Master Thesis in Economics

Effects of Age-specific Incentive Policy for Sectoral Reallocation of Labor

: Overlapping Generations Computable General Equilibrium Model Approach

산업별 노동 인력 재분배를 위한 연령별 보조금 정책 효과 연구
: 중첩세대 연산가능 일반균형모형 접근을 통하여

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Graduate School of Seoul National University

Technology Management, Economics, and Policy Program

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Abstract

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Over the last few decades, Korea has been recognized as one of the most dynamic economies in the world. Recently, however, the country has lost its growth momentum and concerns over its stagnant economy have mounted. Among many contributors, this study is centered on deindustrialization (shift to service economy) and an aging population.

To address the two issues, an age-specific division of the labor system is proposed as an alternative. The core idea is to allocate workers of various ages to better suited sectors based on the sectoral and occupational productivity by age. The age-based reallocation of labor is believed to increase overall productivity, and thus, production of the entire economy. Among a number of policies to realize the intended division of labor, the purpose of this study is to investigate the effects of incentive policies in reallocating workers of different generations to better suited sectors.

This paper designs five different incentive policy scenarios, each of which intends sectoral switches in different directions by various age-groups. To examine the reallocation incentive policies, this study adopts the four-period Overlapping Generations (OLG) Computable General Equilibrium Model, incorporating individuals' heterogeneity in abilities and career path choices. The general trend of heterogeneous attributes is estimated with labor and income panel data.

The findings show that there are two types of contributors to the labor reallocation results intended by the policies, the incentive beneficiaries changing their sector and non-recipients who also switch their sectors due to changes in economic variables, including wage rate. It is observed that for a certain incentive scenario, the contribution of sector switches indirectly affected by the policies is the same or even larger than that of direct incentive benefits. Furthermore, a different mix of incentive policies results in various levels of discrepancy in the sectoral standard wage rates.

Hence, it is of great importance to carefully examine the direct and indirect effects of incentive policies in a long-term period, as well as the wage rate inequality for better policy-making.

Keywords: Aging, Labor Reallocation Policy, Overlapping Generations, Computable General Equilibrium Model
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Chapter 1. Introduction

1.1 Research Background

Over the last few decades, Korea has been recognized as one of the most dynamic economies. In the 1960s and 1970s, its yearly growth rate was around 10%. In 2012, the World Bank categorized Korea as one of 13 countries that escaped the middle-income trap and entered a group of high-income economies from 2008 (Word Bank, 2012).

Recently, however, Korea's economy has been faced with difficulties in propelling its economic growth. The decrease in its economic vitality can be seen in various macroeconomic indicators, such as slower gross national product (GDP) growth rate, weakened growth potential, a slowdown in productivity growth and an aging population (Lee and Cho, 2017).

Of the number of factors that induced the sluggish economy, this paper focuses on two: aging and deindustrialization (a shift to a service economy or low productivity industries). Aging, together with seriously low fertility rates, has reduced the number of economically active people, and, at the same time, has experienced an increase in welfare costs (Ahn, Kim, and Ryuk, 2017). While the aging population is a problem shared by most developed countries across the world, no country in the Organization for Economic Co-operation and Development (OECD) has experienced at a faster pace than Korea

(OECD, 2016).

To deal with the low fertility rate and aging issues, the Korean government has implemented three consecutive five-year programs named ‘Plan for Aging Society and Population’ from 2005 to 2020. The programs are mostly centered on policies to increase the total fertility rate, alarming potential shortage of labor, stagnant economic growth and the rising cost of welfare. However, the government programs have been questioned for their direction and effectiveness (Lee, 2018), with a fertility rate of 1.2 (births per woman) in 2016, the lowest among OECD countries (OECD, 2018). Furthermore, in terms of detailed plans for the older population, the scope of the program has been largely limited to welfare approaches, despite the importance of encouraging them to more actively participate in the economy (Lee, 2016). According to United Nations Economic Commission for Europe (UNECE), older workers, when assigned to a better suited post for their skills, can work productively (UNECE, 2011). Kim (2018) also emphasizes the significance of the government role in facilitating the supply of jobs suitable for the old workers and actively cultivating the social environment where they can participate.

In terms of deindustrialization, as shown in **Figure 1**, the employment share of Korea’s services sector has continued to increase, but its share of value-add has not. **Figure 2** shows that the shift to a services economy is a commonly found trend in developed countries, including the US, Japan, and Germany. However, unlike those countries, in Korea, the gap between the productivity of service industries and that of other industries has grown larger with time, thus making it a more serious issue (Lee and

Cho, 2017). Kim (2013) states that the share of employment in Korea has increased in the less productive and stagnant services sectors, and this has reduced overall economy's productivity. Oh (2009) also pointed out that in Korea, the share of employment in industries with high productivity has decreased, while that in low-productive sectors shows an increasing trend, lowering the growth rate of the entire economy, widely known as 'Baumol's effect'.

Korea's Manufacturing Sector　　　　Korea's Services Sector

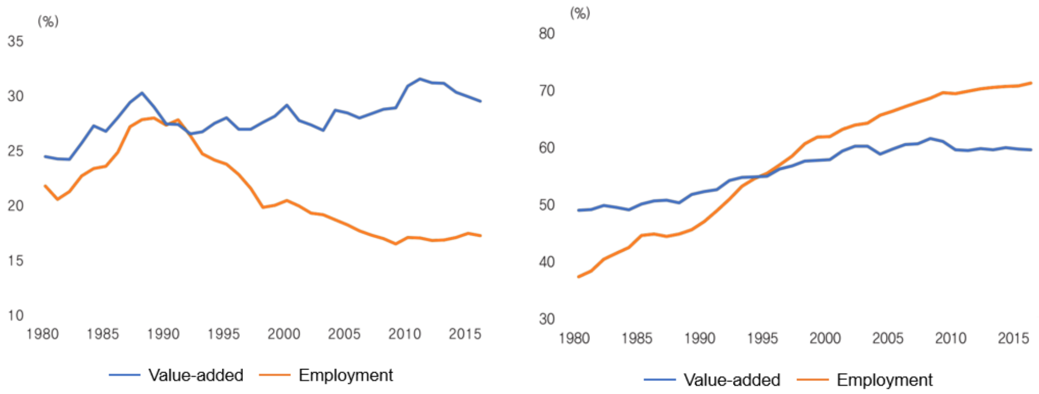


Figure 1. Share of employment1) and value-added2) by sector in Korea

Note: 1) % of total employees, 2) % of GDP

Source: Reprinted from Lee and Cho (2017), Data from Bank of Korea and Statistics Korea.

The US's Services Sector　　　Japan's Services Sector　　　Germany's Services Sector

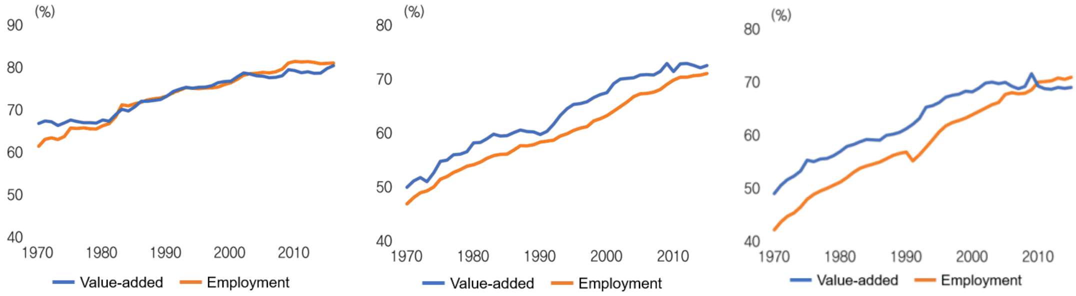


Figure 2. Share of employment1) and value-added2) of services sector in the US, Japan, and Germany

Note: 1) % of total employees, 2) % of GDP

Source: Reprinted from Lee and Cho (2017), Data from Bank of Korea and Statistics Korea.

1.2 Research Purpose and Methodology

In such a backdrop, this paper aims to address the aging population and the shift to services economy, which are counted among the causes of the low productivity and sluggish economic growth in Korea. The age-specific division of labor system, first suggested by Kim (2013), can be regarded as an alternative. He maintains that young and middle-aged workers hold a comparative advantage in occupations which necessitate creativity, learning ability, and physical abilities, while the old have a comparative advantage in jobs concerning networking and communication abilities and experience. He further argues that if the economy realizes the age-specific division of labor reflecting those comparative advantages, it can effectively avoid the decline in its productivity and GDP. In this context, this research examines his theory and explores how to better design a policy to induce age-specific reallocation of labor.

With fixed labor and full employment in the market assumed, the present paper attempts to allocate workers of each generation to industries with their respective advantages; younger workers to progressive industries (fast-changing, creativity-based, and high productivity industries) and older workers to stagnant industries (repetitive, experience-based, and low productivity industries). The current paper designs incentive policy scenarios to examine the effectiveness of each scenario in reallocating labor in such way.

To examine the labor market, this paper proposes a computable general equilibrium model (CGE). CGE models have been found in a wide range of studies on economy-wide impacts of events such as pension schemes, tax policies, and climate change. Among the CGE models, to investigate the effects of age-specific policies and labor with age-specific heterogeneity, an OLG model is adopted. An OLG-CGE model provides a clear advantage in understanding the demographic behavior, as it can model explicitly the interactions of age-specific effects (Lisenkova, Mérette, and Wright, 2013).

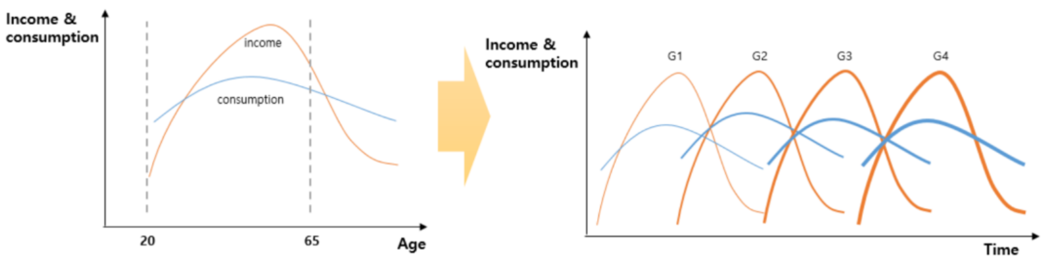


Figure 3. The graphical description of 4-generation OLG structure

Using the OLG-CGE model, this paper considers two types of incentive programs; first, to reallocate the youngest generation to the progressive sector, and the second is to reallocate older workers to the stagnant sector. This study's findings show that there are two different contributors to the sectoral reallocation intended by the policies; the incentive recipients and non-recipients, who also switch their sectors due to other economic variables, including wage rate. It is also observed that, in terms of a group of policy scenarios, the contribution of individuals indirectly affected by the policies is as significant as that of direct incentive beneficiaries. Furthermore, the simulation results imply that despite of their similar aggregate effects, only incentivizing a certain group of workers to move in one direction can increase the wage rate inequality and fluctuate the rate more, compared to inducing the movement of two cohorts of workers.

1.3 Outline of the Study

The study is organized as follows. Chapter 2 describes the theoretical background of the study. It summarizes the related previous research on age-specific labor productivity, incentive policy in the labor market, general equilibrium analysis of labor market and overlapping generations models. Chapter 3 explains the method used, which is OLG-CGE approach. This chapter first presents the basic concept of the model and then describes the specific model suggested by this paper. Chapter 4 discusses the results of the scenario simulations of different incentive policies for labor reallocation. Finally, Chapter 5 concludes this paper with the summary of the results and policy implications. This chapter also states the limitations of this study and presents a proposal for future study.

Chapter 2. Literature review

2.1 Age-Specific Labor Productivity

Verhaeghen and Salthouse (1997), using a meta-analysis of 91 studies, show that processing speed, cognitive abilities, and memory deteriorates greatly before the age of 50. However, despite the decline in abilities, retraining is effective in slowing the negative effects of aging (Schaie and Willis, 1986a; 1986b). Ji (2016) also concluded that education and training offsets the negative association between aging and capacity.

