In the last chapter, I provide a possible mechanism for the empirical result of Park and Lee (2018) through the lens of the life-cycle model. One of the main findings of Park and Lee (2018) is that the estimated labor supply response to the EITC becomes substantially small and insignificant if 2014–2016 is included in the sample periods. One of the unique features of the EITC expansions in Korea is that there was an age limit for single households, which was gradually relaxed over time. Specifically, singles above 60 became eligible for the EITC in 2013, those above 50 in 2015, those above 40 in 2016, and so on. These observations suggest that the heterogeneous labor supply response by age could be the driving force behind the empirical result. Consistent with this conjecture, I find that the model implies substantially higher labor supply elasticity in the 60s than in middle age. The differential labor supply elasticity by age comes from heterogeneity in labor productivity and wealth by age. In the 40s, an EITC-eligible low income individual is likely to already be in the labor market even without the EITC because it is his prime age and he needs to accumulate more wealth against retirement. This means there is little room for the EITC to induce labor supply. For those nearing retirement, in contrast, their average labor productivity tends to be lower than at prime age, and they already have enough wealth to finance retirement consumption. This makes them closer to the participation margin, which implies more room

for the EITC to induce labor market participation. The result suggests that we need more empirical work on for whom the EITC is effective in inducing labor supply, not just the estimates for the average effect.

Keywords : EITC, Life-cycle model, Long-term impact, Public Pensions, Labor Supply, Salience

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Chapter 1

The Earned Income Tax Credit and the Tax-benefit Link of Public Pensions

Effects on Labor supply and Income

1.1 Introduction

The Earned Income Tax Credit (EITC), or in-work benefits, has been widely adopted and expanded across OECD countries over the past few decades (Immervoll and Pearson, 2009; Laun, 2019). As a cash assistance program for low-income families, the distinct feature of the EITC from other welfare programs is that it requires earned income as a qualification. Due to this unique feature, the EITC provides labor supply incentives to low-income households as well as cash transfers. Thus, the EITC can raise the income of its target household through two channels. In addition to providing direct cash assistance, it can increase labor earnings by inducing labor market participation. Therefore, we need information about the labor supply and earnings responses to the EITC to evaluate its effectiveness at raising income.

While many empirical studies, pioneered by Eissa and Liebman (1996), found that the tax credit program increased labor market participation,[1] relatively few studies analyzed the earnings response to the tax credit. Re-

[1] See, for example, Meyer and Rosenbaum (2001), Francesconi and Van der Klaauw (2007), Sánchez-Mangas and Sánchez-Marcos (2008), Azmat and González (2010), and Laun (2017).

cent work by Hoynes and Patel (2018) addresses this important issue. The key contribution of their work is that they quantify how much we miss the EITC's impact on income by not accounting for the increase in earnings due to the labor supply response. Their estimates show that the income-increasing effect of the EITC is substantially larger if we consider the earnings response.[2]

Based on this short-run empirical evidence of the labor supply and income-increasing effects of the tax credit policy, a growing body of literature examines its *long-term* impact over the life cycle using a structural model. Athreya et al. (2014), Blundell et al. (2016), and Koşar (2019) build a life-cycle model and show that the tax credit program increases labor market participation for those with low lifetime income.[3]

In this chapter, I develop a life-cycle framework to argue that the *long-term* impact of the tax credit on labor supply and lifetime income can be larger if we take into account the tax-benefit link of public pensions. In the public pension systems of many countries, contributions before retirement and benefits after retirement are linked. In other words, an increase in lifetime earnings and pension contributions through more labor supply during the working age increases pension benefits after retirement. Considering this pension tax-benefit link, the EITC can raise the target household's *lifetime* income through three channels. In addition to the two *static* channels (direct cash transfers and earnings increases), a new *dynamic* channel arises: the labor supply response to the EITC raises *future* pension income through the pension tax-benefit link. Furthermore, if

[2] Neumark and Wascher (2001) and Grogger (2003) also made a similar point by exploring the EITC's effects on cash income.

[3] See also Keane and Wolpin (2010) and Chan (2013).

the EITC's target individuals do not fully comprehend the dynamic return on labor supply when making decisions, improving their understanding of the contribution-benefit link could amplify the EITC's effects on labor supply and earnings. This is likely to be the case considering the empirical findings of Liebman and Luttmer (2015) that information intervention about the pension tax-benefit link induces an increase in labor supply.[4] Therefore, the future return on labor supply can amplify the benefits of the EITC by (1) raising pension income and (2) intensifying the labor supply responses to the EITC. While the first component is what we have missed by abstracting the contribution-benefit link from the model, the second is what we can achieve by providing information about the pension tax-benefit link. This chapter quantitatively examines the importance of the dynamic labor supply return through the pension tax-benefit link for the *long-term* impact of the EITC on labor supply and lifetime income.

To this end, I construct a heterogeneous-agent life-cycle model in the tradition of Huggett (1993) and Aiyagari (1994). Individuals face idiosyncratic labor productivity risk, which is uninsurable and persistent. Persistent labor market risk is an essential element that generates the distribution of lifetime income (and wealth) and thus affects eligibility for the EITC. It also allows me to capture the consumption insurance effect of the tax credit emphasized in the previous studies. Individuals make consumption-savings decisions over their lives while facing borrowing

[4] The recent literature on the salience issue of public policies finds that informational intervention to help people better understand the government-intended incentive can affect individual behaviors such as savings and labor supply. These findings suggest that people may fail to fully understand the incentives generated by such programs when making decisions. See, for example, Duflo et al. (2006), Chetty and Saez (2013), and Chetty et al. (2013).

constraints. Labor supply is endogenous at the participation margin in each period, as in Chang and Kim (2006), until the mandatory retirement age.[5] The key innovation of the model is that it embeds a public pension system with an explicit link between labor market histories and pension benefits.[6] In this setting, pension benefits are determined endogenously through endogenous labor supply decisions over the working periods of life. The model also incorporates mortality risk so that lifespan is uncertain. This feature allows me to avoid overstating the role of the pension tax-benefit link since the mortality risk is more pervasive in retirement periods.

The selected laboratory environment for the analysis is South Korea (Korea, hereafter), which runs a sizable EITC program yet its impacts have been understudied so far in the literature.[7] The tax credit is means-tested: only those with sufficiently low earnings and wealth are eligible. The calibrated benchmark economy successfully replicates some important features in the data, such as the age-employment rate profile, the EITC recipiency rate, and the distribution of income and wealth. Also, the labor supply elasticities implied by the model are within the range of the literature on the extensive margin of labor supply. The main focus of the analysis is the impact on the life cycle of newborns with unfavorable productivity

[5] The empirical literature has found the labor supply effects of the tax credit program mostly at the participation margin. See, e.g., a review by Hotz and Scholz (2003) and Eissa and Hoynes (2006).

[6] Previous structural analyses for the tax credit program abstracted the pension tax-benefit linkage. Athreya et al. (2014) assumes the Social Security pension benefit as a lumpsum transfer to the retiree. In the life-cycle model of Blundell et al. (2016), retirees are assumed to receive no public pension income.

[7] According to the National Tax Service of Korea, about 10% of the working-age population received the tax credit in 2019, and the overall expenditure amounted to 0.2% of GDP.

histories. This group is supposed to be the most affected by the EITC because their income and wealth would be persistently low over their lives. Throughout the analysis, I proceed in partial equilibrium framework in which equilibrium prices (wages and interest rates) and tax rates are held fixed. This setting is consistent with the previous structural studies on the tax credit, thus allowing me to shed light on the role of the *dynamic return* due to the contribution-benefit link for the *benefit* side (or direct effect) of the tax credit policy.

Using the calibrated model, I first remove the EITC and compare the two steady states of the economies: one with the EITC and one without the EITC. This exercise allows me to quantify the effects on labor supply, earnings, and pension income, as well as the importance of the increase in lifetime pension benefits for the increase in lifetime income. In this environment, however, individuals are aware of *both static and dynamic* returns on labor supply when adjusting their labor supply and savings in response to the EITC, which seems to be at odds with the salience literature (Liebman and Luttmer, 2015). In the second experiment, I consider a counterfactual environment in which the pension tax-benefit link is active only for EITC-ineligible (sufficiently high earnings or wealth) employment. Therefore, in this setting, the target individuals adjust their labor supply and savings, considering the *static return only* (earnings and tax credits) in response to the EITC. Comparing the EITC and NO EITC economies in this environment shows the effects without the *dynamic return*. Finally, by comparing the two results—ones from the model with *both static and dynamic returns* and ones from the model with *static return only*—I can identify how much of the EITC's effects on lifetime income and welfare are attributable to the *dynamic return* through the pension tax-benefit link.

The results show that the *dynamic return* on labor supply through the contribution-benefit link can play a quantitatively important role for the *long-term* impact of the EITC. In the first experiment, newborns with low lifetime income increase their labor supply, and their lifetime years of employment increase by about one year in response to the EITC. As a result, their lifetime earnings and pension contributions increase by 1.4%. The consequent increase in lifetime pension income amounts to 60% of the lifetime receipts of tax credits and explains a quarter of the increase in lifetime income. This result shows that the spillover effect on pension income is substantial. In addition, the labor supply response and the consequent increase in earnings in the second experiment (using the *model with static return only*) are much smaller than those in the first experiment, which shows the importance of the *dynamic return*. The *dynamic return* explains about one-third of the EITC's effects on lifetime labor supply and earnings. The result implies that knowledge provision about the contribution-benefit link can significantly enhance the EITC's benefit. Taking all this together—increase in pension benefits and more earnings response—the pension tax-benefit link can explain half the increase in lifetime income due to the EITC. In terms of welfare, measured by consumption equivalence, the pension tax-benefit link can account for a quarter of the welfare gain from the EITC.

This chapter contributes to two strands of the literature. First, I extend the literature on the effect of the tax credit policy by showing the quantitatively significant role of the dynamic labor supply return through the pension tax-benefit link for the *long-term* benefits of the tax credit program.

The results suggest that informational intervention about the contribution-benefit link could be a fruitful policy avenue to amplify the EITC's benefits. The findings also imply that it is crucial to consider the pension tax-benefit link when assessing EITC reforms, analyzing its optimal scale, or studying the optimal shape of the income transfer program (Saez, 2002). Second, this chapter contributes to the literature on retirement financing. The findings suggest that the work-promoting labor market policy for the working age population can be an alternative policy tool to prevent old-age poverty *in advance* through the contribution-benefit link.

The rest of the chapter is organized as follows. Section 1.2 describes the EITC and the public pension system in Korea along with the model economy. Section 1.3 explains the calibration of the model economy. An exploration of the results is presented in Section 1.4. Conclusions are provided in Section 1.5.

1.2 Model

In modeling choice, I consider the following empirical facts: (i) 70% of the EITC recipients pay pension contribution.[8] (ii) 75% of those who receive the tax credit and contribute to the public pension pay for 12 months per year.[9] (iii) The labor supply effect of the EITC is concentrated to participation margin in the literature (see literature review by Eissa and Hoynes, 2006). (iv) Most of the tax credits rewarded to eligible households are cal-

[8] Author's calculation using the Survey of Household Finances and Living Conditions (SHFLC) data for 2017–2020.

[9] Author's calculation using the National Survey of Tax and Benefit data for 2009–2019.

culated based on *individual*—not family—earnings in Korea.[10]

Taking into account these facts and Korea's individually assessed tax and old age pension system, I build a life-cycle model in which *individuals* are units of decision-making. Time is discrete and one period in the model corresponds to one year. Labor supply is endogenous at the participation margin until the exogenously set retirement age (Chang and Kim, 2006). Labor market participation is tied to the public pension system. Individuals choose how much to save and consume in each period. They also face uninsurable idiosyncratic labor productivity risk, as in Aiyagari (1994) and Huggett (1993), which is the driving force that generates the distribution of lifetime income and wealth in this environment. Individuals also face borrowing constraints and uninsurable mortality risk. The model can also be viewed as an extension of the standard incomplete markets overlapping-generations model of Huggett (1996).

1.2.1 EITC

The basic structure of the Korean EITC is similar to its US counterpart. To qualify for the tax credit, one needs strictly positive and sufficiently low earnings, and the amount of tax credits is calculated based on annual earnings.[11] The tax credit amounts increase up to a certain amount of earnings (the phase-in region), then do not change (the plateau), and then gradually phase out. There is also asset-based means-testing so that households with

[10] In Korea, the tax credits are calculated on family earnings, but 94% of households that received the tax credit were singles or single-earner couples in the 2019 tax year, according to administrative data from the National Tax Service of Korea.

[11] In contrast, in the US system, the tax credit amounts are calculated on adjusted gross income (earned income plus asset income). Although the income limit for the tax credit is applied to adjusted gross income as well in Korea, I ignore this aspect for simplicity.

sufficiently low asset holdings (instead of asset income in the US EITC) can receive the tax credit.

A notable difference from the US EITC is that the tax credit schedule—the trapezoid—does not vary by the number of dependent children. Instead, it differs by the type of household: whether they are singles, families with a single earner, or families with dual-earners. Since I do not distinguish household composition in the model, it is necessary to choose a specific tax credit schedule to be analyzed. In this dissertation, I consider the schedule for single-income families. Because the earnings limit and the maximum tax credit are generous in that order of the stated household type, it can be thought of as an intermediate one.

The schedule for the EITC can be summarized by eq. (1.1) and eq. (1.2), consisting of six parameters $\{\beta_{in}, \beta_{out}, \alpha_{out}, \bar{\psi}, \bar{a_1}, \bar{a_2}\}$:[12]

$$\psi(a,y) = \begin{cases} \psi(y) & \text{if} \quad a < \bar{a_1} \\ 0.5 \cdot \psi(y) & \text{if} \quad \bar{a_1} \leq a < \bar{a_2} \\ 0 & \text{otherwise} \end{cases} \tag{1.1}$$

where

$$\psi(y) = \begin{cases} \beta_{in} \cdot y & \text{if} \quad 0 < y < \underline{T} \\ \bar{\psi} & \text{if} \quad \underline{T} \leq y < \bar{T} \\ \alpha_{out} - \beta_{out} \cdot y & \text{if} \quad \bar{T} \leq y < \hat{T} \\ 0 & \text{otherwise} \end{cases} \tag{1.2}$$

[12] I closely follow the notation used in Froemel and Gottlieb (2021) for comparability to the US program.

and $\underline{T} = \frac{\bar{\psi}}{\beta_{in}}$, $\bar{T} = \frac{\alpha_{out} - \bar{\psi}}{\beta_{out}}$, $\hat{T} = \frac{\alpha_{out}}{\beta_{out}}$. β_{in} and β_{out} in eq. (1.2) are the phase-in and phase-out rates, respectively, of the tax credit schedule applied to earned income y. $\bar{\psi}$ is the maximum amount of the tax credit, and α_{out} is the intercept of the phase-out region. $\bar{a}_1$ and $\bar{a}_2$ in eq. (1.1) represent the asset test: those with asset holdings a greater than $\bar{a}_2$ are ineligible for the tax credit even if their earned income y is below the earnings limit $\hat{T}$. The tax credit is reduced by half for those with asset holdings greater than $\bar{a}_1$ but less than $\bar{a}_2$.

Figure 1.1 graphically illustrates the tax credit schedule I will analyze in this dissertation, where the solid line represents the schedule for the full tax credit $\psi(y)$ and the dashed line is the schedule cut by half due to the asset test.

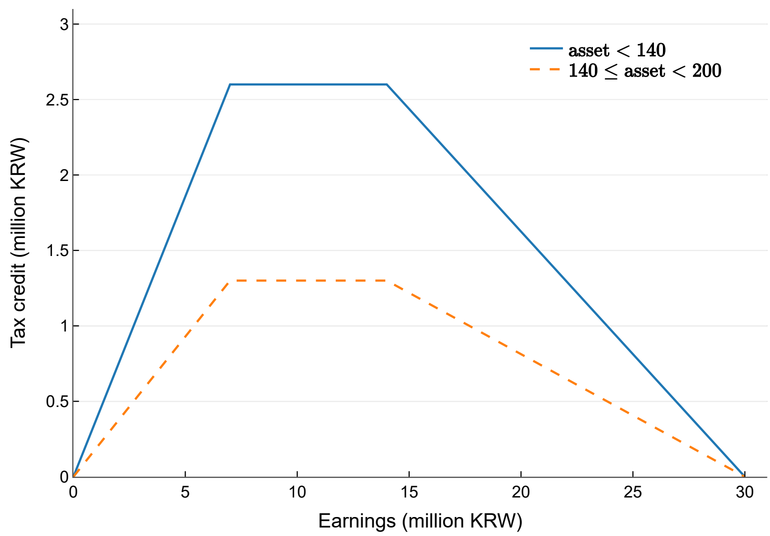


Figure 1.1: EITC schedule for married single-earner, 2019, Korea

1.2.2 Public pension

This subsection describes how the old-age pension of the National Pension System in Korea is embedded in the model economy. From the mandatory retirement age, an individual receives pension benefits $\xi(n, e)$, the amount of which depends on the individual's contribution period, n, and the individual's average taxable earnings over the contribution period, e, as follows:[13]

$$\xi(n, e) = \kappa(E + e)n \tag{1.3}$$

where E denotes the economy-wide average taxable earnings, and κ is the scale parameter that controls the replacement rate of the pension benefit.[14]

It is worth noting that the pension benefit ξ grows with the contribution period n, which implies that the labor supply response to the EITC during working age may increase pension income after retirement. For example, if an individual works for one more year over his life in response to the EITC while his career average earnings do not change, his annual pension benefits will increase by $\kappa(E + e)$.

The expenditure for the pension benefit is financed by the pension contribution in a pay-as-you-go fashion. The contribution rate is τ_p, and it is applied to labor earnings y up to the taxable maximum of $\bar{y}$.

[13] Pension benefits are provided for those with a contribution period of at least 10 years as of retirement age. I confirmed that all individuals in the simulated economies work for more than 10 years throughout their lives.

[14] The pension benefit formula is constructed based on the National Pension Service of Korea. Details of the manipulation are left in the appendix.

1.2.3 Income

Until the mandatory retirement age, individuals earn before-tax labor earnings $y = w\epsilon_j z$ if they work at each age j. w is the market wage rate, ϵ_j is the age-specific component of labor productivity, and z is a persistent idiosyncratic shock to labor productivity. Individuals also receive returns on their asset holdings a at a risk-free interest rate r for each period.

Labor earnings is subject to a progressive income tax $T(y)$ as well as public pension contributions, as explained in the preceding subsection. Returns on asset holdings, ra, are subject to proportional capital income tax at a rate of τ_k.

Working-age individuals can receive three kinds of welfare transfers: the EITC $\psi(a, y)$; lump-sum transfer tr; and welfare benefits to those not working Ω. I separate Ω and tr to reflect the regressive nature of public transfer programs in a simple way. Retired individuals receive pension benefits $\xi(e, n)$, the amount of which is determined by their own labor market histories, as well as a lump-sum transfer to the retiree bp (basic pension).[15]

Thus, disposable income before retirement is market income minus income taxes and pension contributions, plus the tax credit $\psi(a, y)$, welfare benefits tr and $\Omega(h)$. The retiree's disposable income is after-tax asset income plus pension income $\xi(e, n)$ and basic pension bp.

[15] The basic pension in Korea is a means-tested old-age income support program that plays a similar role to the Supplemental Security Income in the US. I do not incorporate its means-tested feature into the model because the means-test is quite generous. In 2019, almost 70% of those aged 65 or above received the benefits, and more than 80% of the beneficiaries received the maximum benefits (according to the Ministry of Health and Welfare).

1.2.4 Individual's problem

Individuals enter the economy at age 25 (which corresponds to age 1 in the model economy) with the same initial asset holdings of $a_{j=1}$. Until the retirement age of J_R, they choose whether or not to work at each age j if they are alive with the probability $\prod_{k=1}^{j} \phi_k$. They also make consumption-savings decisions every period. An individual's problems consist of working-age periods and retirement periods.

Recursive form of the working-age individual's ($j < J_R$) problem is,

$$V_j(a, z, e, n) = \max_{c, a', h} \log c - \nu_j h + \beta \phi_{j+1} E_{z'|z} V_{j+1}(a', z', e', n') \tag{1.4}$$

subject to

$$\begin{aligned} (1+\tau_c)c + a' &= y + (1-\tau_k)ra + a - T(y) - \tau_p \cdot \min\{y, \bar{y}\} \quad (1.5) \\ &\quad + \psi(a, y) + \Omega \cdot (1-h) + tr \end{aligned}$$

$$y = w\epsilon_j zh \tag{1.6}$$

$$a' \geq 0, \quad c \geq 0, \quad h \in \{0, 1\} \tag{1.7}$$

$$n' = n + h \tag{1.8}$$

$$e' = \frac{e \cdot n + \min\{y, \bar{y}\}}{n'}, \tag{1.9}$$

where $V_j(a, z, n, e)$ denotes the discounted expected lifetime utility of an individual at age j with asset holdings a, idiosyncratic labor productivity z, contribution period n, and career average earnings e. The next-period utility is discounted by the time discount rate β and the (conditional) survival probability ϕ_{j+1}, and also the expectation is taken over the realization of the next-period labor productivity z'. (The logarithm of) z is assumed to exogenously evolve over the life cycle according to an AR(1) process as in eq. (1.10).[16] The four individual state variables, (a, z, n, e), imply that individuals at the same age j could be different in those dimensions. The exogenous evolution of idiosyncratic labor productivity over the life cycle is the driving force behind this within-cohort heterogeneity.

$$\log z' = \rho_z \log z + \epsilon_z', \quad \epsilon_z' \sim i.i.d\ N(0, \sigma_z^2) \tag{1.10}$$

Consumption and savings decisions are represented by c and a', respectively. Borrowing is not allowed, and consumption is subject to tax at a rate of τ_c. It is worth noting that the labor supply h is modeled as a binary variable with a value of 0 or 1, indicating that individuals are allowed to choose the labor supply at the participation margin. Participation in the labor market entails a fixed utility cost ν_j that varies with age j. Also, if an individual works ($h = 1$), his contribution period n increases by one (year), and his career average earnings e is updated, affecting his future pension benefits as described in Section 1.2.2. The other terms in the budget constraint are as explained in the preceding subsection.

It is important to note that in this environment (the *full model*), individuals are aware of both *static* (post-tax earnings) and *dynamic* (increase in future pension benefits) returns on their current labor supply when making choices on labor supply and savings. In the last part of the quantitative analysis (Section 1.4.3), I will consider a counterfactual environment (the *model with static return only*) in which I isolate the behavioral responses to

[16] This is similar to the settings in Athreya et al. (2014) and Blundell et al. (2016).

the EITC due to the *static* return to highlight the role of the *dynamic return*.

Recursive form of the retiree's ($j \geq J_R$) problem is,

$$V_j(a, n, e) = \max_{c, a'} \log c + \beta \phi_{j+1} V_{j+1}(a', n, e) \tag{1.11}$$

subject to

$$(1 + \tau_c)c + a' = \xi(n, e) + bp + (1 - \tau_k)ra + a \tag{1.12}$$

$$a' \geq 0, \quad c \geq 0, \tag{1.13}$$

where pension benefits ξ and basic pension bp are as described in Sections 1.2.2 and 1.2.3. Retirees only decide how much to consume and save in each period while facing only mortality risks. Notice that z has been removed from the individual state variables, and the state variables related to pension income, n and e, no longer change over time.

The important departure of my model from the previous structural analysis of the tax credit is that it embeds the linkage between one's labor market history, n and e, and pension income ξ in retirement. With this pension tax-benefit link, the EITC potentially has a spillover effect on pension income through its impact on labor supply. Moreover, the magnitude of the labor supply response to the tax credit would also change due to the *dynamic return* on labor supply.

In this environment, individuals make savings decisions to smooth consumption over the idiosyncratic labor productivity state and over the life cycle.

1.3 Calibration

This section describes the calibration of the benchmark model economy. The benchmark economy features general equilibrium so that factor prices and tax rates are determined in equilibrium by market clearing conditions and balanced budget conditions. I calibrate this general equilibrium economy to the data, but the equilibrium variables are held fixed when conducting counterfactual analyses. Therefore, further details of the model regarding general equilibrium are left in Appendix B.

1.3.1 Demographics and preferences

The mandatory retirement age and the maximum age are set to 66 and 100, respectively. Conditional survival probability by age $\{\phi_j\}_{j=2}^{J}$ (upon survival at age $j-1$) is constructed from the Life Table (2015) by Statistics Korea. Figure 1.2 depicts the survival probabilities, which shows that the mortality risk is pronounced in retirement periods. Age-dependent fixed utility cost of work $\{\nu_j\}_{j=1}^{J_R-1}$ is calibrated to match the employment rate by age in the data, using the power function: $\nu_1 + \nu_2 \cdot j^{\nu_3}$.[17,18] Discount rate β is set to match the annual real interest rate of 4%.

1.3.2 Endowments

The initial wealth $a_{j=1}$ is calibrated to match, together with the age-dependent utility cost of work, the employment rate at age 25. The cal-

[17] Employment rates are computed using the Economically Active Population Survey data from Statistics Korea. I use 2015–2019 data and compute the average employment rate by age during this period.

[18] The calibrated age profile of fixed cost of work is presented in Figure A1 in Appendix B.

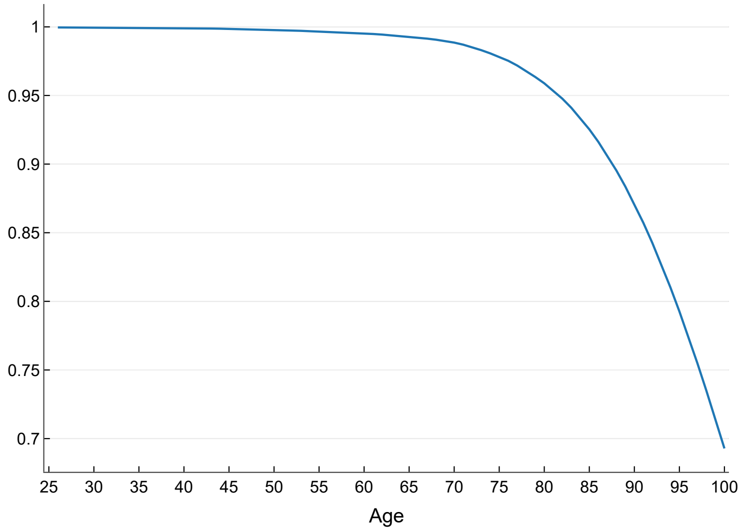


Figure 1.2: Conditional survival probability by age ϕ_j
Source: Life Table (2015)

ibrated initial wealth is 6 million KRW which is about one-third of the mean earnings at age 25.[19] The age-specific component of labor productivity $\{\epsilon_j\}_{j=1}^{J_R-1}$ is estimated using the Survey of Household Finances and Living Conditions (SHFLC, henceforth) data. The advantage of the SHFLC is that the surveyed information on labor earnings is complemented by administrative data, which allows me to precisely estimate the age-earnings profile. I regress the log of annual labor earnings to age and age squared, then take an exponential to the estimated polynomial function and normalize the productivity at age 25 by one. The result is illustrated in Figure 1.3, which shows the standard hump-shaped age profile peaking around the mid-forties.

The persistence ρ_z and the variance σ_z^2 of the AR(1) process for idiosyncratic productivity, described in eq. (1.10), are set to 0.773 and 0.04, re-

[19] cf. Huggett and Kaplan (2016)

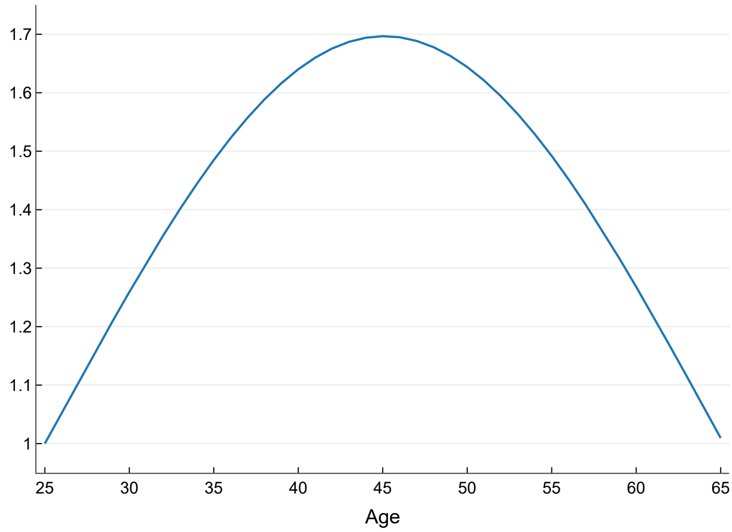


Figure 1.3: Age productivity profile ϵ_j
Source: SHFLC, 2019

spectively. The values are taken from Han et al. (2019).[20,21] The stochastic process is approximated into a 27-state Markov chain following Tauchen (1986). Also, the logarithm of initial productivity $z_{j=1}$ is drawn from the normal distribution with mean 0 and variance $\sigma_z^2/(1-\rho_z^2)$.

1.3.3 Tax and transfer

Parameters for the EITC are constructed from the National Tax Service of Korea. Figure 1.1 graphically illustrates the tax credit schedule for families with a single earner. Those with (positive) annual labor earnings below 30 million KRW($\approx$ 30,000 USD) and asset holdings lower than 200

[20] They develop a large-scale heterogeneous-agent overlapping-generations model, in which agents differ by sex and marital status and have both extensive and intensive margin labor supply choice, to assess the macroeconomic impact of the EITC reform in Korea. They estimate the persistence of the AR(1) process from a Korean household panel data and find variance that matches income Gini in the data.

[21] The values are also similar to the estimates in Chang and Kim (2006).