Schaie (1994) shows that the different types of cognitive abilities have relatively independent tendencies during the life cycle. Horn and Cattell (1966; 1967) categorize abilities into two; fluid and crystallized abilities. According to them, fluid abilities are related to the speed of solving new tasks and reasoning, which decline significantly at older ages, while crystallized abilities are relevant to cumulative knowledge and remain at a relatively high level until older age.

Skirbekk (2008), who examines the age-specific supply of abilities using the General Aptitude Test Battery (GATB), shows that with age, the productivity of people generally decreases following an inverted U-shaped curve. However, if a profession requires "management-communication" skills, a worker's performance increases or remains stable with age.

Following such context, this paper attempts to categorize the economy into two sectors which requires seemingly different abilities. The first one is the progressive sector, concerned with cognitive skills, and the other is the stagnant sector, which requires accumulated knowledge and experience.

A similar attempt was made by Kim (2013), by allocating young and prime-age workers to manufacturing sectors, while older workers to services sectors. His simulations showed that such a division of labor can raise the GDP by 66% upon its adoption (in 2010). However, his model is limited in a way that individuals' choices are not incorporated, only two representative occupations are considered, and labor market is not analyzed in a general equilibrium.

2.2 General Equilibrium Analysis of Labor Market

Computable general equilibrium (CGE) models are widely adopted by governments and research institutes to examine the effects of a wide range of economic and environmental "shocks", including tax policies, human diseases, climate changes and labor migration. A CGE models are comprehensive in that they are designed to account for all the behaviors of economic agents simultaneously (different from "partial equilibrium" approach) such as firms' profit maximization and consumers' utility maximization (Burfisher, 2011).

In a CGE model, the economic structure and the agents' behaviors are described with a set of equations. The parameters for the equations are calculated by calibration procedure. Then, the model can be solved for other equilibrium scenarios with alternative policy schemes. With the comparison between the alternative and the benchmark scenarios, it is possible to evaluate the impacts of changed policies (Okkerse, 2008).

The labor market in a CGE model is described as part of the macroeconomic components. It is assumed that labor is a factor input in a neoclassical production functions- a Cobb-Douglas, a CES or a Leontief function. In the neoclassical general equilibrium analysis, labor demand is endogenously determined by wage level and output price. To satisfy the market clearing condition, labor demand is equated to labor supply (Kurzweil, 2002).

2.3 OLG-CGE Model Approaches

Of CGE models, the OLG structure is suggested by Auerbach and Kotlikoff (1987) to meet the purpose of age-specific demographic research. In an OLG-CGE model, a household is comprised of several generations living together at any time. At the beginning of each period, a new generation is born, and at the end of each period, the oldest generation dies, while the other generations become older and the economy is going. In this respect, an OLG-CGE model has a clear advantage as age-specific effects are pivotal in the study of demographic research Lisenkova, Mérette, and Wright, 2013).

Lee (2012) proposed an OLG-CGE model to analyze the growth potential of South Korea. The study considered the major demographic changes, including low birth rates and the aging population, estimating the GDP and growth rate trajectory from 2010 to 2060. In addition, to investigate the effects of policies on economic growth, the model incorporated a range of simulation scenarios, such as an increase in labor immigration, retirement age extension, and growth in female economic participation.

Another study using the OLG-CGE model was conducted by Hong and Kang (2016), and quantitively analyzed the effects of aging and population structure change on the economy. Furthermore, they examined the economic effects of the adoption of retirement age extension policy. However, these two studies have not accounted for the heterogeneous traits of each generation's contribution to the economic state.

The closest research to this paper was carried out by Ryu and Jeon (2013). Using an OLG-CGE approach, their research focused on analyzing employment, retraining, job switch and early retirement. Comparing the results from scenarios of different policy mixes, they assessed the influences on the labor market in equilibrium conditions. This OLG-CGE model is distinctive in that heterogeneous learning abilities are accounted for. One of their major implications was that the earlier the government subsidizes workers' job transition, the more their welfare level increases. Though their study considers the individual's distinctive learning ability, it is limited in that each worker's ability is determined only once, at birth and their age-specific sectoral productivity is not taken into account.

The present study is aimed at investigating the effects of policies to incentivize an age-specific division of labor. The OLG-CGE model in this paper incorporates the heterogeneous sectoral and age-specific labor productivity of individuals. By analyzing the incentive policy in an equilibrium state, the results of this research are expected to offer the comprehensive effects of policy shocks.

Chapter 3. Methods

3.1 OLG-CGE Model Description

This section describes the OLG-CGE model of this present paper, which follows the basic Auerbach-Kotlikoff OLG model (Auerbach and Kotlikoff, 1987; 1998).

3.1.1 Four-period life-cycle model

In this model, four generations coexist at any point in time. For simplicity, it is assumed that the first three generations (young-, prime-, and old- age) work full time and the last generation (oldest-age or retired) is retired. All individuals of a generational cohort are born at the same time and live for four periods and die with probability 1 (exit the model). It is more realistic, definitely, to incorporate every year of each individual's life, but more time periods may increase the model's complexity only, without much change to the basic insights (Auerbach and Kotlikoff, 1998). We assume in this specific model that individuals with age above 15 participate in the economic activities and retire at 65. Thus, each period can be thought to consist of approximately 16.7 years.

In **Table 1**, to simply describe the concept of individuals' life, we draw the two-period model's time-line. Our OLG-CGE model is a simple extension of this two-period model to four-period model. Each generation consists of 200 members (in total, 800) and no population growth is assumed. The three working generations earn income, consume and save at the end of each period. They invest their savings at the next period and the oldest cohort dissaves the principal and interest of the investments.

Table 1. The two-period model's time line

	Gen$_t$ is born		*Gen*$_{t+1}$ is born		*Gen*$_{t+2}$ is born
Gen$_{t-1}$ saves		*Gen*$_t$ saves		*Gen*$_{t+1}$ saves	
	Gen$_{t-1}$ invests		*Gen*$_t$ invests		*Gen*$_{t+1}$ invests
Gen$_{t-2}$ dissaaves and dies		*Gen*$_{t-1}$ dissaves and dies		*Gen*$_t$ dissaves and dies	
End	Beginning	End	Beginning	End	Beginning
Period t - 1	Period t		Period t + 1		Period t + 2

Source: Auerbach and Kotlikoff (1998)

3.1.2 Basic concept of model

This four-period OLG-CGE model consists of three sectors: a household, two producers, and a government. Each sector is represented by a set of nonlinear equations of endogenous variables. Solving the system of all equations simultaneously gives us an equilibrium solution for the economy.

3.1.2.1 Household behavior

At any point in time, the household sector consists of four overlapping generations. Every period, a newly-born cohort of individuals replaces the oldest generation which dies out at the end of the period. All individuals in a certain cohort possess the same preferences in terms of consumptions and savings (though each individual's ability and preference are heterogenous to be explained later in the section). Thus, it is possible in the model that a single representative member fully accounts for the generation she belongs to. The representative household makes the life-time decision on consumption to maximize its utility.

3.1.2.1.1 Utility

The utility function of each household is represented with the level of current and future consumption. This model does not incorporate leisure as an argument that determines the preferences. Individuals are assumed to have constant relative risk aversion (CRRA) preferences.

For the life-time utility function takes the form

$$U = U[u_1(c_1), u_2(c_2), u_3(c_3), u_4(c_4)] = \frac{1}{1-1/\gamma}\sum_{t=1}^{4}\left(\frac{c_t^{1-1/\gamma}}{(1+\delta)^{t-1}}\right), \quad \cdots\cdots\cdots\cdots\cdots \text{Eq. (1)}$$

where δ is a discount rate or agent-specific time preference and γ represents the intertemporal elasticity of substitution. With a larger time preference, individuals will spend more amount of life-time income in earlier periods. The intertemporal elasticity of substitution measures the responsiveness of household's consumption change to the real interest rate.

3.1.2.1.2 Intertemporal budge constraint

At each period, every household makes a decision on how much consume to maximize its utility function Eq.(1) under the lifetime budget constraint. Households have two sources of incomes: labor income and capital income. The excess of earnings is saved as the stock of assets. Household has no surplus or debt at the moment of death.

It is assumed that households have perfect foresight, and thus with a one-time optimization decision at their birth (on entry to the model), the life-time consumption is planned. The household's dynamic budget constraint only depends on the present and future level of interest and wage rates without the consideration of taxation and pension system. As for the budget constraint, it is required that the present value of lifetime earnings not be exceeded by that of lifetime consumption, and then the constrain follows the form

$$\sum_{t=1}^{4}\prod_{s=1}^{t}(1+r_s)^{-1}(w_t e_t - c_t) \geq 0, \quad \cdots\cdots \text{Eq. (2)}$$

where r_t is the interest rate in period t, w_t is the wage rate in period t and differs by sector, and e_t is a earning (or productivity) profile that account for the heterogeneity in ability and skill by sector for different generations or individuals.

3.1.2.1.3 Consumption and saving decision

The first order conditions (FOC) are derived from the utility maximization problem Eq.(1) under the lifetime budget constraint Eq.(2).

$$(1+\delta)^{-(t-1)} c_t^{-1/\gamma} = \lambda[\prod_{s=2}^{t}(1+r_s)^{-1}] \quad \cdots\cdots \text{Eq. (3)}$$

$$\frac{c_t}{c_{t-1}} = \left(\frac{1+r_t}{1+\delta}\right)^{\gamma} \quad \cdots\cdots \text{Eq. (4)}$$

Eq.(4) means that consumption growth depends on the interest rate r and the rate of time preference δ. If the interest rate is larger than preference rate, then the consumption grows and its growth rate is decided by the γ, the intertemporal elasticity of substitution.

3.1.2.2 Supplier behavior

The model incorporates two production sectors and the competitive market is assumed. Both of the sectors have a constant return to scale (Cobb-Douglas) production function with capital and labor as factor inputs. Labor and capital are assumed to be homogeneous, and the labor is perfectly substitutable between different generations.

3.1.2.2.1 The production function

The production function takes the form

$$Y_t = A(K_t)^{\varepsilon}(L_t)^{1-\varepsilon}, \quad \text{Eq. (5)}$$

where Y_t, K_t, and L_t are output, capital input, and labor input at period t, respectively. A is a scaling factor which measures the productivity of capital and labor used in producing output. ε is interpreted as the share of capital use in production.

3.1.2.2.2 The demand for labor

With the assumption of competitive market stated above, and additionally no labor adjustment costs, in equilibrium, the standardized wage rate w_t must equate the marginal product of labor. The equation that describes the wage rate can be derived from the present from of the production function as follows:

$$w_t = (1-\varepsilon)A(K_t)^{\varepsilon}(L_t)^{1-\varepsilon} / L_t \quad \cdots\cdots \text{Eq. (6)}$$

The wage at period t is expressed as a function of capital and labor at the period.

3.1.2.2.3 The investment decision

Capital in a number of economic models is handled in a symmetrical way with labor. It is assumed that the adjustment cost of capital is zero, and in this present model, as used widely in modeling, the marginal product of capital is equal to the interest rate. Then the function of interest rate takes the following form

$$r_t = \varepsilon A(K_t)^{\varepsilon}(L_t)^{1-\varepsilon} / K_t \quad \cdots\cdots \text{Eq. (7)}$$

The equations of Eq.(6) and Eq.(7) can be thought of over-simplified expression of the true investment and labor demand mechanism, but in fact, they are not always innocuous assumptions, especially when the short term effects of shock are examined.

3.1.2.3 Government behavior

The government collects revenues from tax on households and firms to pay for its own consumption of goods and services. In this model, since it is not of our major issue, we do not account for any indirect effects of the government spending on the individuals, which in real world play a part in the economy. It is simply assumed that the government expenditure grows at the same rate with the population growth.

3.1.2.3.1 The government budget constraint

The government's budget is not required to make a balance in any period as in the real world. If the government's spending exceeds the taxes collected, the outstanding debt level is increased by the difference between them. This can be expressed as

$$D_{t+1} - D_t = G_t + r_t D_t - T_t \quad \cdots\cdots \text{Eq. (8)}$$

where D_t is the stock of debt at the start of the period t, G_t is the government expenditure on its consumption of goods and services in period t, and T_t is the gross tax revenues collected in period t. It should be noticed that G_t consists of not only the expenses of goods and services, but also the debt services and transfer payments.