Parameter	Value	Description	Target/source
Demographics			
J_R	42	retirement age	66 years old
J	76	maximum age	100 years old
$\{\phi_j\}_{j=2}^{J}$	-	survival probability by age	Life Table (2015)
Preference			
$\{\nu_j\}_{j=1}^{J_R-1}$	-	disutility of work by age	employment rate by age
β	0.9767	discount rate	$r = 4\%$
Labor Productivity			
$\{\epsilon_j\}_{j=1}^{J_R-1}$	-	average productivity by age	estimated
ρ_z	0.773	persistence of shock	Han et al. (2019)
σ_z^2	0.04	variance of shock	Han et al. (2019)
Initial conditions			
$a_{j=1}$	0.06	initial asset holdings	employment rate ($j = 1$)
$\sigma_{z_{j=1}}^2$	0.10	variance of initial productivity	$\sigma_z^2/(1-\rho_z^2)$

Table 1.1: Parameter values for economic environment

million KRW are eligible for the tax credit up to a maximum of 2.6 million KRW.[22]

To incorporate the progressivity in the labor income tax schedule into the model, I adopt the functional form used in Heathcote et al. (2017) as in eq. (1.14). The parameter τ_l that governs the progressivity of the tax function is then estimated using the SHFLC data, which provides income tax data complemented by administrative data. The estimation result is presented in Table A1 in the appendix. The estimate for τ_l is 0.02, which is quite low compared to the literature. This is primarily because my measure of progressivity is for pure tax components, excluding transfer components that make the tax-transfer system substantially progressive. Also, the progressivity of income tax in Korea is known to be quite lower than

[22] Hereafter, KRW is used to denote the Korean Won and USD denotes the US Dollar. For simplicity, I use the exchange rate of 1,000 KRW = 1 USD, which is close to the historical average.

that of other countries (Chang et al., 2018). The average rate component of the labor income tax schedule, λ_l, is then calibrated to match the ratio of the income tax revenue to GDP.

$$T(y) = \max\{0, y - \lambda_l \cdot y^{1-\tau_l}\} \tag{1.14}$$

Welfare benefits for the non-employed, Ω, is set to the average difference in public transfer income between workers and non-workers. Using the SHFLC data, I estimate Ω by regressing public transfer income (net of the tax credit) on a dummy for those who earned less than 5 million KRW($\approx$ 5,000 USD) with controls for various socio-demographic factors that could affect eligibility conditions and the benefit amount, such as marital status, number of household members, and housing conditions. The regression result is presented in Table A2 in the appendix. The lump-sum transfer to the working-age individual, tr, is then set to match, together with Ω, total welfare expenditure over GDP. As a result, Ω and tr are set to 3.9 million KRW and 2.6 million KRW, respectively. The basic pension bp is set to match the basic pension expenditure as a percentage of GDP.

1.3.4 Public pension

Finally, the contribution rate of the public pension system τ_p is set to 12.9%, which satisfies the government pension budget as eq. (IB.4) in Appendix B.2. The maximum taxable earnings $\bar{y}$ is determined by multiplying the current system's maximum taxable monthly earnings (4.9 million KRW $\approx$ 4,900 USD) by 12. The economy-wide average taxable earnings E is determined in equilibrium of the benchmark economy, as described in

Parameter	Value	Description	Target/source
EITC			
β_{in}	0.37143	phase-in, slope	NTS, 2019
$\bar{\psi}$	0.026	maximum tax credit	NTS, 2019
α_{out}	0.04875	phase-out, intercept	NTS, 2019
β_{out}	0.16250	phase-out, slope	NTS, 2019
$\{\bar{a_1}, \bar{a_2}\}$	{1.4, 2.0}	asset holdings thresholds	NTS, 2019
Tax and Transfer			
τ_c	10%	consumption tax rate	VAT
τ_k	30%	capital tax rate	literature
τ_l	0.02	progressivity of income tax	estimated
λ_l	0.913	scale parameter of income tax	$T_l/Y = 4.6\%$
Ω	0.039	transfer to non-employed	estimated
tr	0.026	lump-sum transfer	$Welfare/Y = 7.4\%$
bp	0.012	basic pension	$BP/Y = 0.8\%$
Public Pension			
τ_p	12.9%	contribution rate	balanced budget
$\bar{y}$	0.5880	maximum taxable earnings	current system
E	0.4146	economy-wide average earnings	in equilibrium
κ	0.005	scale parameter (replacement rate)	current system

Table 1.2: Parameter values for government policy

eq. (IB.5) in Appendix B.2. The scale parameter κ is set to 0.005, which achieves the replacement rate of 40% for retirees whose career average earnings are equal to the economy-wide average and whose contribution period is 40 years, as in the current system in Korea.[23,24]

1.3.5 Model fit

The calibrated economy successfully replicates some salient features in the data. For the targeted moments, the employment rate by age generated

[23] One can easily see that $\xi(n = 40, e = E) = 0.4E$ or $\frac{\xi(n=40,e=E)}{e} = 0.4$ when $\kappa = 0.005$ from eq. (1.3).

[24] To be precise, the scale parameter κ is under reform so that the average replacement rate gradually goes down to 40% in 2028 (from 50% in 2008). Since the purpose of this study is to analyze the long-term effect of the EITC under a stable public pension system, the average replacement rate is assumed to be constant at 40%.

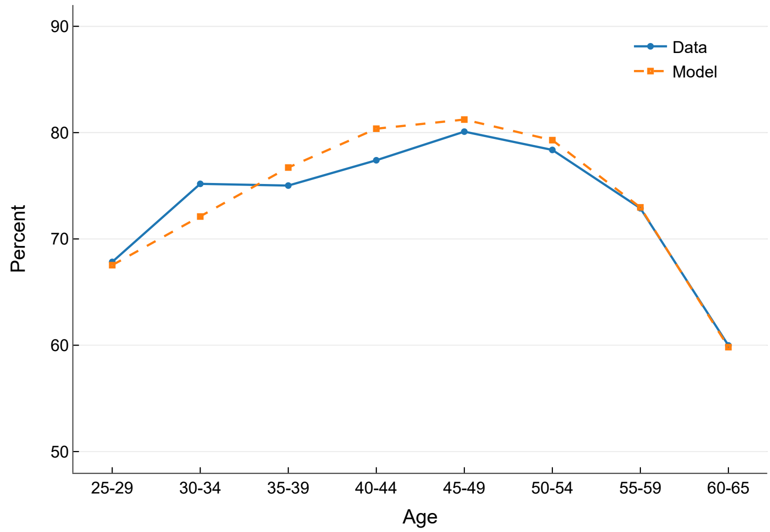


Figure 1.4: Employment rate by age
Source: Economically Active Population Survey, 2015–2019

	Income Tax	Capital Tax	Cons. Tax	Welfare Benefits	Basic Pension
Data	4.6%	4.1%	4.0%	7.4%	0.8%
Model	4.6%	3.6%	6.5%	7.4%	0.8%

Note: Data refers to 2016–2019 economy.
Source: OECD database, Ministry of Health and Welfare.

Table 1.3: Government budget relative to GDP

by the model well matches the data, which shows a hump-shaped profile (see Figure 1.4). Also, the size of tax revenues and expenditures compared to GDP is quite similar to the data (see Table 1.3).

For the moments that are not targeted in the calibration process, the distribution of income and wealth is replicated quite well by the model economy (rows (1) and (2) in Table 1.4). The calibrated model also successfully generates the moments related to the EITC (rows (3), (4), and (5) in Table 1.4). The expenditure for the EITC is about 0.2% of GDP, both in the model and the data. In the model economy, EITC recipients account for 11% of the working-age population, which is slightly higher than the data. The data shows that the recipiency rate is highest at ages below 40, decreases in the 40s and then increases at age 50 or above. Although the model economy overstates the recipiency rate at a younger age and understates it at middle age, the overall pattern is similar to the data. The average tax credit the recipient gets is 1.04 million KRW ($\approx$ 1,040 USD) in the data, and it is 0.80 million KRW in the model.

Lastly, how responsive is labor supply to financial incentives in the model economy? This question is crucial for the quantitative analysis because overstating the labor supply response to the EITC may bias the importance of the increase in pension benefits for the increase in lifetime income upward. For this sake, I compute the elasticity of labor supply to $\pm$ 1% changes in the wage rate while holding the wealth distribution (including the public pension wealth, n and e) fixed to the benchmark economy. The aggregate elasticity of labor supply at the participation (extensive) margin implied by the model is 0.72, which is roughly in line with the estimates in Moon and Song (2016). They estimate the labor supply elasticity in Korea using the methodology of Fiorito and Zanella (2012) and data from the Korean Labor and Income Panel Study. Their point estimate of the elasticity is 0.23 at the intensive margin (hours of those employed) and 0.93 at the total margin, which includes both the intensive and extensive margins.[25] Moreover, the model-implied aggregate elasticity at the

[25] Note, however, that the estimate for the latter is statistically insignificant, possibly due to the small sample size. Nonetheless, the finding that the elasticity at the total margin is much larger than the one at the intensive margin is consistent with Fiorito and Zanella (2012).

extensive margin is similar to those found in other structural studies such as Chang and Kim (2006) and Erosa et al. (2016). Furthermore, the elasticity exhibits a U-shaped pattern over the life cycle and is highest near retirement (see Figure 1.5), which has also been found in other structural life-cycle analyses (Rogerson and Wallenius, 2009; Erosa et al., 2016; Fan et al., 2022).[26]

The observations so far show that the calibrated model economy is well suited to analyze the EITC's impacts on labor supply and income.

			Data	Model
(1)	Disposable income Gini		0.339	0.321
(2)	Wealth share (%)	Q1	0.5	0.8
		Q2	5.1	5.2
		Q3	11.5	14.2
		Q4	21.4	27.0
		Q5	61.5	52.8
(3)	EITC to GDP ratio (%)		0.20	0.19
(4)	EITC recipiency rate (%)		10.4	11.4
	by age group	$<$40	12.7	16.0
		40–49	7.5	3.6
		$\geq$50	9.8	11.2
(5)	Average EITC (million KRW)		1.04	0.80

Note: Data refers to 2019 economy. Data for the EITC expenditure is computed based on recipients aged 69 or below to be consistent with the model. The expenditure for those aged 66–69 is included because the relevant information in administrative data from the National Tax Service is provided based on a 10-year-old basis. Similarly, data for the EITC recipiency rate is computed based on recipients aged 69 or below, the data for ages below 40 is based on those aged 20–39, and the data for ages 50 or above is for those aged 50–69.
Source: National Tax Service 2019, Statistics Korea 2019, SHFLC 2019–2020.

Table 1.4: Untargeted moments

[26] Keane (2022) provides a review of recent research on labor supply, including labor supply elasticity at the extensive margin in the aggregate and by age.

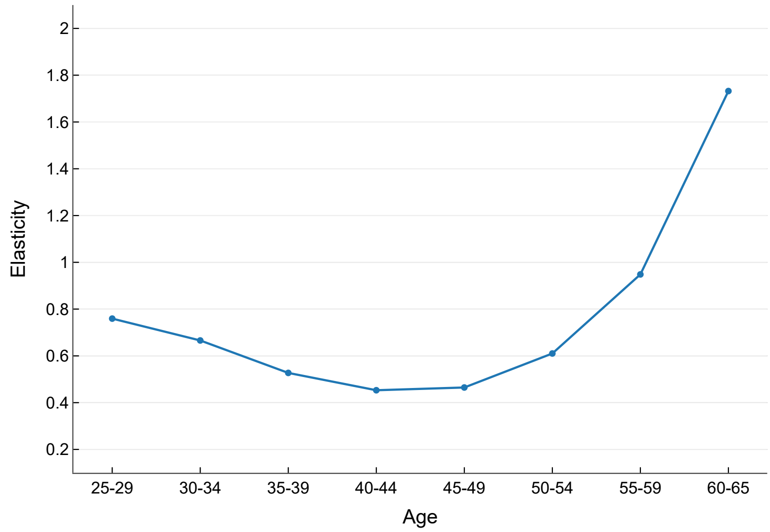


Figure 1.5: Labor supply elasticity by age

1.4 Quantitative analysis

In this section, I start by showing the effects of the EITC by removing the existing program from the benchmark economy and comparing the two steady-states: one with the EITC and one without the EITC. This allows me to describe how the tax credit policy affects labor supply over the life cycle and the consequent impacts on earnings and pension income.

Then I do the same exercise (EITC vs. NO EITC) while shutting down the pension tax-benefit link for EITC-eligible (sufficiently low earnings and wealth) employment. In this environment with the counterfactual public pension system, EITC-eligible employment does not affect the state variables regarding pension benefits (n and e). Henceforth, I will call the model with the benchmark public pension system the *full model* and the one with the counterfactual pension system the *model with static return only*.

By comparing the two results—with and without *dynamic return* through the pension tax benefit link—I can identify the role of the contribution-benefit link in the EITC's impacts on lifetime income and welfare.

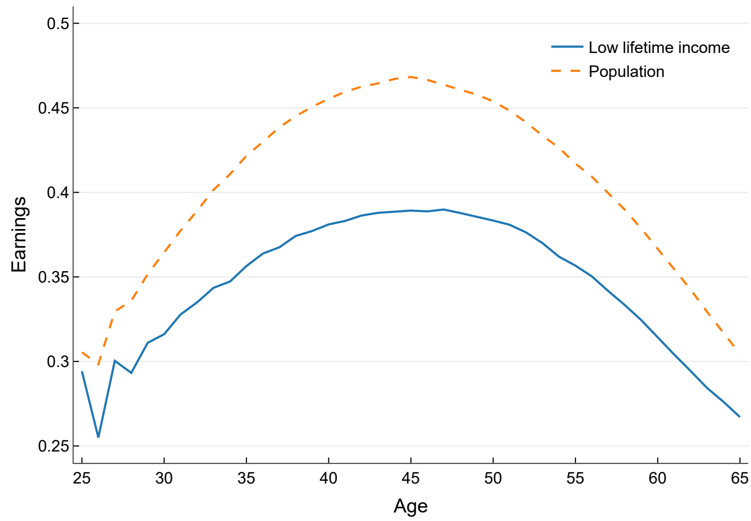
Throughout the analysis, I proceed in partial equilibrium, in which wages, interest rates, and tax rates are held fixed to the benchmark economy. This setting is consistent with the previous studies, thus allowing me to concentrate on the role of the pension tax-benefit link in the direct effect of the tax credit policy.

1.4.1 Who is mainly affected?

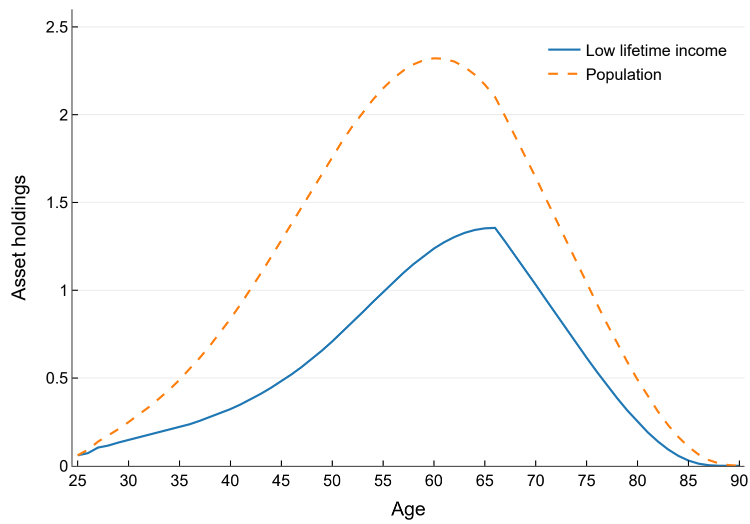
Before jumping into the analysis, it is necessary to determine the target population—mainly affected by the tax credit over the life cycle—because I will focus on the direct effect of the EITC, and the model encompasses the entire population of the economy. A natural candidate for the target group is newborns with unfavorable labor productivity histories: their lifetime earnings and wealth would be low and thus likely to satisfy the earnings test and asset test of the tax credit over their lives.

From now on, I define *low lifetime income* as newborns whose present value of lifetime disposable income belongs to the lowest 30% in the calibrated economy.[27] Figure 1.6 compares the median age profile of earnings (conditional on employment) and wealth for the low lifetime income group with those of the population. As can be seen from the figures, the low lifetime income group's median earnings and wealth are consistently lower than those of the population over the life cycle. This result suggests

[27] The present value of lifetime income is computed as the sum of disposable income at each age discounted by after-tax asset return and survival probabilities.



(a) Labor earnings



(b) Asset holdings

Figure 1.6: Median earnings and assets by age for low lifetime income and population

that the chosen group is a plausible candidate for those mainly affected by the EITC.

The bar graph in Figure 1.7 displays the proportion of the low lifetime

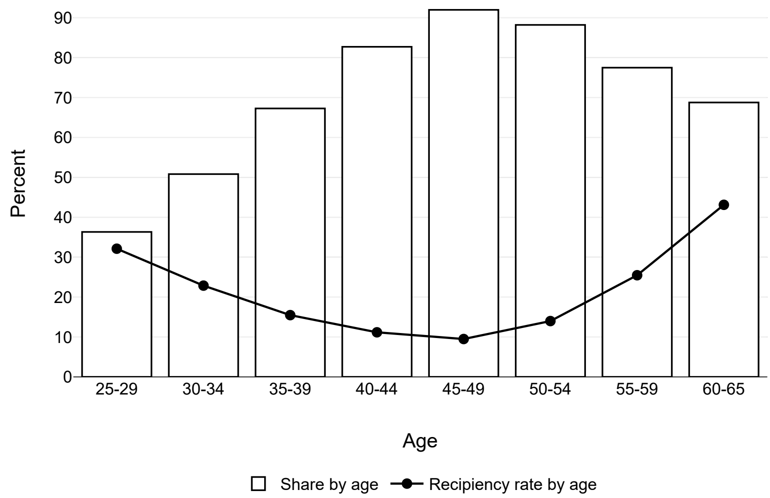


Figure 1.7: Low lifetime income's share of EITC recipients and recipiency rate by age

income group among the EITC recipients by each age group. As expected, the low lifetime income group accounts for the majority of the EITC recipients. The relatively low share at earlier ages is due to the model environment where every individual enters the economy with the same amount of low initial wealth and age-specific labor productivity is relatively low at earlier ages. Recall that the stochastic process for the idiosyncratic component of productivity is persistent, which implies that a high realization of productivity at an age likely results in high productivity the next year. Therefore, higher lifetime income groups earn more and accumulate more wealth over their lives, which makes them gradually ineligible for the EITC. That is why the low lifetime income group shares most of the recipients after the earlier stage in life. From now on, I will concentrate on the impact of the EITC on the *low lifetime income*.

1.4.2 Results with both static and dynamic returns

In this subsection, I contrast the economies with and without the EITC in the *full model* in which individuals understand both *static* and *dynamic* returns on labor supply when making decisions. In other words, individuals know that they can earn post-tax labor income as well as receive more pension benefits after retirement if they work today. I first examine the EITC's effects on labor supply during working life and show how it affects pension income after retirement. Then the impacts on lifetime income and the importance of the changes in each source of income are analyzed. Note that all the results below show the *average effects on the low lifetime income group*.

Effects on labor supply

	Before retirement	By age 25–39	40–49	50–65
Environment	Unit: percentage points			
Full model, (a)	2.08	1.91	0.53	3.22
Static return only, (b)	1.43	1.82	0.24	1.81
Difference, (a)−(b)	0.65	0.09	0.29	1.41
	(100%)	(5%)	(11%)	(84%)
Share, [(a)−(b)]/(a)	31%	5%	55%	44%

Note: The first two rows report the changes in percentage points on average during each life phase compared to the economy without the EITC in each environment. In the *full model*, the pension tax-benefit link is fully active so that there are both static and dynamic returns on the employment response. In the environment with *static return only*, the pension tax-benefit link is active only for EITC-ineligible employment. The third row shows the differences between the employment changes in the two models. The following parentheses show the contributions of the differences at each stage of life to the total difference. The last row shows the shares of the differences between the two models in the results in the *full model*.

Table 1.5: Changes in the employment rate

The first row in Table 1.5 reports the changes in the employment rate compared to the economy without the EITC in the *full model*. The results are presented for the whole working life and by age. It first shows that the employment rate of the low lifetime income group goes up by 2.1 percentage points in the *full model*.[28] This result coincides with previous empirical studies that found the positive impact of the tax credit policy on the target individual's labor market participation (Eissa and Liebman, 1996; Meyer and Rosenbaum, 2001; Francesconi and Van der Klaauw, 2007; Sánchez-Mangas and Sánchez-Marcos, 2008; Francesconi et al., 2009; Azmat and González, 2010; Laun, 2017).

Interestingly, the labor supply response to the EITC varies by age. The (annual) employment rate goes up the most during the 50s and 60s, by more than 3 percentage points on average, while it increases by about 2 percentage points at ages below 40 and by only 0.5 percentage points during the 40s. This pattern of the labor supply response by age is in line with the empirical findings of Park and Lee (2018). They exploit the introduction and subsequent expansions of the EITC in Korea to estimate its impact on labor market participation.[29] One of the main findings of Park and Lee (2018) is that the labor supply response of those aged 60–65 is substantially larger than the average, which supports what I find using

[28] The aggregate employment rate goes by 0.99 percentage points.

[29] Specifically, they use a linear probability model of labor market participation and exploit individual variations in EITC eligibility (except for the condition of positive earnings below some limit) over time caused by the policy reforms. For example, all singles were ineligible for the tax credit until 2012; however, from 2013, singles aged 60 or older can receive tax credits if they meet the other requirements. The authors use various household panel data sets from Korea, empirical specifications, and sample periods for the estimation. Note that singles with an age below 40 were not eligible for the EITC during the sample period they used.

the structural model.[30]

One of the advantages of the structural approach is that it can provide a possible mechanism for such results. There are two reasons for the differential labor supply response to the EITC by age. First, the recipiency rate is high at younger and older ages, as shown in the solid line in Figure 1.7. In other words, the labor supply response is large at those ages because there are many potential recipients. The U-shaped age profile of the recipiency rate stems from the hump-shaped age earnings profile, as in Figure 1.6a, and the earnings test of the EITC (see Figure 1.1). Note, however, that the labor supply near retirement is the most responsive even after controlling for the recipiency rate. This is due to the large labor supply elasticity near retirement as shown in Figure 1.5, which is also consistent with many other structural life-cycle analyses (e.g., French, 2005; Erosa et al., 2016; Fan et al., 2022). In other words, even if the financial incentive works similarly, the responsiveness of the labor supply is substantially larger near retirement. This is because the young worker is more sticky to the labor market than the old. When they are young, individuals do not have enough wealth to smooth their consumption over the life cycle and self-insure against labor market risks, making them work to earn income even without the EITC. In contrast, those near retirement age have some wealth (both financial and public pension) to finance their current and retirement consumption and will soon no longer face labor market risks. Therefore, the EITC recipients near retirement age are more likely to work because of the tax credit than the young recipients.

[30] Relevantly, Laun (2017) finds that the Swedish tax credit reform for workers aged 65 or over increased their labor market participation.

Effects on pension income

	EITC		Change (%)
	without	with	
Contribution periods (years)	29.66	30.52	0.85 (2.9%)
Career average earnings (million KRW)	36.07	35.55	−0.52 (−1.4%)
Pension income (million KRW)	11.50	11.75	0.25 (2.2%)

Note: The units for contribution periods are years, and the units for career average earnings and pension income are million KRW (≈ thousand USD). Contribution periods and career average earnings are as of age 66. Parentheses report proportional changes.

Table 1.6: Effects on pension income

So far, I have confirmed the previous findings that the EITC induces an increase in the labor market participation of its target population. I now take a step further and examine how the labor supply response to the EITC *before retirement* affects pension income *after retirement* through the contribution-benefit link of public pensions. First, due to the increased labor market participation during working life, lifetime earnings and pension contributions go up by 1.4%. How are pension benefits, then, affected by the rise in pension contributions?

Recall that pension benefits are increasing in contribution periods and career average earnings in the National Pension System of Korea (see eq. (1.3)). Table 1.6 reports contribution periods, career average earnings, and pension income—all as of retirement age on average—in the economies with and without the EITC. The last column of the table shows the differences between the two economies. First, due to labor supply responses during working age, contribution periods increase by 0.85 years (2.9%) on average (from 29.66 to 30.52 years).[31] This increase in contribution peri-

[31] Notice that one period in the model corresponds to one year, so individuals can choose to work one or two (or more) more years over their lives in response to the in-

ods would raise pension income by 0.33 million KRW, assuming average earnings over the contribution period remain unchanged. However, career average earnings slightly go down, which mitigates the rise in pension income. The decrease in career average earnings is because the EITC-induced labor market participation mainly occurs at a lower productivity age. As a result, the annual pension income increases by 0.25 million KRW (2.2%).

Considering the average tax credit that the recipient of the low lifetime income group receives is 0.85 million KRW, the spillover effect on pension income is substantial. The increase in annual pension income is about 30% of it. This result indicates that ignoring the long-term impact on pension income might considerably underestimate the EITC's effect on lifetime income.

Effects on lifetime income

Finally, I examine how the EITC affects lifetime income and decompose the contribution of each income source. The first row in Table 1.7 shows the overall amount of tax credits received over the life cycle. The second to fourth rows in the table report the level changes in lifetime post-tax earnings, lifetime pension income, and the sum of the three incomes (lifetime labor-related income). Note that survival probabilities are taken into account when computing the lifetime values.

The left column of the table reads as follows. First, the low lifetime income group receives 7.5 million KRW of tax credits over their lives. Due to

troduction of the tax credit, and that I examine the average response of the low lifetime income group. Therefore, a 0.85 years increment in contribution periods means that the low lifetime income group works 0.85 more years *on average*.

	Environment	
	Full model	Static return only
	Unit: million KRW	
Tax credit	7.45	4.41
Post-tax earnings	8.52	6.04
Pension income	4.55	−0.45
Labor-related income	20.52	10.00

Note: Changes in levels compared to the economy without the EITC. The units for incomes and taxes are million KRW (≈ thousand USD). Post-tax earnings are computed as labor earnings plus other means-tested transfers minus taxes on earnings. Lifetime labor-related income is the sum of the three income sources. Lifetime incomes are discounted by survival probabilities. In the *full model*, the pension tax-benefit link is fully active so that there are both static and dynamic returns on the employment response. In the environment with *static return only*, the pension tax-benefit link is active only for EITC-ineligible employment.

Table 1.7: Effects on lifetime incomes

the employment response to the EITC, their lifetime post-tax earnings go up by 8.5 million KRW, which is 14% larger than the receipts of tax credits. Notice that the post-tax earnings is labor earnings plus other means-tested transfers minus taxes on earnings. The increase in post-tax earnings accounts for more than half of the increase in lifetime income. This result confirms the main message of Hoynes and Patel (2018) in a life-cycle context. Furthermore, lifetime pension income goes up by 4.6 million KRW, which amounts to 60% of the lifetime receipts of the tax credit. The increase in lifetime pension benefits accounts for more than *one-fifth* of the increase in lifetime (labor-related) income.

1.4.3 Role of dynamic return through the pension tax-benefit link

The previous subsection shows that the spillover effect of the EITC on pension income is quantitatively sizable by comparing the economies with and without the EITC in the *full model* in which the pension tax-benefit link is fully active. In that environment, individuals understand all the returns on their *current* labor supply—the *current* post-tax earnings and the *future* increase in pension benefits—when adjusting their labor supply and savings in response to the EITC. According to the empirical evidence of Liebman and Luttmer (2015), however, this may not be the case. From the randomized field experiment, they find that informational intervention about the marginal public pension benefits of labor supply induces labor market participation. Their findings show that people are not fully aware of the tax-benefit link of public pensions when making labor supply decisions. Considering such a salience problem of the pension tax-benefit link, providing potential EITC recipients with information to improve their understanding of marginal pension benefits of labor supply may amplify the EITC's effects on labor supply and income. In this last subsection, I isolate the behavioral responses to the EITC due to the *dynamic return* on labor supply through the contribution-benefit link to estimate the value of such an informational intervention.

To this end, I consider a counterfactual public pension system in which the contribution-benefit link is shut down only for EITC-eligible employment while keeping all the structural parameters fixed to the calibrated economy. Specifically, the constraints (1.8) and (1.9) on the working-age individual's maximization problem (1.4) are changed as follows:

$$n' = n + h \cdot I(\psi = 0) \tag{1.8'}$$

$$e' = \frac{e \cdot n + \min\{y, \bar{y}\} \cdot I(\psi = 0)}{n'}, \tag{1.9'}$$

where $I(\psi = 0)$ is an indicator function with a value of 1 if an individual does not receive the tax credit ($\psi = 0$) or 0 otherwise, and the indicator function is the only difference. In this *model with static return only*, EITC-eligible labor market participation—sufficiently low earnings and asset holdings—does not affect contribution periods n, career average earnings e, and hence the pension benefits ξ. In other words, pension contributions during EITC-eligible employment are pure taxes. Then, in this environment, I remove the EITC and compare the two steady-states (EITC vs. NO EITC). The results from the *model with static return only* capture the behavioral responses to the EITC due to the *static* return only. Finally, I contrast the EITC's effects with and without the *dynamic return* (*full model* vs. *static-return-only model*) to shed light on its importance for the *long-term* impacts of the EITC.

Labor supply

How does the *dynamic return* through the pension tax-benefit link affect the labor supply response to the EITC? The second row of Table 1.5 reports the employment responses to the EITC in the *model with static return only*, and the third row shows the difference between the results from the two environments. As can be seen, the overall increase in the employment rate due to the EITC is 0.65 percentage points smaller in the *model with* *static return only*. The last row shows that this difference accounts for *one-third* of the labor supply response in the *full model*. The result shows that the *dynamic return* through the pension tax-benefit link is crucial for the employment effects of the EITC.