The recursive substitution of the Eq.(8) from period 0 to N yields the government budget constraint as follows:

$$\sum_{t=0}^{N}\left[\prod_{s=0}^{t}(1+r_s)-1\right]T_t = \sum_{t=0}^{N}\left[\prod_{s=0}^{t}(1+r_s)^{-1}\right]G_t + D_0 - \prod_{t=0}^{N}(1+r_t)^{-1}D_N \quad \cdots\cdots \text{Eq. (9)}$$

It is assumed that the government cannot borrow indefinitely, and thus the public debt cannot grow as fast or faster than the interest rate indefinitely (sometimes known as a *transversality condition*). Hence the last term in the equation above goes to zero as N approaches infinity.

3.1.2.4 Equilibrium under perfect foresight

In this dynamic simulation model, all economic agents-households, firms, and government- are modeled with perfect foresight. They make decisions taking into account perfectly correctly and rationally the future changes of economic variables. Perfect foresight assumption can be seen as extreme to some extent, but it can offer a meaningful benchmark case compared to the model with bounded rationality.

Equilibrium under perfect foresight in this dynamic model can be explained as follows. The household makes an optimal decision in the supply of labor and consumption, given the trajectory of future interest rates, wage rate, and tax rates. In the case of investment decisions, the firms perfectly consider the conditions of interest rates and the stock market in the future. The government also optimally decides its tax schemes under its intertemporal budget constraint. Given the current and future behavior of all sectors, market clearing conditions for goods, labor and capital must be satisfied.

Under the perfect foresight assumption, the current economy's conditions and behaviors are contingent on those of future economy. Hence, one must solve the equilibrium for the entire time frame, not for a given period.

3.1.3 The model description

Here, the specific model suggested in this paper is described. The model is an extension of the basic concept explained in 3.1.2.

3.1.3.1 Household

Individuals are faced with dynamic budget constraints over their lifetime. The general pattern is that the amount of consumption and saving is equalized to the sum of wage income and interest revenues.

$$(1+\tau_{ct})c_{t,gen} + A_{gen+1,t+1} - A_{gen,t} = (1-\tau_{wt} - \Theta_t)w_t e_{t,gen} + (1-\tau_{rt})r_t A_{t,gen} + Trans_{t,gen} \quad \text{Eq. (10)}$$

$$(1+\tau_{ct})c_{t,gen} = (1-\tau_{rt})(1+r_t)A_{t,gen} + B_t \quad \text{Eq. (11)}$$

Eq.(10) is the budget constraint at period t for the working generations, and Eq.(11) for the retired generation. The equation includes the three proportional taxes - the wage tax τ_w, the capital income tax τ_r, and the consumption tax τ_c. The household at the end of period t holds private assets (savings) A_t and invest it at the beginning of the next period t+1, thus earning capital income. $Trans_{t,gen}$, a parameter standing for the government transfer payments, represents the government incentive to be discussed in 3.4. It is assumed that young individual who just enters the job market has no savings and the last generation who retired have no wage. Θ_t is the contribution rate in "pay-as-you-go (PAYG)" pension plan and B_t represents the pension benefits received by the retired age group.

There are two types of pension plan in terms of its source of funding: fully-funded and unfunded, also known as PAYG. Since the social security system, mostly, is unfunded, this model also adopts the PAYG and defined benefit system for pension scheme. Hence, we first determine the amount of retirees' pension benefits, proportional to lifetime labor income (pension replacement rate). It is assumed that the retirees' pension benefits are completely financed by current younger working generations.

The net present value of life-time budget constraint is as shown below that present value of consumption spending does not exceed that of labor income.

$$\sum_{k=0}^{k=3} \prod_{\tau=t}^{t+k} [1+(1-\tau_{k\tau})r_\tau]^{-1} \{(1-\Theta_t-\tau_{wt+k})w_{t+k}e_{gen+k,t+k} - (1+\tau_{ct+k})c_{gen+k,t+k}\} \geq 0 \quad \text{......Eq. (12)}$$

Under the dynamic budget constraint, households maximize their utility, which is assumed to be of the CRRA function.

$$\frac{c_{gen+1,t+1}}{c_{gen,t}} = \left(\frac{(1+(1-\tau_{rt+1})r_{t+1})(1+\tau_{ct})}{(1+\delta)(1+\tau_{ct+1})} \right)^{\gamma} \quad \text{......Eq. (13)}$$

3.1.3.2 Supply behavior

There are two representative firms in two different sectors – namely progressive and stagnant. They use the primary factor inputs of labor and capital. The type of production functions is a Cobb-Douglas with a constant return to scale as in Eq.(5).

The difference from the basic model lies in the introduction of depreciation rate DR_t. In the basic model, it is assumed that the marginal product of capital is equal to the interest rate, while in this present model its marginal product is expressed as R_t and takes the form

$$r_t = \mathrm{R}_t - DR_t \quad \text{......Eq. (14)}$$

When we assume there is depreciation of capital, the conventional rule is that the interest rate is smaller than the rental price of capital (the marginal product of capital) because the firm which rentals the capital must compensate the loss of the capital owner, the household, stemming from the deprecation. Hence, the equations of the marginal product of labor and the marginal product of capital are modified into the following:

$$w_t = (1-\varepsilon)A(K_t)^{\varepsilon}(L_t)^{1-\varepsilon} / L_t \quad \text{......Eq. (15)}$$

$$R_t = \varepsilon A(K_t)^{\varepsilon}(L_t)^{1-\varepsilon} / K_t \quad \text{......Eq. (16)}$$

3.1.3.3 Government behavior

In this section, we specify the sources of tax revenues and aim to incorporate them into the model. The tax T_t included in the equations Eq.(17) is collected from all the generations through taxes on consumption (τ_c), labor income (τ_w) and capital income (τ_r).

$$T_t = \sum_{gen} Pop_{t,gen}\{\tau_{wt}(w_t e_{t,gen}) + \tau_{ct}(c_{t,gen}) + \tau_{rt}(r_t A_{t,gen})\} \quad \text{......Eq. (17)}$$

The government direct spending G_t is exogenous and given. In this model, the government spending stays constanMat over time. The total spending exceeds the budget constraint, the model assumes that the debt is automatically financed by the newly-issued government bonds, increasing the level of debt, D_t. Based on such assumptions, the government budget constraint is derived.

3.1.3.4 Market equilibrium conditions

For the goods market, the production of goods must be equal to the sum of consumption, investment and government consumption as in (18).

$$Y_t = \sum_{gen} Pop_{t,gen} c_{t,gen} + I_t + G_t \qquad \text{Eq. (18)}$$

In the same context, in terms of capital, the amount of accumulated capital at period t must be equated to the that of capital demanded by firms.

$$Kstock_t = K_t \qquad \text{Eq. (19)}$$

To satisfy the asset market equilibrium conditions, the assets of the entire economy must be the sum of assets held by each generation deducted by the public debts.

$$Kstock_{t+1} - Kstock_t = (\sum_g Pop_{t+1,g+1} A_{t+1,g+1} - \sum_g Pop_{t,g+1} A_{t,g+1}) - (D_{t+1} - D_t) \quad \text{Eq. (20)}$$

3.1.3.4.1 Labor market equilibrium and earning profiles

As other factors stated, labor market clearing conditions must be fulfilled, which requires the supply of labor be equal to the demand of labor. The equation takes the form

$$L_t = \sum_{gen} (Pop_{t,gen} e_{t,gen}) \quad \text{Eq. (21)}$$

where $e_{t,gen}$ is the earning (or productivity) profile as in the basic concept model. In our present model, it is assumed that the earning profiles are heterogeneous by sector, generation, and career path. Based on the earning profiles, together with other economic variables including wage and interest rates, individuals decide their career path, which is to be explained in 3.2.

3.2 Career Path Choice Model

The career path choice model describes the individuals' initial job choices and career change decisions. In career path choice modeling, only a one-time job change is allowed for simplicity. The possible career path options one can choose from are listed in **Table 2**.

Table 2. Individual's Career Path Possible States

1st stage (young worker: sector choice upon initial job market entry)	
Progressive Sector (P)	Stagnant Sector (S)

2nd stage (prime worker: choice of job switch) State (S2, S1)			
State (P, S)	State (S, P)	State (P, P)	State (S, S)

3rd Stage (old worker: choice of job switch/retirement) State (S3, S2)			
State (P, S)	State (S, P)	State (P, P)	State (S, S)

4th stage (oldest worker: no economic decisions made)
Mere existence (living on pension if still alive)

* P: Progressive Sector, S: Service Sector

Figure 4. Life-cycle Choice of Individuals

3.2.1 Career Path Choice Mechanism

While in the real world a myriad of factors account for one's career path choice, the basic assumption in this paper is that the choices are based on three factors: income, sector-preference and resistance to sector change. The general trend of earning profiles is estimated econometrically using panel data analysis, one of the most widely used methods, explained in detail in Appendix 1. To incorporate the heterogeneity in individual preferences and abilities, as well as the level of job change resistance unobserved in the panel data, the model adds the parameters, $prefer_{s,i}$ and $resist_{cp,gen}$, respectively. These individual-specific parameters are assumed to follow normal distribution. Though ability and aversion to job changes cannot be simply calculated at a certain level of income, for the modeling purpose, those parameters are set proportional to individual wages. In this career path choice sub-model, individuals decide their career path, so that they can maximize the net present value of their life-time incomes, as in Eq.(22), which is comprised of earning profiles (e), their preferences ($prefer$), resistance to sector shift ($resist$), equilibrium wage rate (w), and interest rate (r).

$$prefer_{s,i} \sim N(\mu_{s,i}, \sigma_{s,i}{}^{2})$$

$$resist_{cp,gen} \sim N(\mu_{cp,gen}, \sigma^{2}{}_{cp,gen})$$

$$\max_{cp} Income^{npv} = w_{s,t} e_{cp,s,gen,i} + \frac{w_{s,t+1} e_{cp,s,gen+1,i}}{1+r_t} + \frac{w_{s,t+2} e_{cp,s,gen+2,i}}{(1+r_t)(1+r_{t+1})} + prefer_{s,i} - resist_{cp,gen}$$

Eq. (22)

3.2.2 Soft-linking with CGE Model

In this paper, the OLG-CGE and career path choice models can be classified as a top-down and bottom-up model, respectively. In general, there two types of linking methods between the models: hard-linked or soft-linked. In terms of a soft-linking (or partial link) method, the two models operate together iteratively, passing the price and quantity variable between the two, to find the convergence in those variables (Kumbaroğlu and Madlener, 2003). In comparison, the hard-linking approach fully integrates the two models and solves them with simultaneous optimization. Those two approaches are generally named hybrid-models. Hard-linking has advantages in analyzing the global trend with marginal stress on the regional details, while soft-linking is effective when it is necessary to consider the regional details (Krook-Riekkola, et al., 2017).

This present paper adopts the soft-linking approach to exploit its strengths in keeping the regional attributes (individuals' career choice) intact.

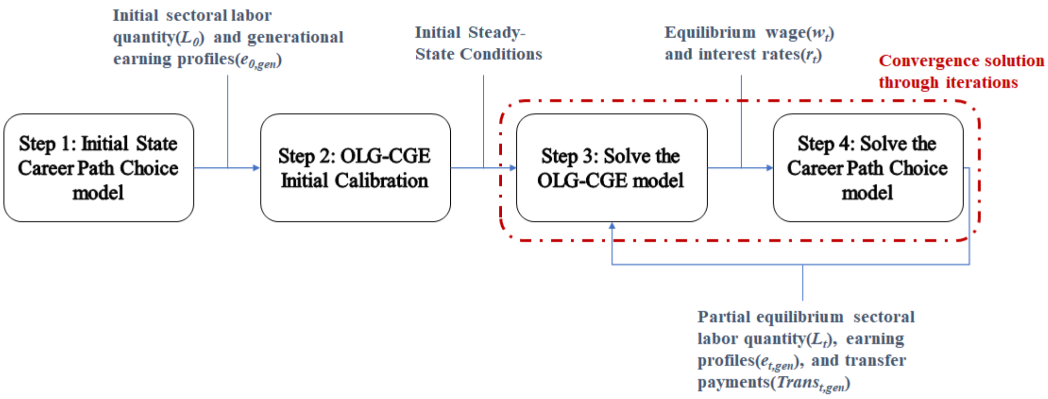


Figure 5. The Diagram of Soft-link between OLG-CGE model and Career Path Choice model

3.2.2.1 Convergence of Iterative Methods

As shown in **Figure 5**, the hybrid model, by iterating between the top-down CGE model and the bottom-up career path choice model, finds a convergent solution. In Step 1, given the initial wage and interest rates, individuals decide their career, which leads to the sectoral allocation of labor in the economy, as in Eq. (23),

$$L_{0,s} = \sum_{gen} Pop_{gen} \zeta_{gen,s} \quad \cdots\cdots \text{Eq. (23)}$$

where $L_{0,s}$ is the sectoral labor supply quantity and $\zeta_{gen,s}$ is the sectoral share of each generation.

Every individual has their own earning profiles, depending on their choices and the average aggregate earnings by generation constitute the generational heterogeneous earning profiles ($e_{t,gen}$) in Eq. (10). This procedure is expressed in Eq. (24),

$$e_{t,gen} = \sum_i ei_{t,gen,i} / Pop_{gen} \quad \text{Eq. (24)}$$

where $ei_{t,gen,i}$ is each individual's earning profile.

In Step 2, with the transmitted labor supply quantity and earning profiles, the OLG-CGE model is calibrated to the initial steady-state data set. In the next step, the OLG-CGE model is solved for equilibrium prices and quantities without any shock introduced. The total number of time periods for the model are assumed to be 20 (each equivalent to the length of one generation). The equilibrium wage and interest rates derived for all periods in Step 3 are passed over to the career path choice model.

In Step 4, incorporating the wage and interest rates newly given by the OLG-CGE model, the career path choice model has individuals re-choose their career. This generates new levels of sectoral labor and earning profiles, which again, updates the values in the OLG-CGE model.

Without any shocks, the iterations of Step 3 and 4 produce the same results of quantities and prices as set and calibrated in Step 1 and 2. However, any changes in parameters due to the introduction of a new policy can alter equilibrium prices and quantities, and through numerous interactions, the models obtain the converging solutions.

3.3 Calibration

3.3.1 Initialization

The model is calibrated to the fictional data stated in the social accounting matrix (SAM) of **Table 3** and level of parameters in **Table 4** and **Table 5**. It is assumed that there is no intermediary goods and production is sole based on the primary factors (capital and labor). Full employment is assumed and involuntary unemployment is not allowed in the model. In the calibration process, the prices of variables including labor and capital are initially set to one.

Table 3. The Social Accounting Matrix

		Activity		*Factor*		*Agents*			
		Progressive	Stagnant	Capital	Labor	Household	Government	Investment	Total
Activity	Progressive					61.167	25	5	91.167
	Stagnant					32.833	26	15	73.833
Factor	Capital	45	20						65
	Labor	46.167	53.833						100
Agents	Household			49	83				132
	Tax			16	17	18			51
	Saving					20			20
Total		91.167	73.833	65	100	132	51	20	

Table 4. Initial values of parameters for the CGE model

Parameters	Descriptions	Values
γ	Intertemporal elasticity of substitution	0.133

δ	Discount rate (or time preference)	1.978
A	Total factor productivity	*Prog*: 2.781 *Stag*: 2.149
ε	Share of capital use in production	*Prog*: 0.494 *Stag*: 0.271
τ_w	Wage tax	0.170
τ_c	Consumption tax	0.191
τ_r	Capital income tax	0.246
DR	Depreciation rate	0.6

* *Prog* stands for progressive, *Stag* for stagnant.

Table 5. Initial values of parameters for the Career Path Choice model

Parameters	Descriptions	Values
$(\mu_{s,i}, \sigma^2_{s,i})$	Mean and variance of normal distribution for sectoral preference	*Prog*: (0, 0.4* I^{npv}) *Stag*: (0.1* I^{npv}, 0.3* I^{npv})
$(\mu_{cp,gen}, \sigma^2_{cp,gen})$	Mean and variance of normal distribution for sectoral switch resistance	*cp2,gen2:* (0.15* I^{npv}, 0.1* I^{npv}) *cp3,gen3:* (0.2* I^{npv}, 0.5* I^{npv}) *cp4,gen2:* (0.15* I^{npv}, 0.1* I^{npv}) *cp5,gen3:* (0.4* I^{npv}, 0.5* I^{npv})

* *Prog* stands for progressive, *Stag* for stagnant. The mean and variance values of parameters are approximately expressed as a scaled value of I^{npv}, the maximum income.

3.3.2 Population

In this specific model, the population of each generation is assumed to be equal (population growth rate equals 1). It can be stricken as an extreme assumption, but the model still provides meaningful benchmark to future advanced models with real demographic data.

$$Pop_{t,gen+3} = Pop_{t,gen+2} = Pop_{t,gen+1} = Pop_{t,gen}$$

3.3.3 Initial Steady-State

In this model, individuals decide their career path from six options to maximize their net present income level considering heterogenous earning profiles dependent on career path, preferences, ability and penalties. Since this heterogeneity is unobserved from the earning profiles only, I try to calibrate those factors to make the share of initial career path choice of individuals and sectoral employment share similar to those of labor and income panel data.

Table 6. Initial Career Path Choice Share

Career Path No.	States			No. of Individuals (%)
	S1	S2	S3	
1	Progressive	Progressive	Progressive	50 (0.250)
2	Progressive	Stagnant	Stagnant	24 (0.120)
3	Progressive	Progressive	Stagnant	14 (0.070)
4	Stagnant	Stagnant	Stagnant	73 (0.365)
5	Stagnant	Progressive	Progressive	26 (0.130)
6	Stagnant	Stagnant	Progressive	8 (0.040)

Table 7. Initial Sectoral Share by Generation

	Generation			Total (%)
	Gen 1	Gen 2	Gen 3	
Progressive	93	95	89	277 (46.17)
Stagnant	107	105	111	323 (53.83)

3.4 Incentive Policy Scenarios

There are two types of incentive programs to be considered in the model and both are aimed at reallocating the youngest generation to the progressive sector and older workers to the stagnant. The first one, expressed as *Incentive_S*, is to provide incentive to those who change their job from the progressive to stagnant sector at Generation 3. The other one, *Incentive_P*, is to incentivize starting career in the progressive sector at Generation 1. It is noted that the aggregate amount of incentives of different policy mixes are fixed at equal. The incentive policy scenarios are planned, as in **Table 8**.

As in the real world, the incentive beneficiary's career plan prior to the execution of a policy is unknown to the government. In other words, those who change their career path to the one targeted by the policy (thanks to the increased income) and those who originally intend to choose the targeted path, can both be the recipients.

Table 8. Incentive Scenarios

Scenarios	*Incentive_P*	*Incentive_S*
BAU (No Incentive)	-	-
Scenario 1	-	100 %
Scenario 2	100 %	-
Scenario 3	50 %	50 %
Scenario 4	20 %	80 %
Scenario 5	80 %	20 %

Chapter 4. Simulations and Results

This section examines the labor reallocation effects of each incentive policy. Each policy is put into effect for only one period, at T8, and then the changes in the labor quantity of each specific generation by sector are analyzed over periods affected after the adoption of the policy.

4.1 Scenario 1

The first incentive scenario to be investigated is to spend the entire amount of incentive budget on the old workers (*Gen 3*) who switch from the progressive to stagnant sector (*career path 3*). Given the assigned budget and incentive, the total number of beneficiaries is calculated to be 12.

Table 9 demonstrates the results of labor reallocation by the incentive policy. It is noted that while the policy is placed in effect at period T8, the actual effect begins to appear at period T6. Given perfect foresight assumption, when the individuals of the first generation choose which sector they enter, they rationally make a decision based on the complete information about the future changes of economic variables and government transfer payments.

First, we examine the major purpose of this policy--*Gen 3* switching from progressive to stagnant sector at period T8. It is observed that, six of 200 oldest workers (3%p) move from the progressive to stagnant industry. More detailed analysis of the policy effects necessitates the examination of the results at an individual level.

Table 9. Scenario 1's Labor Reallocation Results

	Gen 1		Gen 2		Gen 3	
	Prog	*Stag*	*Prog*	*Stag*	*Prog*	*Stag*
~ T5	93	107	95	105	89	111
T6	97 **(+2%p)**	103 **(-2%p)**	95	105	89	111
T7	93	107	99 **(+2%p)**	101 **(-2%p)**	89	111
T8	94 **(+0.5%p)**	106 **(-0.5%p)**	96 **(+0.5%p)**	104 **(-0.5%p)**	83 **(-3%p)**	117 **(+3%p)**
T9	93	107	94 *(-0.5%p)*	106 *(+0.5%p)*	90 *(+0.5%p)*	110 *(-0.5%p)*
T10	93	107	95	105	88 **(-0.5%p)**	112 **(+0.5%)**

T11~	93	107	95	105	89	111

Note: The bold characters in parentheses are the originally intended effects of a policy, while the italic is not. *Prog* stands for progressive, *Stag* for stagnant.

Figure 6 and **Figure 7** show the change of individual career path choices after the adoption of the policy. Among the 12 recipients of the incentive, four individuals changed their original career path. Of those four workers, only two contributed to the intended increase in the stagnant sector's share of Generation 3, while ones who originally chose career path 2 or 4 does not make a contribution. The rest of the changes (four of six *Gen 3* at T8) stems from the change of wage rate in equilibrium. Hence, in this scenario, at period T8, the direct consequence of the incentive is less than that of the change in labor rental price due to the employment share change in the economy.

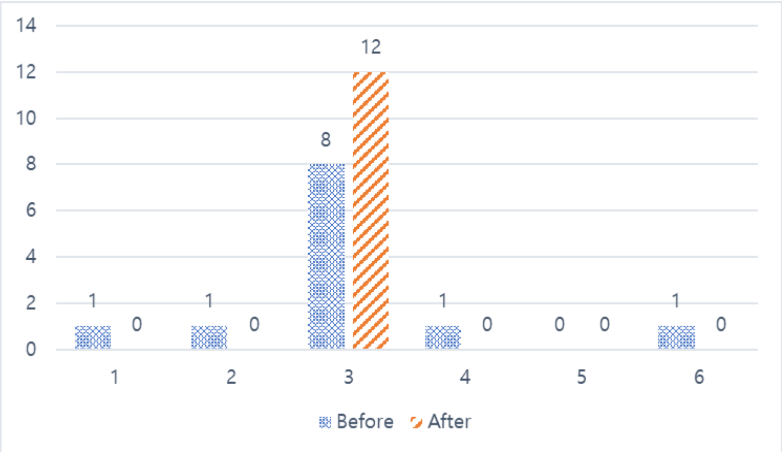


Figure 6. Scenario 1's Career Path Changes of Recipients of *Incentive_S* at T6

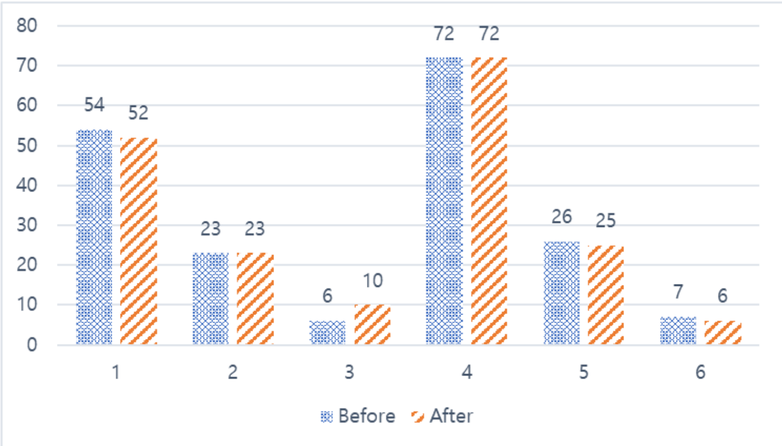


Figure 7. Scenario 1's Career Path Changes of Non-recipients of *Incentive_S* at T6

Next, the wage rate fluctuations are examined. In Scenario 1, the biggest difference in wage rate between the progressive and stagnant sectors is 0.018 at T4, as shown in **Figure 8**. The largest difference within each industry over time is 0.009 for the progressive sector and 0.031 for the stagnant one.