When we further look at how the labor supply response due to the *future return* varies with age, it increases with age and is substantially large at near retirement. The second to fourth columns in the third row of Table 1.5 show the differences between the employment responses in the two models by age group. The difference between the employment responses from the two models is 0.1 percentage points among the young, 0.3 percentage points at middle age, and 1.4 percentage points near retirement. The following parentheses show that more than 80% of the lifetime employment response due to the *dynamic return* occurs between 50 and 65 years old.[32]

Why does the labor supply response to the EITC, especially near retirement, become so large with the *dynamic return*? To answer this question, let me compare the *static* and the *dynamic returns* on the labor supply response. To compute the *static return*, consider an individual at a certain age who works with the EITC but does not work without the EITC in the *static-return-only* environment. Then, his labor supply response would be due to the *static return* on labor supply—post-tax labor earnings. Next, to compute the *dynamic return* on the labor supply response, I first compute how much his pension income at retirement age will increase due to the labor supply response at each age.[33] The *dynamic return* is the sum of the

[32] The contribution of the employment response (due to the *dynamic return*) between 50 and 65 to the lifetime response can be computed as $(1.41 \times \frac{16}{41})/0.65$.

[33] Specifically, I calculate the difference between the same individual's actual pension

	Before retirement	By age		
		25–39	40–49	50–65
	Unit: million KRW			
Static return, (a)	14.54	14.37	14.88	14.48
Dynamic return, (b)	2.65	1.72	2.46	3.65
Share of (b), (b)/[(a)+(b)]	15%	11%	15%	20%

Note: The static return is post-tax labor earnings due to the employment response to the EITC in the model with *static return only*. The *dynamic return* at each age is the sum of the present discounted value of the increment in pension income at each age in the retirement period due to the employment response. Discounting is done using after-tax real interest rates and survival probabilities. The average values during each life phase are reported in the first and second rows.

Table 1.8: Static and dynamic returns on the employment response

present discounted value of the increment in pension income at each age in the retirement period.

Table 1.8 reports the static and *dynamic* returns on the employment response, and the proportion of the *dynamic return* over the total return. The first column shows that the *future return* amounts to 15% of the total return on the lifetime employment response to the EITC. Furthermore, the size and share of the *future return* get larger with age. While the *dynamic return* shares 9% of the total return on average at age 25–39, it becomes 20% at age 50–65. This result is mainly because the increased pension income through the employment response is realized sooner as one gets closer to retirement and hence is less discounted. Therefore, if people do not fully understand the *dynamic* labor supply return through the pension tax-benefit link, as Liebman and Luttmer (2015) find, providing them with information about it could substantially enhance the EITC's labor supply

income at retirement age in the *full model* and his hypothetical pension income. The hypothetical pension income is what he would get during retirement if his earnings record at that age were subtracted from the actual contribution period and career average earnings at retirement age.

effects. Also, such an effect would be particularly large for those nearing retirement.

Lifetime income

Finally, due to the different degrees of labor supply responses to the EITC, how different are the increases in lifetime income due to the EITC with and without the *dynamic return*? The right column of Table 1.7 reports the changes in lifetime incomes in the environment with *static return only*. The second row of the table shows that an increase in lifetime (post-tax) labor earnings is substantially larger in the *full model* compared to the *static-return-only model*. The EITC increases lifetime earnings of the low lifetime income group by 6 million KRW in the *static-return-only model*, which is about two-thirds of the result in the *full model*. Together with more receipts of tax credits (the first row in the table), the increase in pre-retirement lifetime income is more than 50% larger in the *full model*. Thus, providing information about the contribution-benefit link to the potential EITC eligible could substantially enhance the EITC's impact on pre-retirement income by intensifying the labor supply response.

Combined with the spillover effect on pension income as analyzed in the previous subsection, the EITC's impact on lifetime income could be substantially larger through the *dynamic* labor supply return through the pension tax-benefit link. The fourth row of Table 1.7 shows that the increase in labor-related lifetime income due to the EITC in the *full model* is *twice* as much as in the *static-return-only model*.

1.5 Conclusion

This chapter examines the *long-term* impact of the EITC on labor supply and income over the life cycle and highlights the role of the tax-benefit link of public pensions. Through the marginal *future* public pension benefits of labor supply, (1) the labor supply response to the EITC during the working age also raises pension income in retirement, and (2) the labor supply and earnings responses to the EITC are amplified. Using the structural life-cycle model calibrated to the Korean economy, I show that the *dynamic* labor supply return is quantitatively crucial for the *benefit* of the EITC.

The results provide two fruitful policy implications: First, due to its spillover effect on pension income through the contribution-benefit link, the tax credit policy for the working age can also prevent elderly poverty *in advance*. Second, if the target household of the EITC is not well aware of the *dynamic* labor supply return due to the salience of the pension tax-benefit link (Liebman and Luttmer, 2015), informational intervention about it could substantially increase the EITC's impact on labor supply and earnings.

However, notice that the proportion of the employment response that is due to the *future return* is much larger than the proportion of the *future return* over the total return. While the employment response due to the *dynamic return* accounts for 31% of the overall response (see the last row in Table 1.5), the *dynamic return* itself explains 15% of the total financial return on the labor supply response (see the last row in Table 1.8). This means that the financial incentive alone cannot explain the large labor supply response in the *full model*. To fill this gap, it is crucial to understand how the *dynamic* labor supply return through the contribution-benefit link affects the consumption-savings response to the EITC. I will explore this issue in the next chapter.

Chapter 2

The Earned Income Tax Credit and the Tax-benefit Link of Public Pensions

Effects on Savings, Consumption, and Welfare

2.1 Introduction

In Chapter 1, I have shown that the *dynamic return* on labor supply through the pension tax-benefit link can play a crucial role in the employment response to the EITC. Due to the greater labor supply response as well as the spillover effect on pension income, the EITC's impact on lifetime income can be substantially amplified through the *dynamic return*. Then, how valuable is the increased income due to the EITC for the target household?

The key contribution of Athreya et al. (2014) and Blundell et al. (2016) is the finding that the tax credit does more than increase the level of income (and thus consumption) in the dynamic context. That is, it provides partial insurance against income risk. In other words, the tax credit provides an income top-up for the negative shock to future labor productivity, which enables the target population to reduce precautionary savings and enjoy more consumption. They find that the tax credit policy enhances the welfare of newborns with low lifetime income through this consumption insurance effect over the working periods of life without hampering labor supply incentives.[1,2]

With the *dynamic return*, the consumption insurance of the EITC can also be amplified. Because the labor supply response to the EITC increases pension income after retirement through the pension tax-benefit link, the target individuals can reduce their savings against retirement and consume more during their working age if they perceive such a *future return*. Therefore, the knowledge provision of the *dynamic return* can not only enhance the EITC's income-increasing effect by inducing a greater labor supply response but also amplify the consumption-smoothing effect of the EITC.

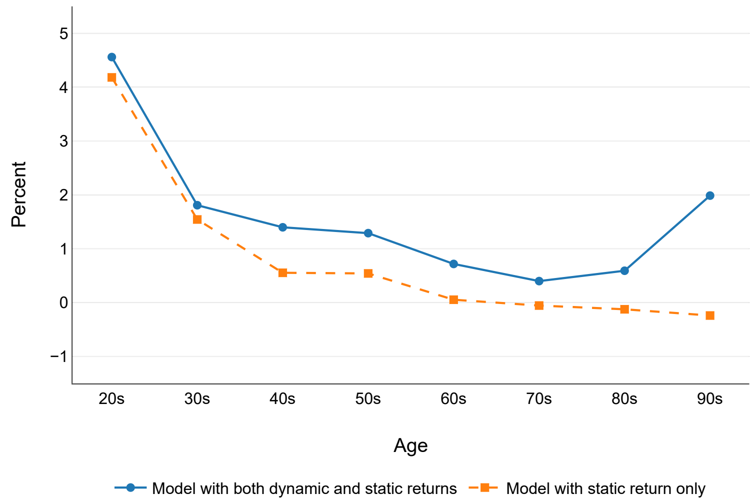
In this chapter, I quantitatively examine the impacts of the EITC on savings, consumption, and welfare and the role of the *dynamic* labor supply return through the pension tax-benefit link. Then its implication for the labor supply response is discussed.

2.2 Effects on consumption and savings

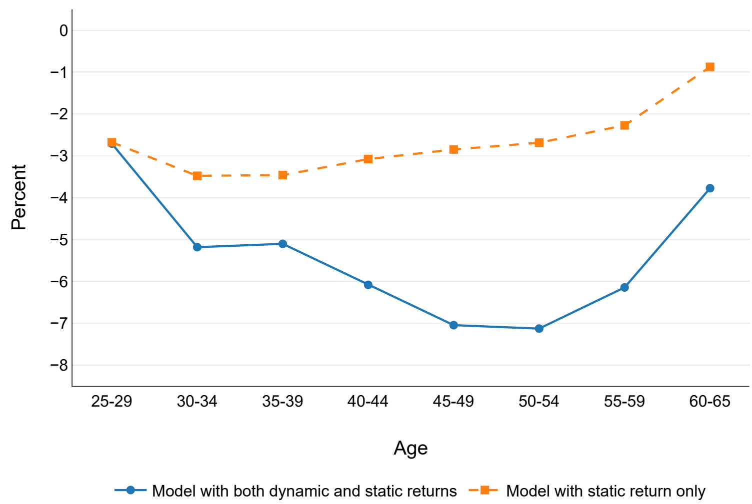
Figure 2.1 displays the proportional changes in consumption and (gross) savings in response to the EITC by age. The solid lines represent the re-

[1] Froemel and Gottlieb (2021) also find the consumption insurance effect of the EITC using a DSGE model with idiosyncratic labor productivity risks. However, their focus is on how the EITC affects the distribution of earnings and wealth through the behavioral response of labor supply and savings and the resulting change in the skill premium in general equilibrium.

[2] This point is one of the important things that makes Athreya et al. (2014) and Blundell et al. (2016) distinct from other studies on tax credit programs using dynamic structural models, such as Keane and Wolpin (2010) and Chan (2013). The life-cycle models of Keane and Wolpin (2010) and Chan (2013) are rich in that individuals make various decisions such as labor supply, educational attainment, fertility, marriage, or participation in multiple welfare programs. However, there are no savings decisions as in Athreya et al. (2014) or Blundell et al. (2016), so the models could not capture the consumption smoothing effect of the tax credit.



(a) Consumption, c



(b) Savings, a'

Figure 2.1: Effects on consumption and savings

sults from the *full model*, while the dashed lines show the results from the *model with static return only*.

2.2.1 Results with the static return only

Let me begin with the result from the setting with the *static return only*. As the dashed line in Figure 2.1a shows, in the *static-return-only* environment, the target household's consumption increases over their working lives due to the EITC. This result is, in part, due to the increased income—tax credits and an increase in earnings—which I have shown in the previous chapter. The other crucial force behind the rise in consumption is a decrease in savings. The dashed line in Figure 2.1b shows that the low lifetime income group reduces their (gross) savings over the life cycle in response to the EITC in the same environment. The decrease in savings is due to (partial) insurance the EITC provides against labor market risks. Since the EITC provides some income top-up against bad shocks to future labor productivity, the target population can reduce precautionary savings and enjoy more consumption. In other words, the EITC helps its target individuals better smooth their consumption over the states of nature. This result is consistent with the previous life-cycle analyses that do not take into account the pension tax-benefit link (Athreya et al., 2014; Blundell et al., 2016).

To make this argument more apparent, I also compare an increase in the present discounted value of lifetime consumption with that of disposable income. If the EITC provides such consumption insurance, the target individual's consumption would increase (by reducing their savings) before their income would increase due to the tax credit receipts. Therefore, an increase in the PV of lifetime consumption would be larger than that of income. Table 2.1 reports an increase in the PV of lifetime income and consumption due to the EITC, as well as their difference. As the right column of the table shows, an increase in the PV of lifetime consumption (5.91 million KRW) is 9% larger than that of disposable income (5.43 million KRW) in the *static-return-only model*, demonstrating the consumption-smoothing effect.

Then, when does the consumption smoothing occur over the life cycle? The dashed lines in Figure 2.1 shows that the decrease (increase) in savings (consumption) is the largest early in life and then gets smaller with age. This result implies that the EITC's insurance provision against labor market risks is most valuable when young and less so as one gets closer to retirement, which is in line with Gourinchas and Parker (2002). In their seminal paper, Gourinchas and Parker (2002) demonstrate that in an incomplete markets economy—like the one in this study—an individual's primary savings motive is different by age: while the dominant savings motive for young households is to accumulate buffer stock wealth against uninsurable income risks (the precautionary motive), the retirement motive becomes more crucial as one gets closer to retirement. Therefore, in the *static-return-only* environment, the EITC not only increases the lifetime consumption of the target household but makes their consumption profile smoother by allowing them to reduce precautionary savings and enjoy more consumption when young.

2.2.2 Role of the dynamic return

How are the consumption and savings responses to the EITC affected by the *dynamic return* through the contribution-benefit link? First of all, the solid line in Figure 2.1a shows that retirement consumption increases

	Environment	
	Full model	Static return only
Changes in PV of	Unit: million KRW	
Lifetime disposable income, (a)	8.01	5.43
Lifetime consumption, (b)	9.55	5.91
Consumption smoothing, (b)/(a)−1	19%	9%

Note: The first two rows report the changes in the present discounted value of lifetime income (consumption) for newborns with low lifetime income compared to the economy without the EITC for each environment. In the *full model*, the pension tax-benefit link is fully active so that there are both static and dynamic returns on the employment response. In the environment with *static return only*, the pension tax-benefit link is active only for EITC-ineligible employment. The units are million KRW (≈ thousand USD). Discounting is done using after-tax real interest rates and survival probabilities.

Table 2.1: Effects on consumption smoothing

due to the EITC in the *full model*, which does not happen in the *static-return-only model*. The reason for this result is relatively obvious: the labor supply response to the EITC increases pension benefits through the pension tax-benefit link only in the *full model*.

Furthermore, Figure 2.1a shows that the increase in pre-retirement consumption is larger in the *full model* compared to the *static-return-only* environment. Again, there are both income effect and insurance effect behind this result. First, the greater consumption response is partly because of a larger increase in income (income effect) due to a greater employment response in the *full model*, as shown in the previous chapter. In addition, notice that the target household reduces their savings even more in the presence of the *dynamic return*, as illustrated in Figure 2.1b. This result stems from the EITC's insurance provision against retirement through the pension tax-benefit link. Since the *dynamic return* is an increase in pension benefits, it provides some insurance against retirement. As a result, in the *full model*, the EITC's target individuals can reduce their savings against retirement (as well as against income risks) and consume more even before retirement, and the consumption smoothing effect becomes larger.

Table 2.1 makes it more obvious how the *dynamic return* amplifies the consumption smoothing effect of the EITC. The left column shows that an increase in the PV of lifetime consumption (9.55 million KRW) is 19% larger than that of disposable income (8.01 million KRW) in the *full model*. The result is much greater than the counterpart in the *static-return-only model* (9%), which implies that the EITC makes the consumption profile of the target household smoother with the *dynamic return* through the pension tax-benefit link.

It is worth noting that the difference between the solid line and the dashed line before retirement in Figure 2.1a is the most significant across the 40s and 60s. This result shows that the increase in consumption due to the *dynamic return* is similarly large across this life phase. This result may be odd considering most of the labor supply response attributable to the *dynamic return* comes from near retirement, not middle age.[3] The reason is as follows: Let us think about how newborn households adjust their consumption and savings responses to the EITC (compared to the *static-return-only* environment), given the increased employment response near retirement.[4] First, due to the consumption-smoothing motive, they may want to increase consumption not only near retirement but before

[3] See Table 1.5 and the discussions in Section 1.4.3 of Chapter 1 for the labor supply response due to the *dynamic return*.

[4] Recall that the counterfactual exercise here is to compare the EITC's long-term impacts over the life cycle in the two environments: the *static-return-only model* versus the *full model*. Therefore, the exercise shows how the change in the newborn household's allocation of consumption and savings over the life cycle due to the EITC is different in the two environments.

that age. Nearing retirement, they can consume more either by reducing retirement motive savings or through increased income because the employment response increases the most at this age. In middle age, however, they can increase consumption almost only by reducing retirement motive savings[5] since there is little room for employment to respond at that age because of the EITC's means-test and the hump-shaped age productivity profile. That is why the decrease in savings due to the *dynamic return* is the most significant in middle age (see Figure 2.1b), and the increase in consumption due to the *future return* is similar in the 40s and near retirement.

The findings in this section can be summarized as follows: (1) The EITC's (partial) insurance provision against labor market risks makes the target individual consume more early in life, and (2) its insurance against retirement through the pension tax-benefit link allows them to enjoy more consumption in middle age and near retirement as well as the retirement period. The second finding provides an important policy implication. Even if the *dynamic return* through the pension tax-benefit link plays a small role in inducing more labor supply responses in middle age, providing them with information about it could substantially enhance the consumption smoothing effect of the EITC. Therefore, it would be better for the information provisions to target the middle-aged as well as those nearing retirement.

[5] Another important finding of Gourinchas and Parker (2002) is that the transition of the primary savings motive between income uncertainty and retirement occurs during the 40s in an incomplete markets life-cycle economy.

2.2.3 Implication for the labor supply response

In the previous subsection, I described how the savings (and consumption) response to the EITC changes due to the *dynamic return*, given the greater labor supply response. However, notice that there could also be an adjustment in labor supply response because of the adjustment in savings response since labor supply and savings are joint decisions. In other words, it could be that some portion of the employment response due to the *dynamic return* occurs because of the greater decrease in savings.

Why? Recall that I am comparing how newborns' response to the EITC over the life cycle changes due to the *dynamic return*. This means that in the *full model*, individuals at any age know that their labor supply at any future age (before retirement) as well as at that age increases pension income. Therefore, if more employment response to the EITC during the rest of the working life is a better insurance tool against retirement than private savings, individuals would substitute the two.

Table 2.2 compares the pension contribution paid and the consequent increase in lifetime pension income due to the employment response to the EITC at each life phase.[6] Note that the increase in lifetime pension income is evaluated at each age of the employment response using after-tax real interest rates to compare with the return on private savings. The first row shows that the pension contribution paid is relatively stable at around 2.9 million KRW across the life cycle, which is because of the earnings test of the EITC. Second, the consequent increase in PV of lifetime pension

[6] To be consistent with Table 1.8 in Chapter 1, the employment response to the EITC in the *static-return-only model* is used to compute the pension contribution and the consequent increase in lifetime pension benefits.

income is similar to the pension contribution at an early stage in life but then increases with age.[7] As a result, the rate of return on the employment response from the public pension system is greater than 1 from middle age on and gets larger as one gets closer to retirement. This result shows that the employment response to the EITC from middle age on, especially near retirement, is better insurance for retirement than private savings, which indicates the possibility of the substitution between labor supply near retirement and private savings.

Then, what portion of the labor supply response due to the *dynamic return* is the substitution of private savings against retirement? Answering this question is crucial to filling the gap between the large employment response due to the *future return* and the size of the *future return* itself, as I have mentioned in the conclusion of the previous chapter.[8] To this end, I compute the changes in the employment rate due to the EITC in the *full model* and the *static-return-only model*, holding the distribution of wealth fixed to the EITC economy in each model.[9] This exercise shows the *short-run* labor supply responses to the EITC in the two models and thus captures the employment responses without savings adjustment in prior periods. The second column of Table 2.3 reports the *short-run* result, whereas the first column is the same as the second column of Table 1.5 and shows the *long-run* counterpart, in which the wealth distribution is allowed to

[7] For the reason why it increases with age, refer to Section 1.4.3 and Table 1.8 there in Chapter 1.

[8] Remind that while the labor supply response due to the *dynamic return* explains one-third of the overall response (see the last row in Table 1.5), the *future return* itself accounts for 15% of the total financial return on the employment response (see the last row in Table 1.8).

[9] The wealth includes asset holdings a, career average earnings e, and contribution period n.

	By age		
	25–39	40–49	50–65
	Unit: million KRW		
Pension contribution, (a)	2.90	2.99	2.92
PV of lifetime pension income, (b)	2.86	4.06	5.80
Rate of return, (b)/(a)	0.98	1.36	1.99

Note: The first row shows the pension contribution paid due to the employment response to the EITC in the model with *static return only*. The second row is the sum of the present discounted value of the increment in pension income at each age in the retirement period due to the employment response. Discounting is done using after-tax real interest rates. The average values during each life phase are reported.

Table 2.2: Rate of return on the employment response from public pension

vary. I report the result for ages 50–65 because most of the employment response due to the *future return* comes from this life phase, and the *future return* itself cannot alone account for it. In the *short run*, the employment rate increases by 2.32 percentage points in the *full model* and 1.61 percentage points in the *static-return-only model* due to the EITC. It implies that in the *short run*, 0.71 percentage points increase in the employment rate is due to the *dynamic return*. Notice that the result is only half of the *long-run* counterpart. This result shows that a substantial portion of the large employment response due to the *future return* I have shown in the previous chapter occurs in the *long run*, i.e., in conjunction with the adjustment in savings.

The results in this subsection thus imply that the impact of information provision about the pension tax-benefit link on the EITC's labor supply effects can be substantially larger in the *long run*.

	Age: 50-65		Difference
	Long-run	Short-run	
Environment	Unit: percentage point		
Full model	3.22	2.32	0.90
Static return only	1.81	1.61	0.20
Difference	1.41	0.71	0.70

Note: The long-run is the baseline result in which the distribution of asset holdings, career average earnings, and contribution period is allowed to vary when the EITC is removed. In the short run, the distribution of asset holdings, career average earnings, and contribution period is held fixed to the economy with the EITC in each environment. In the *full model*, the pension tax-benefit link is fully active so that there are both static and dynamic returns on the employment response. In the environment with *static return only*, the pension tax-benefit link is active only for EITC-ineligible employment.

Table 2.3: Comparison of the labor supply response near retirement: long-run and short-run

2.3 Effects on welfare

Finally, Table 2.4 shows the welfare consequences of the tax credit policy as measured by consumption equivalence. Consumption equivalence is computed as follows:

$$CEV = \exp\left[\{\sum_{j=1}^{J}\beta^{j-1}(\prod_{s=1}^{j}\phi_s)\}^{-1}(W^{TC} - W^{NOTC})\right] - 1, \tag{2.1}$$

where W^{TC} and W^{NOTC} represent the ex-ante lifetime expected discounted utility of a newborn (with low lifetime income) in the steady states of the economies with and without the EITC, respectively.

The first row of Table 2.4 is the result considering both the changes in the allocation of consumption and leisure over the life cycle, whereas the second row is the one considering the changes in the consumption profile only. The second row shows that ignoring the changes in the value of leisure, the existing EITC in Korea is equivalent to a 2.33% increase in per-period consumption for newborns with unfavorable productivity histories in the *full model*, whereas it is equivalent to a 1.78% increase in lifetime consumption in the *static-return-only model*. As a result, the *dynamic* labor supply return through the pension tax-benefit link explains *a quarter* of the consumption-component welfare effect of the EITC. As I have shown so far, the welfare effect of the EITC due to the *dynamic return* comes from three factors: (1) Retirement consumption goes up; (2) Pre-retirement consumption increases; and (3) the consumption profile is more smoothed (consumption smoothing effect).

	Environment	
	Full model	Static return only
Consumption equivalence (%)	0.73	0.54
Consumption component (%)	2.33	1.78

Note: Consumption component shows the welfare gain from the changes in consumption only. In the model with *full model*, the pension tax-benefit link is fully active so that there are both static and dynamic returns on the employment response. In the environment with *static return only*, the pension tax-benefit link is active only for EITC-ineligible employment.

Table 2.4: Effects on welfare

2.4 Discussion and conclusion

Despite the quantitatively significant role of the *dynamic return* I have shown so far, it would be better interpreted as an upper bound value, and its policy implications should be carefully interpreted for the following reasons.

2.4.1 No knowledge in reality?

First, note that the result captures the difference between the two extreme cases—one with perfect knowledge of the linkage and one with no knowledge about the pension tax-benefit link. In reality, however, the potential EITC recipients may have some sense of it, especially those nearing retirement. Relevantly, Liebman et al. (2009) find that the extensive margin labor supply near retirement responds to kinks in the US Social Security tax-benefit link. Also, the analysis does not provide the implications for how we can make potential EITC recipients fully understand the tax-benefit link as in the model.

Given the insolvency issue of the public pension system due to population aging, it could be that people do know but do not trust the pension tax-benefit link. If this is the case, the policy implications become quite different: what is important is not the informational intervention but the pension reform to stabilize the pension budget. More research on this issue is needed in the future.

2.4.2 Design of pension systems

Furthermore, while the contribution-benefit link is quite common across the public pension systems of many countries, how they are linked would be different across countries. Since the quantitative results in this chapter are based on the National Pension System in Korea, the magnitude may not be directly applied to other countries.

For example, pension benefits are increasing in contribution periods *linearly* in the National Pension System as described in the previous chapter. In the US Social Security, on the other hand, pension benefits are computed based on the average earnings of the best 35 years of earnings, so the marginal public pension benefits of labor market participation would be diminishing with contribution periods. Therefore, other things being equal, such as the replacement rate and progressivity, the *dynamic return* on labor supply through the pension tax-benefit link would be larger in Korea.

The design of means-tested old-age support programs is also important because it mitigates the increase in effective pension income due to labor market participation, making the marginal public pension benefit smaller. As described in Section 1.2.3, the means-test of the Basic Pension in Korea is quite generous, so such an effect would not be large, but this may not be the case for other countries.

2.4.3 Old age labor supply

To be consistent with the literature, I assume that individuals do not work at all after the mandatory retirement age in the model. However, the data shows that the employment rate of the elderly is not negligible: in Korea, the employment rate of those above 64 in 2019 was about 30%. This indicates that labor income could be an important source to finance old-age consumption. Considering this fact, the additional pension income could be less valuable in reality (than in the current setting), so the impact of the information provision about the pension tax-benefit link on the EITC's benefits could be smaller.

2.4.4 Part-time choice

One of the limitations of the model is that it does not allow for part-time choices that may affect the quantitative result. For example, if all the labor supply response to the EITC is labor market participation for a couple of months, the consequent increase in the contribution period and pension benefits would be smaller than what the model implies. However, it may also be the case that most of the employment responses are getting a part-time job and working for the whole year. In this case, the quantitative result do not change.

In this dissertation, I assume that all the EITC recipients pay pension contributions for 12 months, which encompasses the latter case, based on a Korean household panel data set. However, it is necessary to investigate more detailed characteristics of the labor supply response to the EITC in the future.

2.4.5 General equilibrium

I also do not consider the general equilibrium effect of the EITC to concentrate on its direct impacts or benefits, as in previous literature. However, the labor supply response to the EITC can reduce the equilibrium wage rate in general equilibrium—as some empirical studies have suggested (Rothstein, 2010), and tax rates also need to be increased to finance the spending for the EITC. Those indirect (or general equilibrium) effects mitigate the benefits of the EITC.

The *dynamic return* through the pension tax-benefit link amplifies such equilibrium effects because it intensifies the increase in labor supply and the decrease in savings in response to the EITC, reducing the marginal product of labor. Also, an increase in labor supply response means more spending for the EITC, which requires tax rates to rise further. In other words, the *dynamic return* amplifies not only the benefits but also the costs of the EITC. Therefore, the optimal design of the EITC should carefully take into account these forces.

2.4.6 Avenues for future research

Lastly, there are some interesting avenues for future research. First, it is important to examine how robust the importance of the *public pension channel* will be with increasing life expectancy. If people live longer, on the one hand, the *dynamic* labor supply return through the contribution-benefit link would become more valuable, strengthening the employment response to the EITC. On the other hand, increased life expectancy would induce cuts to pension benefits to balance the pension budget, lowering the *dynamic return*. Also, it would be interesting to compare the effects of the EITC on retirement income with those of the conventional old-age means-tested income support programs.

Chapter 3

Why were some EITC expansions in Korea less effective in inducing labor supply?

Role of heterogeneous labor supply elasticity by age

3.1 Introduction

The last chapter utilizes the quantitative life-cycle model developed above to provide an interpretation for the empirical result of Park and Lee (2018), which examines the labor supply effects of the EITC in Korea. One of the main findings of their work is that the estimate for the labor supply response to the EITC is substantially diminished and statistically insignificant if 2014–2016 is included in the sample periods.

The rest of this chapter is organized as follows: First, I provide an overview of the introduction and subsequent reforms of the EITC in Korea and briefly go over the empirical strategy and the results of Park and Lee (2018). Second, I test whether and how successfully the life-cycle model can replicate the results of Park and Lee (2018). Specifically, I run a regression using the identification strategy of Park and Lee (2018) and hypothetical panel data simulated from the structural life-cycle model and then compare the two results. Lastly, through the lens of the life-cycle model, I suggest a new perspective for the reason why such results could be derived.

3.2 The EITC in Korea and literature review

3.2.1 Institutional background

Year	Eligibility Conditions				Max. Credit[c]
	Housing	Gross Worth[a]	Household Type	Gross Income[b]	
2008∼2012	Renter or owner[d]	<100	Families	<13∼25	0.70∼2.00
2013	Renter or owner[d]	<100	Singles (age≥60)	<13	0.70
			Single-earner families	<21	1.70
			Dual-earner families	<25	2.10
2014	Renter or owner[e]	<140	Singles (age≥60)	<13	0.70
			Single-earner families	<21	1.70
			Dual-earner families	<25	2.10
2015	Renter or owner[e]	<140	Singles (age≥50)	<13	0.70
			Single-earner families	<21	1.70
			Dual-earner families	<25	2.10
2016	-	<140	Singles (age≥40)	<13	0.77
			Single-earner families	<21	1.85
			Dual-earner families	<25	2.30

[a,b,c] Unit: million KRW, [d] who owns only one house worth less than 60 million KRW, [e] who owns only one house

Table 3.1: Introduction and reforms of the EITC in Korea

Korea introduced the EITC program in 2008, which has been reformed almost every year until recently. Table 3.1 shows the eligibility conditions and the maximum amount of the EITC in Korea for each year between its inception in 2008 and 2016. The second to fourth columns of the table shows some selected eligibility conditions, such as household wealth and income.