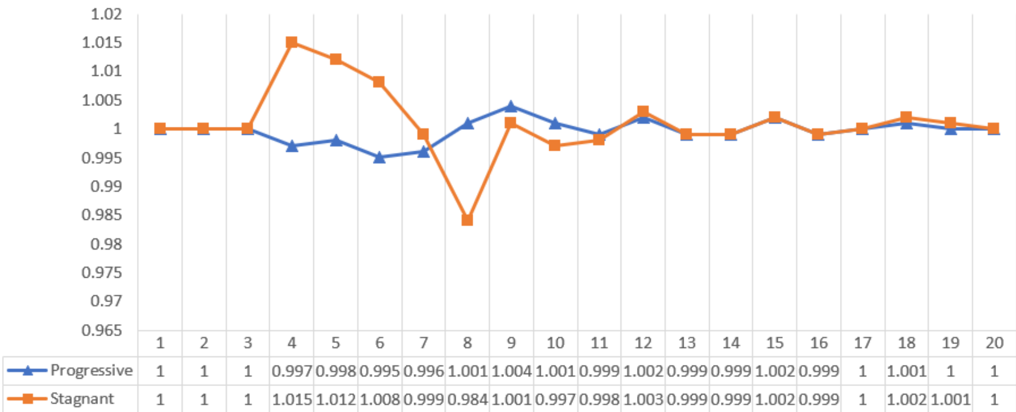


Figure 8. Scenario 1’s Wage Rate Fluctuations over Time

4.2 Scenario 2

The second incentive scenario is to have the entire amount of incentive budget spent on the young workers (*Gen 1*) who enter the progressive sector upon their first job market entry (*career paths 1, 2, 3*). Given the allocated budget and incentive, the total number of beneficiaries is estimated to be 60.

Table 10 illustrates the results of labor reallocation by the incentive policy. It is notable that, unlike Scenario 1, the policy effects start at period T8, synchronized with the time when the policy is actually enforced. The results showed that at period T8, of 200 young workers, 11 (5.5%p) changed their career paths and chose to enter the progressive sector.

Table 10. Scenario 2's Labor Reallocation Results

	Gen 1		Gen 2		Gen 3	
	Prog	*Stag*	*Prog*	*Stag*	*Prog*	*Stag*
~T7	93	107	95	105	89	111
T8	104 **(+5.5%p)**	96 **(-5.5%p)**	95	105	89	111
T9	93	107	96 **(+0.5%p)**	104 **(-0.5%p)**	89	111
T10	93.5 **(+0.25%p)**	106.5 **(-0.25%p)**	95.5 **(+0.25%p)**	104.5 **(-0.25%p)**	83.5 **(-2.75%p)**	116.5 **(+2.75%p)**

T11	93	107	95	105	89.5 *(+0.25%p)*	110.5 *(-0.25%p)*
T12	93	107	95	105	89	111
T13~	93	107	95	105	89	111

Note: The blue colors in parentheses are the originally intended effects of a policy, while the red-colors are not. *Prog* stands for progressive, *Stag* for stagnant.

As for the individual career path change, among the 60 incentive recipients, only five individuals changed their original career path, with the remaining 55 having originally planned to start their career in the progressive industry (**Figure 9**).

In fact, the rest of the contributions to labor quantity change in **Table 10** (six individuals) stems from the wage rate change in equilibrium. Hence, in this Scenario 2, at period T8, the incentive's effect can be counted a little less than that of the labor price rate adjustment due to the employment share change in the economy.

The individuals directly or indirectly affected by the implementation of the policy at period T8 continue to affect the sectoral labor quantity at period T10, resulting in the increase in *Gen 3*'s quantity in the stagnant sector by 5.5.

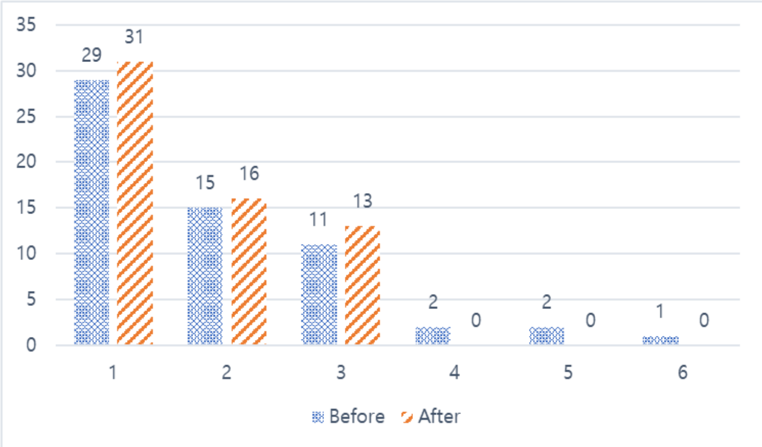


Figure 9. Scenario 2's Career Path Changes of Recipients of *Incentive_P* at T8

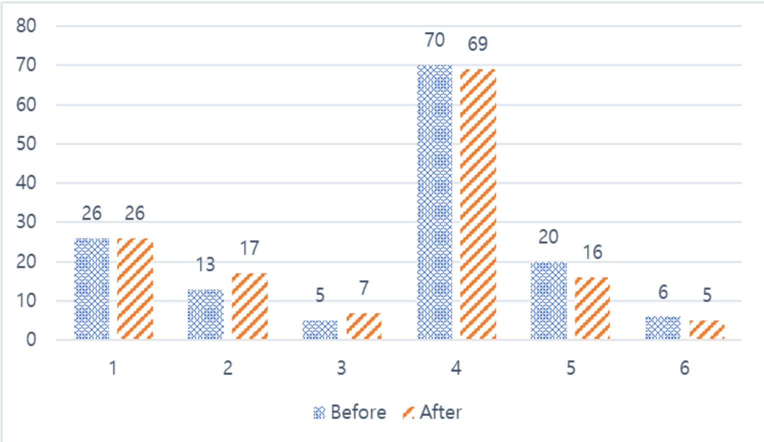


Figure 10. Scenario 2's Career Path Changes of Non-recipients of *Incentive_P* at T8

Next, the wage rate fluctuations are examined. In Scenario 2, the biggest difference in the wage rate between the progressive and stagnant sectors is 0.038 at T8, as shown in **Figure 11**. The largest difference within each industry over time is 0.031 for the progressive sector and 0.062 for the stagnant one.

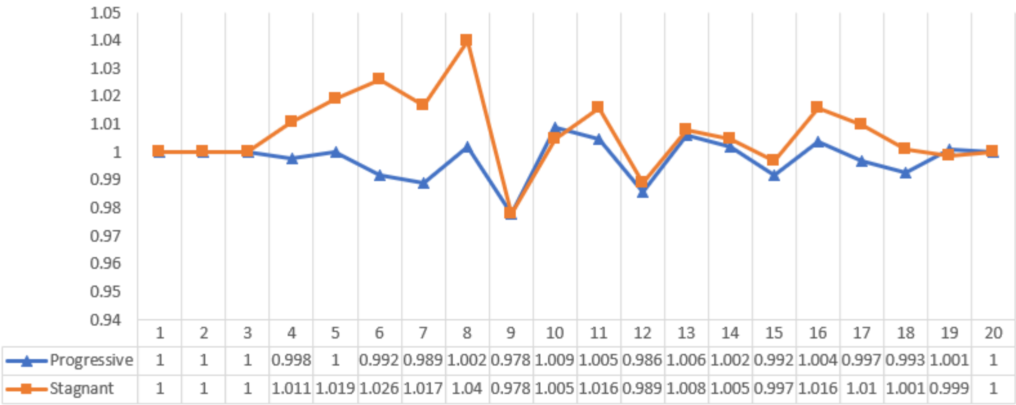


Figure 11. Scenario 2's Wage Rate Fluctuations over Time

4.3 Scenario 3

Scenario 3, 4, and 5 are designed to combine two incentive plans - *Incentive_S* of scenario 1 and *Incentive_P* of scenario 2-- within the fixed budget. The incentive for Scenario 3 allocates each half of the budget to each incentive plan. Therefore, the number of beneficiaries of *Incentive_S* is six, and those of *Incentive_P* are 30.

Table 11 illustrates the results overview of labor reallocation by the incentive policy. To examine this mixed incentive plan, it is required to attend to two time periods, T6 and T8. As stated in 4.1 and 4.2, the effects of *Incentive_S* begin to appear from T6, while *Incentive_S* starts to have an influence primarily from T8.

Table 11. Scenario 3's Labor Reallocation Results

	Gen 1	Gen 2	Gen 3

	Prog	Stag	Prog	Stag	Prog	Stag
~T5	93	107	95	105	89	111
T6	97 **(+2%p)**	103 **(-2%p)**	95	105	89	111
T7	93	107	99 **(+2%p)**	101 **(-2%p)**	89	111
T8	95 **(+1%p)**	105 **(-1%p)**	96 **(+0.5%p)**	104 **(-0.5%p)**	83 **(-3%p)**	117 **(+3%p)**
T9	93	107	96 **(+0.5%p)**	104 **(-0.5%p)**	90 *(+0.5%p)*	110 *(-0.5%p)*
T10	93	107	95	105	90 *(+0.5%p)*	110 *(-0.5%p)*
T11~	93	107	95	105	89	111

Note: The blue colors in parentheses are the originally intended effects of a policy, while the red-colors are not. *Prog* stands for progressive, *Stag* for stagnant.

At T8, it is observed that of the 200 individuals, six individuals of *Gen 3* (3%p) moved from progressive to stagnant, as intended by *Incentive_S*. As shown in **Figure 12** and **Figure 13**, non-recipients contributed to the greater part of reallocation, where the total was five of six, while the incentive increased the quantity to one. In contrast, in the case of *Gen 1*'s switch from stagnant to progressive sectors, this was solely made by incentive beneficiaries, as shown in **Figure 14** and **Figure 15**. In this model *Gen 3*'s sectoral labor quantity changes are more relevant to future economic variable changes, while *Gen 1*'s choices are more dependent on the incentive itself.

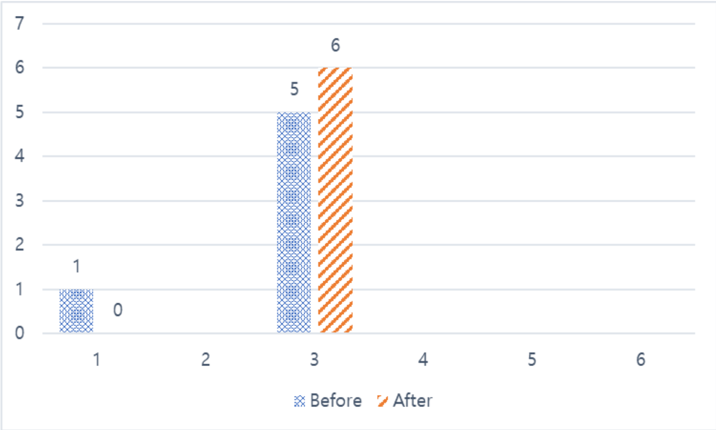


Figure 12. Scenario 3's Career Path Changes of Recipients of *Incentive_S* at T6

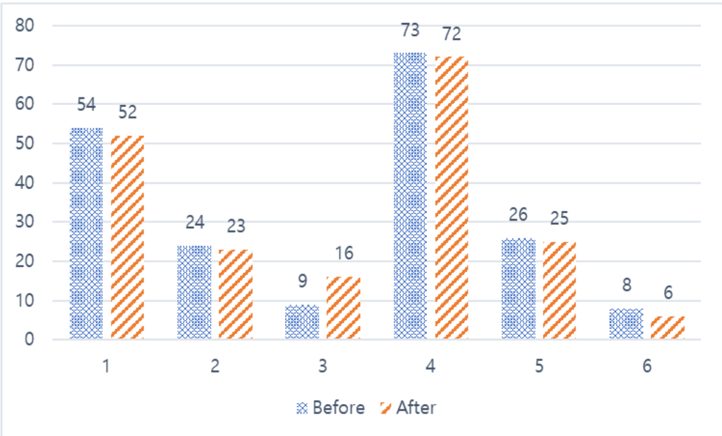


Figure 13. Scenario 3's Career Path Changes of Non-recipients of *Incentive_S* at T6