Among the reforms during the given periods, three points are worth noting for the purpose of this chapter: First, only families were eligible for the EITC until 2012, and single households that are 60 years old or older became eligible in 2013. Second, singles in their 50s and 40s became eligible in 2015 and 2016, respectively. Third, the gross income limit and the maximum amount of tax credits almost did not change during the given periods.

3.2.2 Literature

Park and Lee (2018) estimate the labor supply effects of the EITC by exploiting the exogenous policy variations described above and using all available household panel data sets in Korea. Specifically, they estimate the following linear probability model:

$$Emp_{i,t} = \alpha + X_{i,t}\beta + \gamma Eligible_{i,t} + \delta_t + \epsilon_{i,t} \tag{3.1}$$

where $Emp_{i,t}$ is an indicator that has a value of 1 if an individual i in period t has positive earnings. $Eligible_{i,t}$ is another indicator with a value of 1 if an individual i in period t satisfies all the eligibility conditions except for the income limit. Note that the income limit is excluded when generating $Eligible_{i,t}$ due to the endogeneity issue. $X_{i,t}$ is the control that includes various demographic and economic characteristics of households, such as age, wealth, home ownership, gender, marriage, and education level. δ_t is a time dummy.

Park and Lee (2018) argue that the variable $Eligible_{i,t}$ they construct using the data is likely to be uncorrelated with $\epsilon_{i,t}$ because they include a rich set of controls in $X_{i,t}$ that can affect both $Emp_{i,t}$ and $Eligible_{i,t}$ such as age, wealth and home ownership. This means that the estimate for γ can be interpreted as the causal impact of the EITC on labor supply because it is likely that the estimate captures the average change in $Emp_{i,t}$ with respect to the exogenous variation in $Eligible_{i,t}$ due to the policy reforms.

One of the main contributions of Park and Lee (2018) is that they estimate eq. (3.1) using various household panel data, samples, and time periods. For the purpose of this chapter, a result worth noting is that the estimate for γ is substantially different by the sample periods. The last four columns of Table 3.2 are the estimates directly taken from Park and Lee (2018). It shows that the estimate for γ becomes considerably smaller and statistically insignificant when 2014–2016 is included in the sample period. The estimate using the KWPS (Korean Welfare Panel Study) data and the sample period of 2008–2013 shows that the employment rate of those who became $Eligible_{i,t} = 1$ during the period due to the policy reforms goes up by 4.4 percentage points. However, the estimate using the sample period including 2014–2016 is reduced to 0.7 percentage points increase and is statistically insignificant. The result is similar for the estimates using the SHFLC data or in another specification in which the eligibility fixed effects are added to the controls (see Table 3.3).

In their conclusion, Park and Lee (2018) suspect that the 2014 reform may have played an important role for this result. In 2014, (1) the recipients of the Basic Livelihood Security Program (BLSP) and (2) self-employed individuals became eligible for the EITC.[1] Park and Lee (2018) note that BLSP recipients are less likely to respond to the EITC's incentive because they are more likely to have a limited ability to work. In the case of self-employment, it is likely that starting a new business and making revenues

[1] Until 2012, those groups of people could not receive the tax credit even if they satisfied all the conditions, such as the income and asset limits.

will take some time, so the labor supply response to the EITC may not appear in the short run.

	Data: Simulated		Park & Lee (2018)'s estimates			
			Data: KWPS		Data: SHFLC	
	≤2013	≤2016	≤2013	≤2016	≤2013	≤2016
Eligible	0.053***	0.043***	0.044***	0.007	0.072***	0.016***
	(0.004)	(0.001)	(0.014)	(0.010)	(0.011)	(0.005)
Obs.	4,100,000	10,250,000	33,931	43,879	26,887	56,262
R^2	0.054	0.055	0.109	0.131	0.102	0.179

Note: Regression results using the simulated data from the *static-return-only model* are presented in the first two columns. Age, age squared, assets, and assets squared are included as controls. The last four columns are the estimates from Park and Lee (2018) using the Korean Welfare Panel Study (KWPS) and Survey of Household Finances and Living Conditions (SHFLC) data. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 3.2: Comparison with Park and Lee (2018), Baseline Regression

	Data: Simulated		Park & Lee (2018)'s estimates			
			Data: KWPS		Data: SHFLC	
	≤2013	≤2016	≤2013	≤2016	≤2013	≤2016
Eligible	0.062***	0.040***	0.056***	0.012*	0.106***	0.025***
	(0.004)	(0.001)	(0.011)	(0.007)	(0.010)	(0.005)
Obs.	4,100,000	10,250,000	33,931	43,879	26,887	56,262
R^2	0.055	0.056	0.113	0.137	0.108	0.184

Note: Regression results using the simulated data from the *static-return-only model* are presented in the first two columns. Age, age squared, assets, assets squared, and a dummy for age 50s and 60s are included as controls. The last four columns are the estimates from Park and Lee (2018) using the Korean Welfare Panel Study (KWPS) and Survey of Household Finances and Living Conditions (SHFLC) data. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 3.3: Comparison with Park and Lee (2018), Eligibility Fixed Effect

3.3 The analysis using the life-cycle model

In this section, I exploit the structural life-cycle model developed in Chapter 1 to provide another interpretation of the Park and Lee (2018)'s result. It should be mentioned that I am not trying to quantify the dominant factor for the reason why the estimated labor supply effect of the EITC in Korea was reduced. Such a task requires a model that incorporates the BLSP or the self-employment choice, which my model does not have. Hence, this section instead aims to suggest a new perspective through the lens of the life-cycle model.

3.3.1 Regression analysis

In order to follow the estimation procedure of Park and Lee (2018), I first generate hypothetical panel data using the quantitative life-cycle model calibrated to the Korean economy. The constructed panel data consists of five periods, $t \in \{0, 1, 2, 3, 4\}$. Data for $t = 0$ is from the NO EITC economy in the *static-return-only model*, which is also used in the previous two chapters. Then, holding the distribution of individuals fixed, I introduce the 2016 EITC schedule for single-earner households only for those 60s with asset holdings less than 100 million KRW (data for $t = 1$), only for those 60s with asset holdings less than 140 million KRW (data for $t = 2$), only for those 50s and 60s with asset holdings less than 140 million KRW (data for $t = 3$), and only for those 40s, 50s, and 60s with asset holdings less than 140 million KRW (data for $t = 4$). Note that data for $t = 1$ corresponds to the 2013 EITC economy, data for $t = 2$ is for the 2014 EITC economy, data for $t = 3$ is for the 2015 EITC economy, and data for $t = 4$ is for the 2016 EITC economy (see Table 3.1).

Using the simulated panel data, I estimate the following linear probability model:

$$Emp_{i,t} = \alpha + X_{i,t}\beta + \gamma Eligible_{i,t} + \epsilon_{i,t} \tag{3.2}$$

which is very similar to eq. (3.1). The only difference is that the time dummy, δ_t, is excluded because there are no aggregate risks in the model. $Emp_{i,t}$ is constructed as the same as Park and Lee (2018). $Eligible_{i,t}$ has a value of 1 if satisfying both the age limit and asset limit.[2] $X_{i,t}$ includes age, age squared, assets, and assets squared (plus a dummy for ages 50s and 60s for the eligibility fixed effect model).

The first two columns of Table 3.2 show the estimates using the simulated data. While the result in the second column is obtained using the whole data, the result in the first column is from the data for $t \in \{0, 1\}$ which corresponds to the sample periods of 2008 and 2013, respectively. As can be seen, the estimate for γ is smaller when the reforms between 2014 and 2016 (data for $t \in \{2, 3, 4\}$) are included in the sample period, which is consistent with the Park and Lee (2018)'s finding. The first two columns of Table 3.3 are the results from the eligibility fixed effects model, which also shows the same pattern.

It is worth noting that the simulated data from the life-cycle model can only reflect the labor supply responses to the EITC reforms that alleviated the age limit and asset limit during 2013–2016. Therefore, the regression result using the simulated data suggests that 2014–2016 reforms regarding the age and asset limits can be another force behind the Park and Lee (2018)'s finding.

[2] Remind that the model is lacking of some household characteristics related to the eligibility conditions, such as home ownership, house price, and whether an individual is a BLSP recipient or not.

3.3.2 Inspecting the mechanism

To inspect the mechanism for the regression result in the previous subsection, I first compute the average change in the employment rate of those who become newly $Eligible = 1$ for each period $t \in \{1, 2, 3, 4\}$. The result is summarized in Table 3.4. The first row of the table shows that in $t = 1$ (2013 reform), age 60s with asset holdings less than 100 million KRW become newly $Eligible = 1$, and that their employment rate goes up by 0.68 percentage points compared to $t = 0$. However, note that the increase in the employment rate of the newly eligible group is substantially reduced to less than 0.1 percentage points for $t \in \{2, 3, 4\}$ (2014, 2015, 2016 reforms). Note also that the population shares of the newly eligible groups in $t = 3$ and $t = 4$ are larger than the other (see the last column of the table). Thus, it can be inferred that the small labor supply response of these groups—age 50s and 40s with sufficiently low asset holdings—are the main drivers that reduce the estimate for γ when including the data for $t \in \{2, 3, 4\}$.

Period	Newly become $Eligible = 1$	Δ Emp. rate	Share
$t = 1$	age 60s with assets < 100	+0.68 pp	1.1%
$t = 2$	age 60s with assets ≥ 100 & < 140	+0.01 pp	1.8%
$t = 3$	age 50s with assets < 140	+0.03 pp	7.4%
$t = 4$	age 40s with assets < 140	+0.06 pp	15.3%

Note: The periods $t \in \{1, 2, 3, 4\}$ correspond to the 2013–2016 EITC economies in ascending order. The newly eligible group shows those who become $Eligible = 1$ due to the EITC reform in that period. The third column shows the average change in the employment rate of the group compared to the previous period. The last column is the population share of those who become $Eligible = 1$ due to the EITC reform in that period.

Table 3.4: Changes in employment rate and population share of the newly eligible group

Then why is the labor supply response of the 50s and 40s so much smaller than that of the 60s? Recall from Figure 1.5 in Section 1.3.5 that the calibrated life-cycle model implies a U-shaped labor supply elasticity profile over the life cycle. Figure 1.5 shows that the elasticity in the 60s is considerably larger than in the 40s and 50s, which implies that the labor supply response to the EITC is much larger for the 60s than the 40s and 50s.

The difference in elasticity by age is mainly due to heterogeneity in labor productivity and wealth by age. In the 40s, a low income individual is likely to already participate into the labor market even without the EITC because it is his prime age and he has to accumulate more wealth to insure against retirement. This means there is little room for the tax credit to induce labor market participation. For those nearing retirement, in contrast, their average labor productivity tends to be lower than at prime age due to a hump-shaped age efficiency profile (see Figure 1.3 in Section 1.3). Also, it is more likely that they already have enough wealth to finance retirement consumption. Therefore, those nearing retirement are closer to the participation margin than at earlier ages, which implies more room for the tax credit to induce labor supply.

Figure 3.1 shows the employment rate of those with asset holdings less than 140 million KRW in the NO EITC economy by age. Consistent with the above argument, the figure demonstrates that the employment rate of the 40s and 50s with sufficiently low asset holdings is much higher than that of the 60s, even without the EITC.

Finally, Table 3.5 reports the population share of EITC recipients for each period. Despite the large decrease in the labor supply response to the

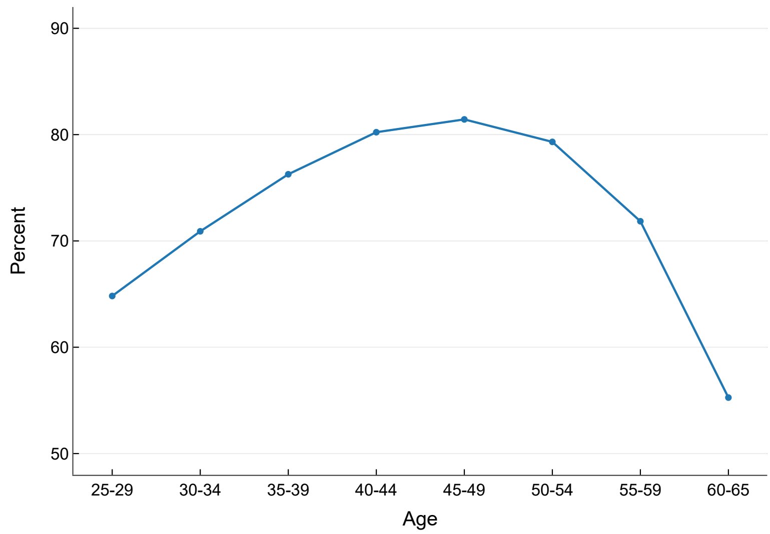


Figure 3.1: Employment rate by age, asset holdings less than 140 million KRW, NO EITC

EITC in periods $t \in \{2, 3, 4\}$, the share of recipients is increasing over the period. This result indicates that the expansion of the EITC during 2014–2016 worked as an income subsidy for low income households that already participated in the labor market rather than a means to induce their labor supply.

Period	Share of recipients
$t = 1$	0.04%
$t = 2$	0.05%
$t = 3$	0.07%
$t = 4$	0.12%

Note: The periods $t \in \{1, 2, 3, 4\}$ correspond to the 2013–2016 EITC economies in ascending order. Population share of EITC recipients is reported for each period.

Table 3.5: Share of EITC recipients

3.4 Conclusion

In conclusion, this chapter provides a new interpretation of the Park and Lee (2018)'s empirical finding for the labor supply effects of the EITC in Korea through the lens of a heterogeneous-agent life-cycle model. First, I show that the regression using the simulated data from the model can also generate the Park and Lee (2018)'s result that the labor supply effects of the EITC are reduced when 2014–2016 are included in the sample period. Then, I inspect the mechanism using the model and find heterogeneity in labor supply elasticity by age as a new contributing factor to the Park and Lee (2018)'s finding.

The results suggest that more empirical work on *for whom* the EITC is effective in inducing labor supply—not just the estimates for the *average effect*—is needed to further understand its labor supply effects.

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Appendix

A Estimations

A.1 Labor income tax progressivity

By rearranging eq. (1.14) and taking logs (ignoring the max operator), I have the following equation:

$$\log(y - T(y)) = \log \lambda_l + (1 - \tau_l) \log y. \tag{IA.1}$$

The estimate for τ_l can be obtained by regressing the log of after-tax earnings $y - T(y)$ on the log of pre-tax labor earnings y with a constant. Using the SHFLC data, I construct after-tax earnings data. Income tax, employment insurance tax, and national health insurance tax data are included in $T(y)$. Note that all public transfers are excluded when constructing after-tax earnings data because public transfers such as the tax credit and other means-tested transfers are explicitly specified in the model. Therefore, the estimate for τ_l represents the progressivity of the pure tax component. The sample is restricted to individuals who are aged 25–65, whose annual labor earnings are greater than 5 million KRW($\approx$ 5,000 USD), and who have no asset income, pension income, or income from self-employment. As a result, the constructed data for taxes $T(y)$ should only include taxes on labor earnings. Regression results are presented in Table A1.

	Estimate
$1 - \tau_l$	0.9796
	(0.0008)
$\log \lambda_l$	0.1126
	(0.0063)
Observations	3,497
R squared	0.9976

Data source: SHFLC, 2019. Sample criteria: individuals who are aged 25–65, earn greater than 5 million KRW, and have no asset income, pension income, or income from self-employment. Standard error estimates are in parentheses.

Table A1: Labor income tax progressivity

A.2 Welfare benefits to the non-employed

To estimate the welfare benefits to those not working compared to those working, Ω, I use the sample of household heads aged 25 to 65 in the SHFLC data. Regression results are presented in Table A2.

B Additional features of the model

Demographics and preferences

The size of the entering cohort grows at a rate of n_p and it is set to 1.1%, which is the long-run average population growth rate in Korea (from 1965 to 2020). The population share by age $\{\theta_j\}_{j=1}^{J}$ is calculated as follows using the growth rate n_p and the conditional survival probability by age ϕ_j:

$$\theta_j = \theta_{j-1} \cdot \frac{\phi_j}{1 + n_p} \tag{IB.1}$$

for $j \geq 2$, and $\theta_1 = 1$ (normalization).

	Estimate
$\mathbb{1}$(non-employed)	389.91
	(10.50)
$\mathbb{1}$(married)	28.68
	(9.13)
$\mathbb{1}$(female)	22.67
	(6.21)
$\mathbb{1}$(rent)	32.81
	(5.10)
$\mathbb{1}$(capital region)	−13.35
	(4.56)
Age	−8.69
	(2.28)
Age squared	0.08
	(0.02)
Number of household members	37.76
	(8.84)
Number of household members squared	−2.82
	(1.33)
Asset	−3.48
	(0.65)
Asset squared	0.03
	(0.01)
Constant	170.72
	(52.68)
Observations	12,979
R squared	0.1148

Data source: SHFLC, 2019. Sample criteria: household heads aged between 25 and 65. Unit: 10,000 KRW. Non-employed is defined to those who earned less than 5 million KRW. Standard error estimates are in parentheses.

Table A2: Welfare benefits to the non-employed

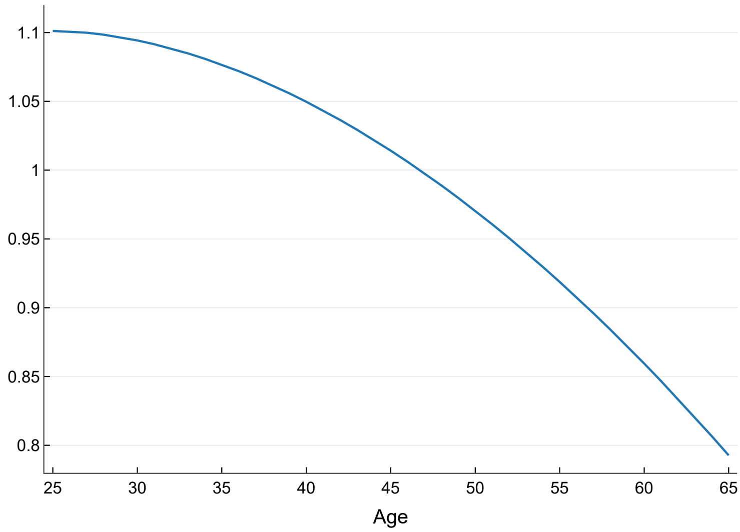

Figure A1: Fixed utility cost of work by age ν_j

B.1 Firms

Representative firm has an access to CRS technology $Y = AF(K, L) = AK^{\alpha}L^{1-\alpha}$. L is the aggregate labor input in efficiency unit:

$$L = \sum_j \theta_j \int \epsilon_j z h(x)\; d\mu_j(x) \tag{IB.2}$$

where $x = (a, z, e, n)$ is a vector of individual state variables, θ_j is population share of age j, and $\mu_j(x)$ denotes a probability measure of age j individuals with state x.

Aggregate capital K depreciates at rate δ. Depreciation rate δ is set to 0.08 to match capital-output ratio of 3. A is the total factor productivity which is assumed to be constant and calibrated to match per capita GDP of Korea in 2019. Labor share α is set to 0.36 following the literature.

B.2 Government budgets

The government balances the tax-transfer system (eq. (IB.3)) and the public pension system (eq. (IB.4)), respectively:

$$G + EITC + Welfare + BP = \tau_c C + \sum_{j=1}^{J_R-1} \theta_j \int T(y)\, d\mu_j(x) + \tau_k r K + Beq \tag{IB.3}$$

$$\sum_{j=J_R}^{J} \theta_j \int \xi(n, e; E, \kappa)\, d\mu_j(x) = \sum_{j=1}^{J_R-1} \theta_j \int \tau_p \cdot \min\{y, \bar{y}\}\, d\mu_j(x) \tag{IB.4}$$

where

$$EITC = \sum_{j=1}^{J_R-1} \theta_j \int \psi(a, y)\, d\mu_j(x)$$

$$Welfare = \sum_{j=1}^{J_R-1} \theta_j \int tr + \Omega \cdot (1 - h(x))\, d\mu_j(x)$$

$$BP = \sum_{j=J_R}^{J} \theta_j \int bp\, d\mu_j(x)$$

and G is government consumption. For each system, expenditures (revenues) are on the left (right) side. Accidental bequests, net of initial wealth of the entering cohort, are assumed to be confiscated by the government, which is denoted by Beq. Note that the public pension system is run in a pay-as-you-go style.

$$E = \frac{\sum_{j=1}^{J_R-1} \theta_j \int \min\{w\epsilon_j z h(x), \bar{y}\}\, d\mu_j(x)}{\sum_{j=1}^{J_R-1} \theta_j \int \mathbb{1}_{\{h(x)=1\}}\, d\mu_j(x)} \tag{IB.5}$$

B.3 Definition of equilibrium

A competitive equilibrium in this environment consists of prices $\{r, w\}$, tax-transfer policies $\{\tau_c, \lambda_l, \tau_l, \tau_k, \Omega, tr, bp\}$, the EITC $\{\beta_{in}, \beta_{out}, \alpha_{out}, \bar{\psi}, \bar{a_1}, \bar{a_2}\}$, the public pension system $\{\tau_p, \bar{y}, \kappa, E\}$, government consumption G, and the individual's policy functions $\{c(x), h(x), a'(x)\}$ such that,

- Given prices and government policies, the policy functions of the individual are solutions to optimization problems (1.4) and (1.11) formulated in Section 1.2.4,
- Given prices, firms determine their demand for capital and labor to maximize profit: $w = AF_L(K, L)$ and $r = AF_K(K, L) - \delta$,
- G and τ_p satisfies government budgets eq. (IB.3) and eq. (IB.4), respectively,
- Markets are cleared,
- The measure of individuals is consistent.

C Pension benefit formula

$$\xi(n, e) = \begin{cases} \gamma(E + e)[0.5 + 0.05 \cdot (n - 10)] & \text{if} \quad 10 \leq n < 20 \\ \gamma(E + e)[1 + 0.05 \cdot (n - 20)] & \text{if} \quad 20 \leq n \end{cases} \tag{IC.1}$$

Note that the terms in the square brackets become $0.05 \cdot n$ for both cases. Defining $\kappa := 0.05 \cdot \gamma$, the formula can be expressed as eq. (1.3) in Section 1.2.2 for $n \geq 10$.

국 문 초 록

비동질적 경제주체를 가정한 거시경제모형과 공공정책에 관한 연구

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저소득 가구에게 현금지원을 제공하는 복지제도인 근로장려세제(Earned Income Tax Credit, 이하 EITC)는 경제활동을 통한 근로소득을 수급요건으로 한다는 점에서 다른 복지제도와 차별화된다. 이러한 노동시장참여 요건으로 인해 EITC는 저소득 가구에게 현금지원뿐만 아니라 노동시장에 참여하고자 할 유인(incentive)을 제공한다. 그 동안 Eissa and Liebman (1996)을 비롯한 많은 실증연구들이 EITC의 노동공급 효과를 분석하여 노동시장참여를 늘린다는 결과를 제시하였다. 그러나 Eissa and Liebman (1996)이 결론에서 언급한 바와 같이 노동공급 효과는 EITC의 전체적인 후생효과를 분석하는데 필요한 정보의 일부이다: *"A full evaluation of [...] the EITC requires more than just an estimate of the [...] impact [...] on the labor supply of transfer recipients. It also requires information on the value of the additional income received by program beneficiaries as well as the change in the amount of leisure that they consume."* 그럼에도 불구하고 소득에 대한 효과(Hoynes and Patel, 2018)나 후생수준 혹은 생애주기에 걸친 장기적 효과(Athreya et al., 2014; Blundell et al., 2016)

에 대한 연구는 비교적 적게 이루어져왔다. 본 논문은 이러한 측면에서 EITC의 효과를 보다 잘 이해함으로써 EITC 연구 문헌의 틈을 메우는 것을 목표로 한다. 구체적으로, 본 논문은 Huggett (1993)과 Aiyagari (1994)로 대표되는 현대 거시경제학의 주요 모형 중 하나인 비동질적 경제주체 기반의 거시경제모형(heterogeneous-agent macroeconomic model)을 구축하여 다음 질문들에 답하고자 한다: EITC의 (i) 노동공급 및 생애소득, (ii) 저축, 소비 및 후생수준에 대한 장기적 효과에 있어 기존연구에서 고려되지 않은 공적연금제도가 어떤 역할을 하는가? (iii) 박지혜 · 이정민(2018)의 실증연구에서 제시된 바와 같이 왜 한국의 일부 EITC 확대개편은 노동공급을 늘리는데 효과적이지 못했는가?

논문의 첫 번째 장과 두 번째 장에서는 공적연금제도가 EITC의 장기적 효과에 미치는 영향에 대해 분석하였다. 많은 나라의 공적연금제도는 근로연령 동안 더 많은 노동공급을 통해 연금기여금(혹은 연금보험료)을 많이 낼수록 은퇴 후 받게 될 연금급여가 증가하도록 설계되어있다. 따라서 근로연령 중 EITC에 대한 노동공급 반응은 현재 소득뿐만 아니라 공적연금제도를 통해 은퇴 후의 연금소득 또한 증가시킬 수 있다. 또한, Liebman and Luttmer (2015)의 연구가 보여주고 있는 것처럼 사람들이 이러한 공적연금을 통한 노동공급의 미래수익(dynamic return)을 잘 인지하지 못하고 있다면, 이에 대한 정보제공을 통해 EITC에 대한 노동공급 반응이 더 커질 수 있다. 더 나아가 이러한 정보제공은 저소득 가구로 하여금 노후대비 저축을 줄이면서 은퇴 이전에도 소비를 늘릴 수 있게끔 하는 소비평탄화(consumption smoothing) 효과를 통해 EITC의 후생효과를 더 크게 만들 수 있다. 이와 같은 맥락에서 본 논문의 1, 2장에서는 EITC의 생애소득과 후생수준에 대한 장기적 효과와 더불어 공적연금에 의해 발생하는 노동공급의 미래수익의 중요성을 정량적으로 분석하였다. 이를 위해 우선 가구의 노동시장참여와 소비, 저축에 대한 선택이 내생적으로 이루어지며 가구의 예산제약식에 EITC 및 공적연금제도를 명시적으로 고려한 비동질적 경제주체 기반의 생애주기 모형(heterogeneous-agent life-cycle model)을 구축하였다.

다음으로 모형이 한국경제를 잘 설명할 수 있도록 모수들은 설정(calibration)하고, EITC의 직접적 영향을 받는 가구들에 대한 분석에 초점을 맞추기 위해 노동생산성이 낮은 삶을 살아가게 될 신생아(newborn)에 대한 장기적 효과를 분석하였다. 분석결과, 공적연금을 통한 노동공급의 미래수익은 EITC의 생애소득과 후생수준에 대한 효과 중 각각 절반, 4분의 1 정도를 설명할 만큼 중요한 것으로 나타났다. 이는 노동공급의 미래수익에 대한 정보제공이 EITC의 긍정적 효과를 상당히 크게 만들 수 있음을 시사한다.

마지막 장에서는 앞서 구축한 생애주기 모형을 활용하여 박지혜 · 이정민(2018)의 실증분석 결과에 대한 해석을 제시하고 있다. 박지혜 · 이정민(2018)의 주요 결과 중 하나는 분석기간에 2014-2016년을 포함하게 되면 EITC 확대개편의 노동공급 효과가 상당히 작거나 통계적으로 유의하지 않게 추정된다는 것이다. 한국 EITC 확대개편의 특징 중 하나는 단독가구가 연령별로 점차 수급할 수 있게 되었다는 것이다. 구체적으로 2012년까지는 수급대상에 단독가구가 포함되어있지 않았으나 2013년부터 60세 이상의 단독가구가, 2015년부터 50대 단독가구가, 2016년부터 40대 단독가구가 수급대상에 포함되었다. 이는 EITC에 대한 노동공급 반응이 연령별로 달랐을 수 있음을 시사한다. 즉, 2014년 이후로 수급대상에 포함된 50대, 40대에서의 노동공급 반응이 비교적 작게 나타났을 수 있다는 것이다. 앞선 장에서 구축한 생애주기 모형에 의하면 연령별 노동공급 탄력성이 60대에서 가장 높고 40대에서 가장 낮은 것으로 나타난다. 이러한 연령별 노동공급 탄력성의 차이는 연령별 노동생산성과 자산수준의 차이에서 비롯된다. 연령별 노동생산성이 가장 높고 노후대비 저축동기를 어느정도 갖는 40대는 EITC가 없더라도 이미 일을 하고 있을 가능성이 높다. 이는 EITC가 이들의 노동시장참여를 늘릴 여지가 적다는 것을 의미한다. 반대로 은퇴가 가까운 60대의 경우, 노동생산성이 40대보다 낮고 이미 노후소비를 충당하기 위한 자산을 어느정도 축적한 상태이기 때문에 EITC 없이 일을 할 유인이 40대에 비해 작다. 이는 EITC가 60대의 노동시장참여를 늘릴 여지가 크다는 것을

의미한다. 이러한 결과는 EITC의 노동공급에 대한 평균적 효과뿐만 아니라 다양한 사회인구학적 집단별 효과에 대해 보다 많은 실증분석이 이루어질 필요가 있음을 시사한다.

주요어 : 근로장려세제, 생애주기 모형, 장기적 효과, 공적연금, 노동공급, 현저성(Salience)

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