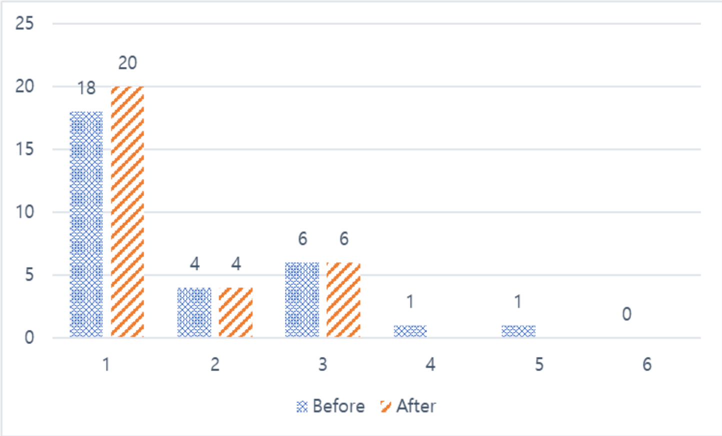


Figure 14. Scenario 3's Career Path Changes of Recipients of *Incentive_P* at T8

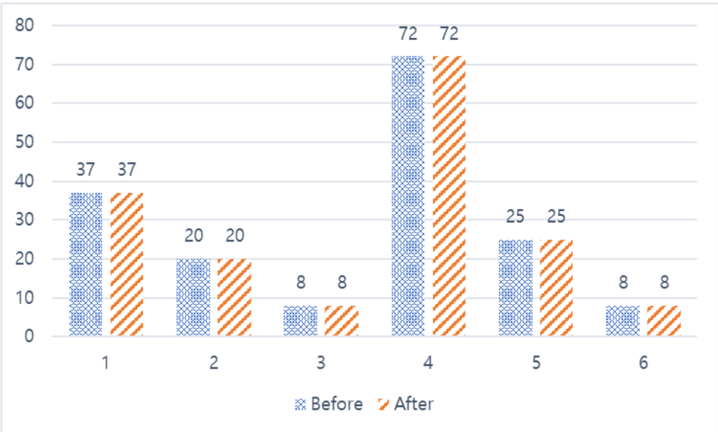
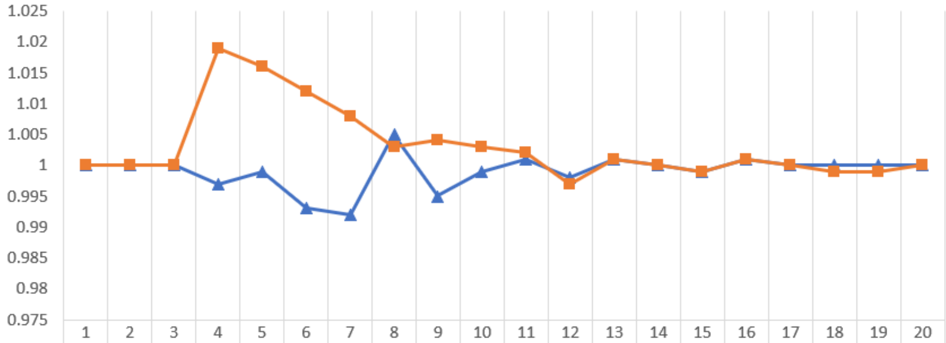


Figure 15. Scenario 3's Career Path Changes of Non-recipients of *Incentive_P* at T8

The wage rate fluctuations are then examined. In Scenario 3, the biggest difference in wage rate between the progressive and stagnant sectors is 0.022 at T4, as shown in **Figure 16**. The largest difference within each industry over time is 0.013 for the progressive sector, and 0.022 for the stagnant one.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Progressive	1	1	1	0.997	0.999	0.993	0.992	1.005	0.995	0.999	1.001	0.998	1.001	1	0.999	1.001	1	1	1	1
Stagnant	1	1	1	1.019	1.016	1.012	1.008	1.003	1.004	1.003	1.002	0.997	1.001	1	0.999	1.001	1	0.999	0.999	1

Figure 16. Scenario 3's Wage Rate Fluctuations over Time

4.4 Scenario 4

Scenario 4 allocates 80 % of budget to *Incentive_S*, and 20% to *Incentive_P*. Given the budget and incentive assigned to each incentive plan, the number of beneficiaries of *Incentive_S* is 9, and those of *Incentive_P* is 15.

Table 12 illustrates the results overview of labor reallocation by the incentive policy. At T8, it is observed that 6 of 200 *Gen 3* individuals (3%p) switch from the progressive to stagnant sectors, as intended by *Incentive_S*. As shown in **Figure 17** and **Figure 18**, non-recipients contribute to the greater part of reallocation, in total five of six, while the incentive increases quantity 1. In contrast, in the case of *Gen 1*'s switch from the stagnant to progressive sectors is solely made by incentive beneficiaries, as shown in **Figure 19** and **Figure 20**. This trend shows large similarity with Scenario 3.

Table 12. Scenario 4's Labor Reallocation Results

	Gen 1		Gen 2		Gen 3	
	Prog	*Stag*	*Prog*	*Stag*	*Prog*	*Stag*
~T5	93	107	95	105	89	111
T6	97 **(+2%p)**	103 **(-2%p)**	95	105	89	111
T7	93	107	99 **(+2%p)**	101 **(-2%p)**	89	111
T8	95.5 **(+1.25%p)**	104.5 **(-1.25%p)**	95.5 **(+0.25%p)**	104.5 **(-0.25%p)**	83 **(-3%p)**	117 **(+3%p)**
T9	93	107	95.5 **(+0.25%p)**	104.5 **(-0.25%p)**	89.5 *(+0.25%p)*	110.5 *(-0.25%p)*
T10	93	107	95	105	89.5 *(+0.25%p)*	110.5 *(-0.25%p)*
T11~	93	107	95	105	89	111

Note: The blue colors in parentheses are the originally intended effects of a policy, while the red-colors are not. *Prog* stands for progressive, *Stag* for stagnant.

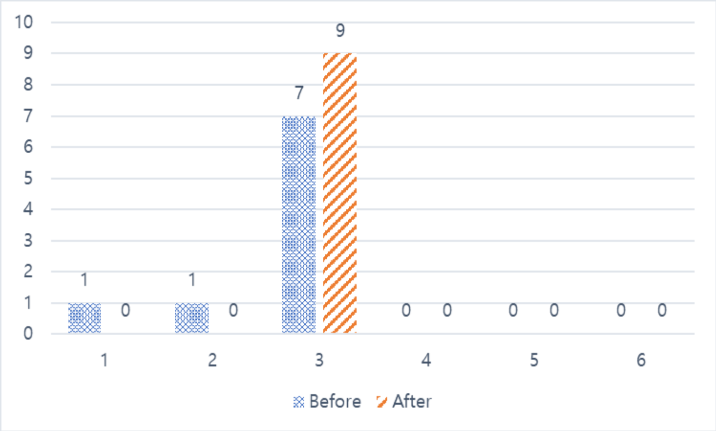


Figure 17. Scenario 4's Career Path Changes of Recipients of *Incentive_S* at T6

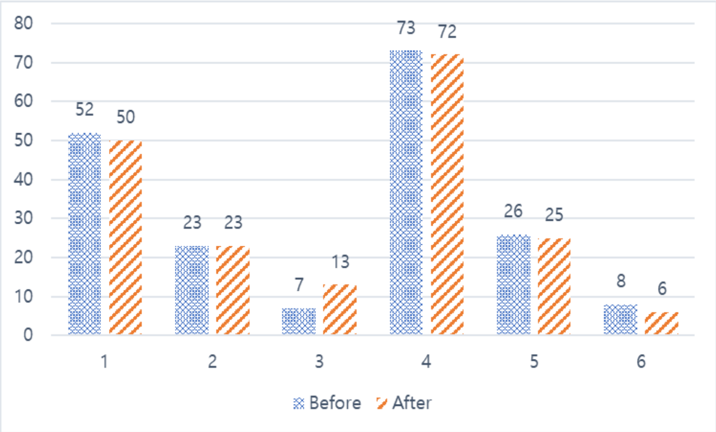


Figure 18. Scenario 4's Career Path Changes of Non-recipients of *Incentive_S* at T6

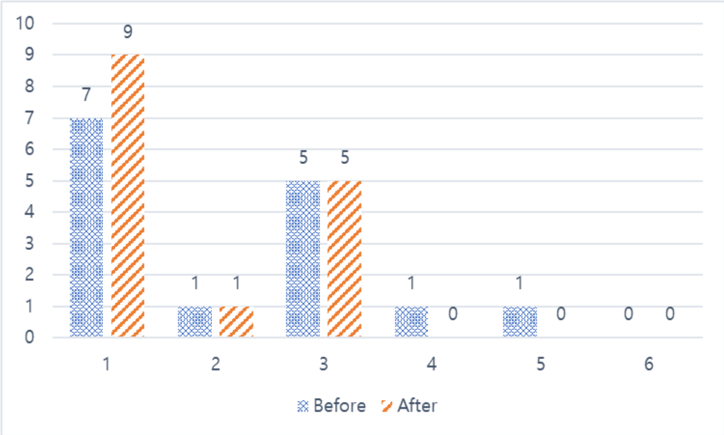


Figure 19. Scenario 4's Career Path Changes of Recipients of *Incentive_P* at T8

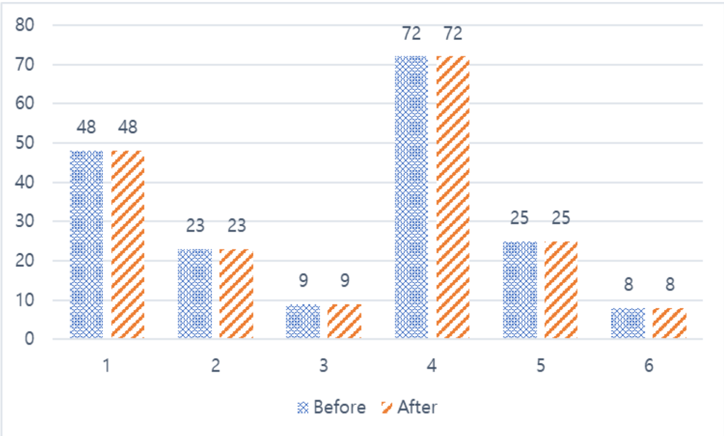


Figure 20. Scenario 4's Career Path Changes of Non-recipients of *Incentive_P* at T8

Then, the wage rate fluctuations are examined. In Scenario 4, the biggest difference in wage rate between the progressive and stagnant sectors is 0.02 at T4 , as shown in **Figure 21**. The largest difference within each industry over time is 0.01 for the progressive sector, and 0.018 for the stagnant one.

Figure 21. Scenario 4's Wage Rate Fluctuations over Time

4.5 Scenario 5

Scenario 5 allocates 20 % of budget to *Incentive_S*, and 80% to *Incentive_P*. Given the budget and incentive assigned to each incentive plan, the number of beneficiaries of *Incentive_S* is 3, and those of *Incentive_P* is 45.

Table 13 illustrates the results overview of labor reallocation by the incentive policy. At T8, it is observed that 6 of 200 *Gen 3* individuals (3%p) switch from the progressive to stagnant sectors, as intended by *Incentive_S*. As shown in **Figure 22** and **Figure 23**, non-recipients solely contribute to the reallocation of labor. In contrast, in the case of *Gen 1*'s switch from the stagnant to progressive sectors is solely made by incentive beneficiaries, as shown in **Figure 24** and **Figure 25**. This trend shows large similarities with the Scenarios 3 and 4.

Table 13. Scenario 5's Labor Reallocation Results

	Gen 1		Gen 2		Gen 3	
	Prog	*Stag*	*Prog*	*Stag*	*Prog*	*Stag*
~T5	93	107	95	105	89	111
T6	97 **(+2%p)**	103 **(-2%p)**	95	105	89	111
T7	93	107	99 **(+2%p)**	101 **(-2%p)**	89	111
T8	99 **(+3%p)**	101 **(-3%p)**	95.5 **(+0.25%p)**	104.5 **(-0.25%p)**	83 **(-3%p)**	117 **(+3%p)**
T9	93	107	97 **(+1%p)**	103 **(-1%p)**	89.5 *(+0.25%p)*	111.5 *(+0.25%p)*
T10	93	107	95	105	88 **(-0.5%p)**	112 **(+0.5%p)**
T11~	93	107	95	105	89	111

Note: The blue colors in parentheses are the originally intended effects of a policy, while the red-colors are not. *Prog* stands for progressive, *Stag* for stagnant.

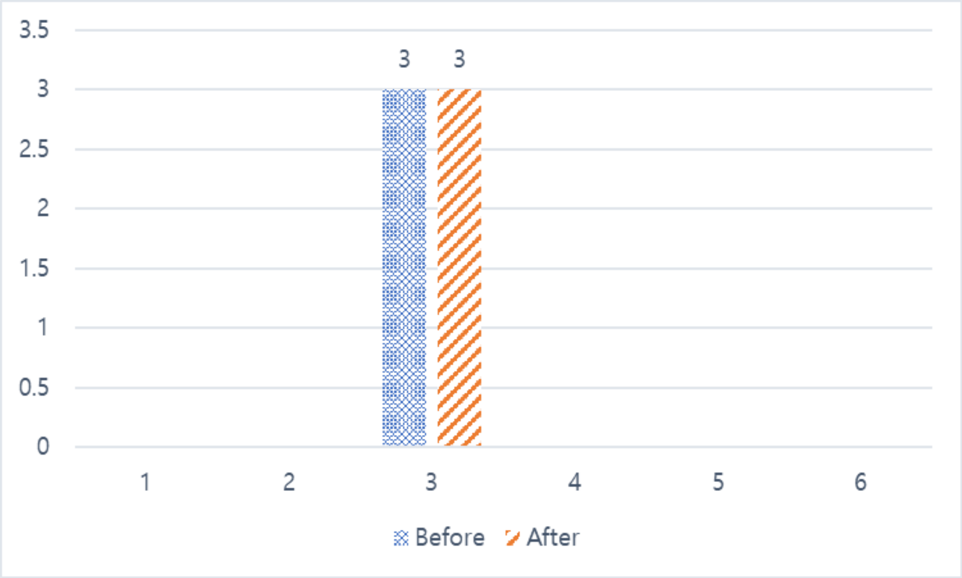


Figure 22. Scenario 5's Career Path Changes of Recipients of *Incentive_S* at T6

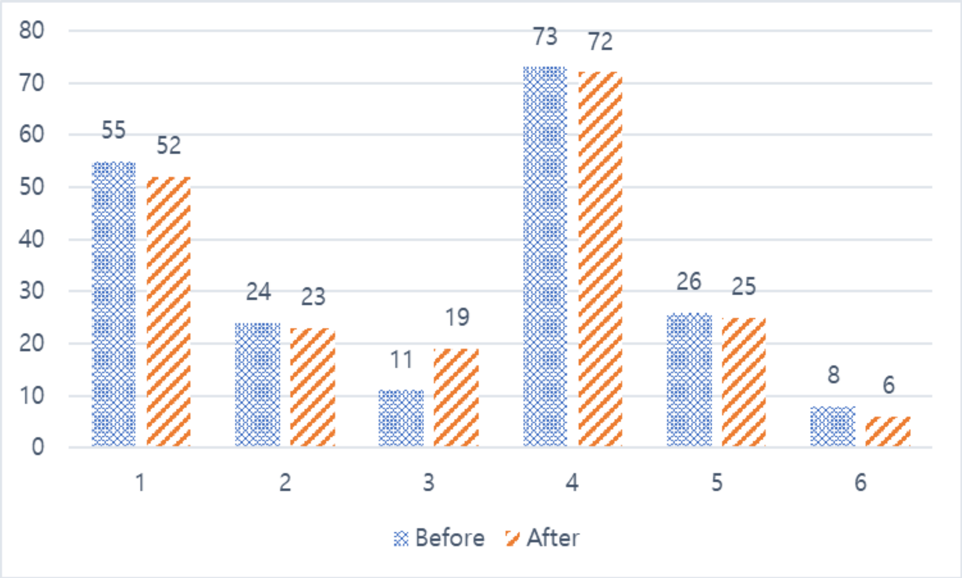


Figure 23. Scenario 5's Career Path Changes of Non-recipients of *Incentive_S* at T6

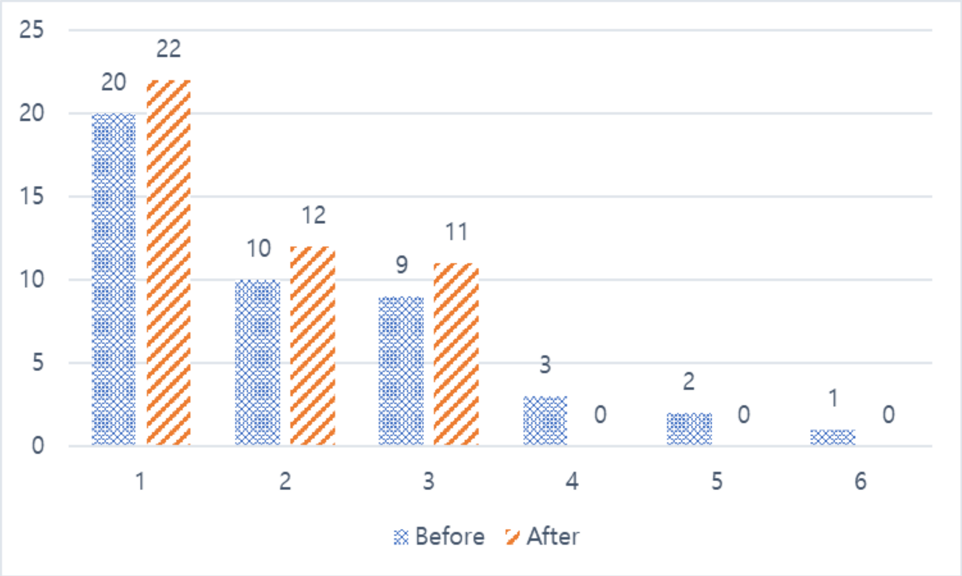


Figure 24. Scenario 5's Career Path Changes of recipients of *Incentive_P* at T8

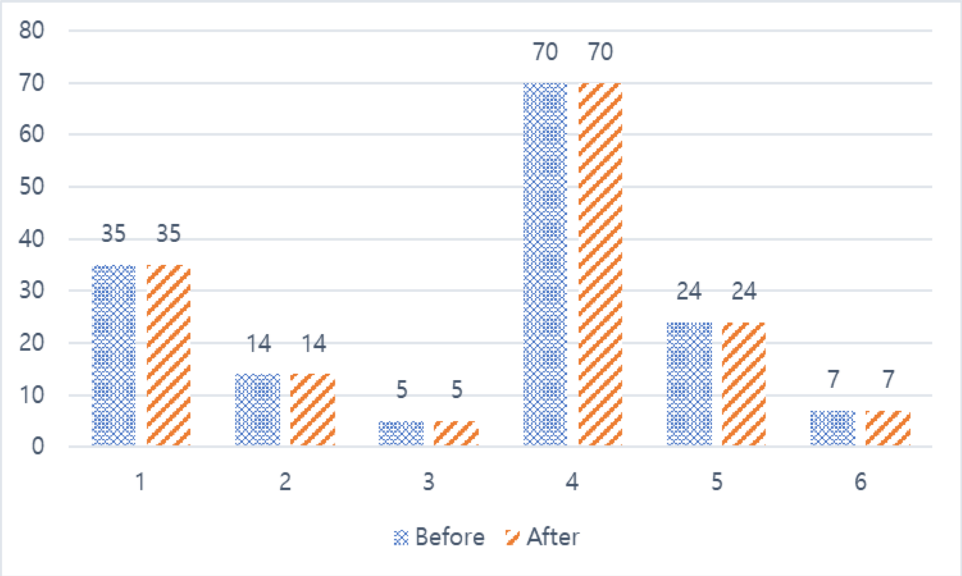
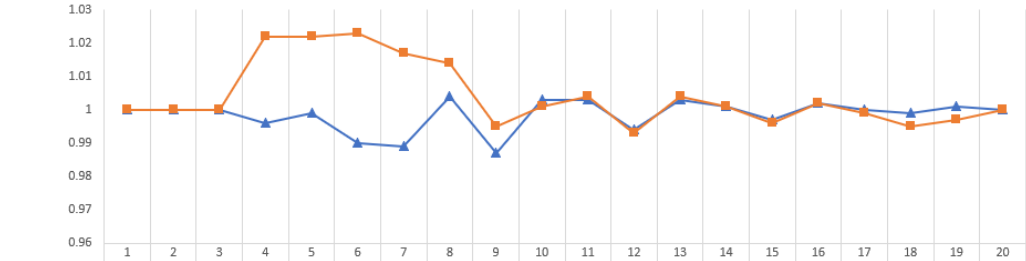


Figure 25. Scenario 5's Career Path Changes of Non-recipients of *Incentive_P* at T8

The wage rate fluctuations are, then, investigated. In Scenario 5, the biggest difference in wage rate between the progressive and stagnant sectors is 0.033 at T6, as shown in **Figure 26**. The largest difference within each industry over time is 0.017 for the progressive sector, and 0.03 for the stagnant one.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Progressive	1	1	1	0.996	0.999	0.99	0.989	1.004	0.987	1.003	1.003	0.994	1.003	1.001	0.997	1.002	1	0.999	1.001	1
Stagnant	1	1	1	1.022	1.022	1.023	1.017	1.014	0.995	1.001	1.004	0.993	1.004	1.001	0.996	1.002	0.999	0.995	0.997	1

Figure 26. Scenario 5's Wage Price Fluctuations over Time

4.6 Aggregate Effects Over All Time Periods

This section covers the aggregate effects of each incentive scenario over all time periods. As shown in previous sections, each policy not only affects directly the incentive beneficiaries, but also indirectly affects the remaining individuals by inducing changes in economic variables. Hence, to properly analyze the policy effect on the economy, it is critical to examine the sum of changes over all time periods in the model. The aggregated sum of changes from before the policy values are listed in **Table 14**.

Table 14. The aggregate effects of incentive scenarios on labor reallocation for entire periods

	Scenario	1 (0: 100)	2 (100 : 0)	3 (50 : 50)	4 (20 : 80)	5 (80 : 20)
Aggregate Effects (%p)	G1	*P* +2.5	*P* +5.75	*P* +3	*P* +3.25	*P* +5
	G2	*P* +2	*P* +0.75	*P* +3	*P* +3	*P* +3.25
	G3	*S* +2	*S* +2.75	*S* +4	*S* +2.5	*S* +3.75
	G1, G3	+4.5	+8.5	+7	+5.75	+8.75
	G1, G2	+4.5	+6.5	+6	+6.25	+8.25
	G1, G2, G3	+6.5	+9.25	+10	+8.75	+12

Note: In the parenthesis are the shares of two incentives, *Incen_P* and *Incen_S*, in each scenario. *P* stands for progressive, *S* for stagnant.

First, the standard by which we compare the two scenarios can be the sum of changes made by the directly affected cohorts, Generations 1 and 3. In this case, incentive scenarios 2 and 5 appear to create the largest amount of movement (17 for scenario 2, and 17.5 for scenario 5) among individuals.

However, comparing another standard tells a different story. When a policy is aimed at allocating a greater number of not only young workers (*Gen* 1), but also prime workers (*Gen* 2), policy Scenario 5 is the most effective. Thus, the second best option is Scenario 3, while Scenario 2 ranks third.

In this particular model, Scenario 1, spending the entire subsidy on Generation 3, shows relatively low performance in obtaining the policy objective.

Figure 14 shows a summary of the effects of each incentive policy mix on the standard wage rate. Despite their similar effects, Scenarios 2, 3, and 5 create distinctive impacts on wage rates. Scenarios 3 and 5, which offer incentives for both groups of people create a smaller level of wage rate gaps between two sectors than did Scenario 2, aimed at incentivizing only young cohorts. In terms of wage rates within each sector, Scenarios 3 and 5 show a relatively low degree of fluctuations.

Table 15. The aggregate effects of incentive scenarios on wage fluctuations for entire periods

Scenario	1 (0: 100)	2 (100 : 0)	3 (50 : 50)	4 (20 : 80)	5 (80 : 20)
Peak difference	0.018(T4)	0.038(T8)	0.022(T4)	0.02(T4)	0.033(T6)
Peak-to-Peak in Progressive	0.009	0.031	0.013	0.01	0.017
Peak-to-Peak in Stagnant	0.031	0.062	0.022	0.018	0.03

Note: In the parenthesis are the shares of two incentives, *Incen_P* and *Incen_S*, in each scenario. *P* stands for progressive, *S* for stagnant.

Chapter 5. Conclusions

The consequences of each scenario show that, when labor policies, including the incentive policy in this model, are implemented, their effects should be comprehensively analyzed. Economic policies not only have a direct impact on the targeted sector or generation, but also place indirect effects on the rest of the economy by making alternations in the economic variables.

Furthermore, as demonstrated in Scenarios 3, 4 and 5, a sectoral change of a certain generation (*Gen 3* in this model) can be more strongly driven by the changes of economic variables, rather than the direct effects of the incentive policy. It was also observed that each policy showed differences in terms of the length of time affected by the policy.

In addition, the scenarios showed that before the implementation of a policy, its effects on the fluctuations in economic variables, exemplified with standard wage rate changes in this paper, might need to be considered. When an incentive policy incentivizes certain groups of workers to move in one direction, as in Scenario 2, the wage rate inequality between the two sectors may be widened and the level of wage rates may be more unstable. Therefore, it would be better to lead one group to switch in one direction and another in the other direction to reduce the fluctuations in wage rate.

Hence, it would be of great consequence for policy making to be carried out by proper standards of how long the policy has a desirable impact on the economy, which generations are affected, and how much wage rate discrepancy can be generated.

There are a number of limitations in this research. First, as presented in the model, the paper was not based on any real data. It would be more practical and offer more insights to labor policy if the model incorporates empirical socio-economic data including demographic changes critical to age-specific research. Second, for simplicity, the model decomposes the economy into two sectors and categorizes the household into four generations, which can be extended to have more variety of sectors and generations to examine the policy effects in more detail. Third, earning (productivity) profiles can be derived in a more comprehensive manner if greater number of variables from labor panel data or parameters from other literature are considered.

To utilize the CGE model, this paper deconstructs the economy by sectors, though it may be more rational to do so by occupations based on the productivity differences in occupations by age. For future research, an empirical analysis of the model should be modified to accommodate not only capital and labor, but also intermediate goods in the production function. Lastly, while the model is a basic and fictious model to examine the effects of policy scenarios with most of the parameters based on assumptions, to obtain more realistic outcomes, it is required to examine each assumption carefully.

Chapter 6.　Bibliography

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Appendix 1: Estimation of Earning Profile

Following one of the widely-used methods of estimating earning profiles, this paper uses labor and income panel data to estimate age-wage equation.

A1.1 Data

The data come from the Korean Labor and Income Panel Study (KLIPS) for the 1998-2017 period. The sample is limited to employed individuals aged 15 – 65. Those who report that weekly working hours are less than 30 and wage lies outside the range between KRW 200,000 and KRW 5,000,000. Those who are serving the military and involved in the agriculture and fishery industry are excluded from the samples. Lastly, those who change their industry more than two times are removed from the sample to simplify the model.

In terms of industry classification, the paper is based on the two-digit 8th Korea Standard Industry Code (KSIC). The classification of progressive and stagnant sectors, somewhat arbitrary, generally follow that in Kim (2013). According to Kim, young and prime age workers have a comparative advantage in sectors which require creativity, learning abilities and physical health, while old workers in industries that necessitate know-how, communication, and networking abilities as discussed in 1.2 and 2.1. The former one, called a progressive sector, includes R&D, manufacturing, software programming, advertisement, architectural design and so forth. The latter one, named a stagnant sector, contains sales, HR, retails, real estate, accommodation, personal services and etc. Though Kim categorize the jobs based on occupations, due to the limitations of SAM, composed of sectors, the paper classify based on sectors as shown in **Table 16**.

Table 16. Sectoral Classification of KLIPS Data

Sector	Industries	KSIC Code
Progressive	Manufacturing	15 ~ 36
	Construction; Architectural design	45, 46
	Information and communication technology; Software programming	72
	R&D; Engineering and science services; Design; Advertisement	73, 74
Stagnant	Electricity, gas, and water supply; sewerage, waste management and remediation activities	37, 40, 41, 90
	Wholesale and retail trade; transportation and storage; accommodation and food service activities	50, 51, 52, 55, 60, 61, 62, 63, 64
	Financial and insurance activities	65, 66, 67
	Real estate; Renting and business activities	70, 71
	Community, social and personal services	73, 74, 75, 76, 80, 85, 86, 87, 88,

	91, 92, 93, 95, 99

A1.2 Summary of Statistics

When the earning profiles are incorporated in the model as in 3.2.1, the statistics of panel data in **Table 17** and **Table 18** are taken into account, though with a certain degree of limitation due to convergence issues.

Table 17. Sectoral Employment Share (of Observations) by Age-group

Sector	Share by Generation (%)		
	Gen 1	*Gen 2*	*Gen 3*
Progressive	39.14	43.33	39.07
Stagnant	60.86	56.67	60.93

Table 18. Share of Career Path Choices

Career Path	1 (P,P,P)	2 (P,S,S)	3 (P,P,S)	4 (S,S,S)	5 (S,P,P)	6 (S,S,P)
Share (%)	29.61	3.19	4.08	52.61	3.43	3.72

A1.3 Estimation Results

Table 19 shows the results of age-earning profile estimation. The explanatory variables for estimation are chosen among the variables that can be modeled in the CGE model. Hence, rather than using continuous age variable, we group ages into three cohorts (age_g in **Table 19**) as described in the OLG-CGE model. To identify the effect of industry, industry-specific dummy variable ind_prog_g is considered in the model.

As the major part of the model, job-switch variables are also included as variables. Job-switch ($switch_{g,s}$) is allowed in two intervals—between young and prime age group, and between prime and old age group—and two directions between stagnant and progressive sectors, thus making it four variables in total.

When the assumption that the individual specific effects are uncorrelated with the independent variables holds, the random effects model is more efficient than the fixed effects model. In the case of KLIPS, samples (individuals or households) are randomly extracted from the population, and thus it is intuitive to estimate panel linear regression models with random effects model (Min and Choi, 2012).

All the variables are reported as statistically significant as shown in **Table 19**.

Table 19. Estimation results of *wage*

: $\log wage = \beta_0 + \beta_{1,g} age_g + \beta_{2,g} ind\_prog_g + \beta_{3,g,sw} switch_{g,sw}$

Variables	Generation	Sector Switch	Coefficient	S.E.

age_g	*Gen 3*		0.6644426***	0.0079392
	Gen 2		0.4048379 ***	0.0056264
ind_prog_g	*Gen 3*		0.0821624***	0.0096679
	Gen 2		0.0680118***	0.0090722
	Gen 1		0.0391861***	0.010676
$switch_{g,s}$	*Gen 2*	P->S	0.2370947***	0.0139178
		S->P	0.1539529***	0.014681
	Gen 1	P->S	0.3155784***	0.0166753
		S->P	0.4493587***	0.0170144
constant			4.572667***	0.0070015
R^2			0.2585	
Observations			73,527	
(Individual)			(12,380)	

Notes: Statistical significance is denoted by *** for p <0.01, ** for p <0.05, and * for p <0.10.

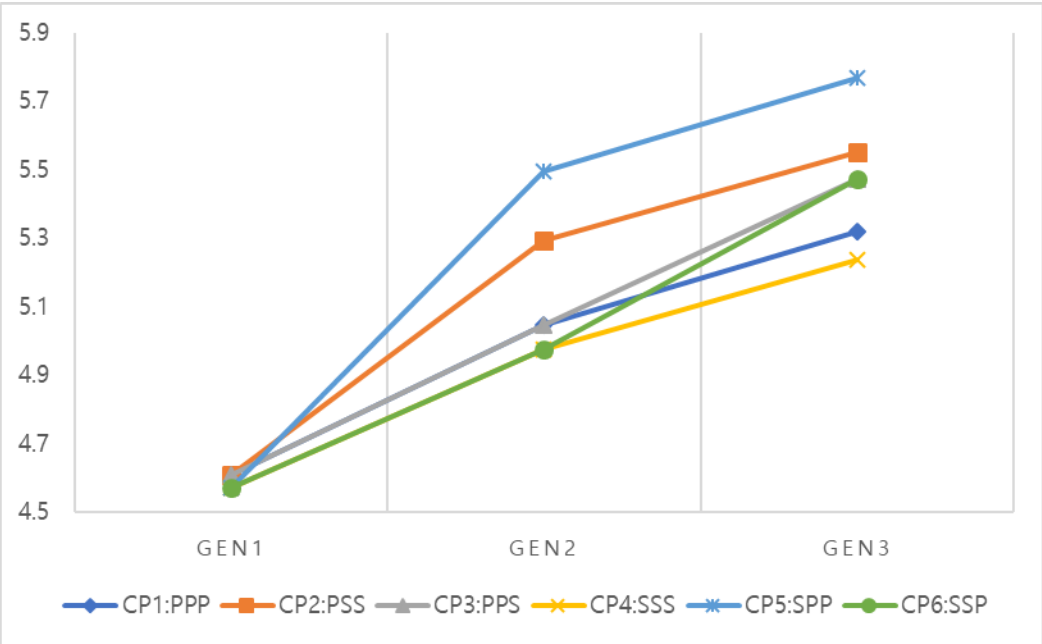

Figure 27. Log Wage Profiles for Different Career Paths

Abstract (Korean)

한국은 과거 가장 역동적인 경제 중 하나로 분류되었지만, 현재는 경제 성장의 동력을 잃어 가고 있다. 다양한 요소들 중에서, 본 연구는 고령화와 경제의 탈산업화(서비스화)에 중점을 두고 있다. 이 두가지 현안을 해결하기 위해 제안되는 방법 중 하나는 청장년층과 고령층 노동자를 각각 비교 우위가 있는 산업군으로의 노동 분업이 있다. 본 연구는 연령별 노동 분업 정책 분석을 위한 기초 단계로 연령에 따른 산업군 이동을 유도하기 위한 보조금을 제공하는 정책에 대해 연구한다.

본 연구에서는 이를 위해서 4기 중첩세대 연산가능 일반균형모형을 이용한다. 또한, 한국 노동 및 임금 패널 자료를 바탕으로 개인의 산업별, 그리고 연령별 능력 이질성을 반영하고자 하였다.

이 모형을 통하여 특정 연령 또는 특정 산업으로의 진입을 유도하는 5가지 보조금 정책 시나리오를 분석하였다. 가상의 시나리오 결과는 보조금의 직접 수혜자 뿐만 아니라, 임금률과 같은 경제변수들의 변화로 인해 간접적으로 정책의 영향을 받는 노동자가 존재함을 보여주었다. 또한, 특정 시나리오에서는 보조금 비수혜자가 산업별 노동 재분배에 기여하는 바가 보조금 수혜자와 같거나 그 보다 클 수 있다는 것이 나타났다. 그리고, 한 세대만의 산업 이동보다는 다양한 세대의 다른 방향으로의 산업 이동은 산업 군 간의 임금 격차를 줄이는 결과를 보였다.

본 연구는 실증 분석은 이루어지지 않았으나, 다양한 시뮬레이션을 통해서 보조금 지원 정책을 입안하는데 있어서 장·단기적, 그리고 직·간접적 효과를 종합적으로 고려해야함을 시사하고 있다.

주요어 : 고령화, 노동 재분배 정책, 중첩세대, 연산가능 일반균형모형

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