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Analysis of Labor Income and Labor Income Taxes Using Final Tax Return Data and Applications of a Heterogeneous-Agent Dynamic General Equilibrium Model

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Analysis of Labor Income and Labor Income Taxes Using Final Tax Return Data and Applications of a Heterogeneous-Agent Dynamic General Equilibrium Model [1]

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Abstract

This study presents a numerical analysis of the consumption, capital distribution, and labor supply of the Japanese economy in aggregate and income quintiles using Japanese tax return data in an incomplete market model with individuals having different incomes or labor productivity. We also discuss the characteristics of administrative and tax return data and what should be kept in mind when comparing them with administrative data from other countries. In the calibrations for obtaining the model parameters, we use labor income tax data from tax returns to estimate the transition process of prorated labor income, and the income tax rate function to analyze the macro model. Specifically, we compare the simulation results of a benchmark model with exogenous labor supply and an endogenous model with endogenous labor supply for consumption and asset distribution trends by income quintile in the steady state. Regarding the feature of the tax function, we find that tax progressivity in FTR data is low and almost linear. The results of the simulation analysis in this study show that consumption and income inequality are larger than those in empirical evidence. However, the results for asset inequality, which is implicitly derived from the model, are generally consistent.

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1. Introduction

In recent years, research on taxation using individual-level data has progressed, using survey data, such as household panel data and administrative data. For example, Guvenen et al. (2021) used payroll data recorded by the US Social Security Administration to analyze the characteristics of workers' payroll income in the United States, and the Global Repository of Income Dynamics (GRID) project is beginning to compile a database on economic disparities. Hoffmann et al. (2022) analyzed disparity trends using administrative data from the Italian National Institute of Social Security for 1985–2016. Halvorsen et al. (2022) estimate income risk using demographic data for 1967–2010, covering the entire Norwegian population.

We refer to the following literature for our study. First, focusing on tax progressivity and inequality, Feldstein (1969) use progressive income tax, a method for estimating income tax progressivity based on the number of labor income customs. Borella et al. (2023) use survey data (the Panel Study of Income Dynamics; PSID) to obtain empirical results on tax progressivity. Abe and Yamada (2009) and Kitao and Yamada (2024) estimate income and consumption inequality in Japan using microdata from the National Survey of Family Income and Expenditure (NSFIE). Lise et al. (2014) document the main features of the distribution of wages, earnings, consumption, and wealth in Japan for 1981–2008 using four main data sources: the Basic Survey on Wage Structure (BSWS), Family Income and Expenditure Survey (FIES), NSFIE, and Japanese Panel Survey of Consumers (JPSC). Ohno et al. (2024) use household microdata from the NSFIE for 1994–2014 to explain deductions and trends in household distribution over 20 years while considering each factor’s contribution to changes in the tax base through their decomposition.

In addition, Heathcote et al.(2017) and Holter et al. (2020) analyze heterogeneous macroeconomic models using progressive income taxes. However, to the best of our knowledge, no studies have used administrative data to analyze progressive income tax structures and calibrate heterogeneous-agent macroeconomic models.

This study addresses two research questions. The first is to what extent tax return data have advantages or drawbacks in comparison with other administrative data on income and income taxes, given the characteristics of tax data (tax returns). The second point is the extent to which heterogeneous-agent models that calibrate the estimated number of labor income customs and income quintile transition matrices explain real income and asset inequality.

This study contributes to existing literature in two ways. First, to the best of our knowledge, this is the first study to estimate labor income functions using administrative data. Borella et al. (2023) use survey data from the Panel Study of Income Dynamics (PSID) for their estimation, while studies using administrative data, such as Guvenen et al. (2021), did not analyze labor income tax and other studies did not analyze labor income tax using administrative data. Second, we show that it is possible to conduct an empirical analysis of the progressive structure of labor income tax, including aggregate and income quintiles, using tax return-based data.

The remainder of this paper is organized as follows: Section 2 explains the Japanese Final Tax Return data and defines labor income and its taxes. Section 3 estimates the labor income tax function. Section 4 analyzes the heterogeneous-agent macroeconomic model with exogenous and endogenous labor supply and numerically simulates income, consumption, and asset distributions. Section 5 concludes.

2. Explanation of Japanese Final Tax Return (FTR)

This section provides a comprehensive overview of the Japanese Final Tax Return (FTR) system. The first subsection details the structure, classification of income types, tax-calculation methods, and reporting requirements. The next subsection discusses the advantages and limitations of using the tax data. The last subsection compares Japan's approach to administrative data usage with those of other countries.

2.1. Explanation of Japanese FTR

In Japan, taxpayers who meet any of the following conditions are required to file a tax return.

- Those working as sole proprietors or freelancers.
- Employees whose employment income exceeds JPY 20 million
- People whose income from side jobs exceeds 200 thousand yen per year
- People who receive a certain amount of public pension
- Persons who earn a certain amount of profit from stock trading
- Those with other income, such as real estate.
- Those who received a certain amount of income from two or more places of employment.

Among the tax data to be provided, for income tax data, the data for each item listed in *Table 1 (Dai 1 pyou)* and *Table 3 (Dai 3 hyou)* of the “Income Tax and Special Reconstruction Income Tax Finalization Form” (hereinafter referred to as “Final Return Form”) are available (however, taxpayers’ names are not accessible for privacy protection reasons). The Japanese income tax system classifies income according to its nature and stipulates a method for calculating the amount of each type of income. The *Table 1* (*Dai 1 pyou*) in the tax return form includes the following items: business income (business and agricultural income), real estate income, interest income (excluding the portion subject to withholding tax), dividend income (excluding the portion subject to withholding tax), employment income, miscellaneous income (miscellaneous income from pensions, miscellaneous income from business, and other miscellaneous income), income from short-term and long-term transfer income, and temporary income other than land and buildings subject to comprehensive taxation.

However, some of the reported income is subject to separate taxation, and the items related to such income are listed in *Table 3* (*Dai 3 Hyou*) in the tax return form. Specifically, the items include short-term (general and reduced) and long-term (general, specific, and light) transfer income from land and buildings, subject to separate taxation, income from the transfer of general stocks, income from the transfer of listed stocks, income from dividends and other income from listed stocks, and miscellaneous income from futures transactions. In addition, forest income and retirement income are subject to different tax treatments than general income and are taxed separately; therefore, they are listed in the Third Schedule of the tax return. For each income listed in the Third Schedule, the income and income amounts are listed in the Third Schedule of tax return. The sum of each income listed in the First Schedule of the tax return for comprehensive income and each income listed in the Third Schedule for separate taxation is called the "total amount of income. (However, only 1/2 of the long-term gains on transfer and temporary income for comprehensive taxation are taxed.) The amount after deducting the deduction for loss carried forward is then called "total income" in the case of comprehensive taxation only, and "gross income, etc." in the case of taxable income, including separate taxation on declarations.

Various additional income deductions are required to calculate the tax amount. The first table of the tax return lists various income deductions (deductions for social insurance premiums, deductions for small-scale enterprise mutual aid premiums, deductions for life insurance premiums, deductions for earthquake insurance premiums, deduction for widows and single parents, deduction for working students and disabled persons, deduction for spouse (special), deduction for dependents, basic deduction, deduction for miscellaneous losses, deductions for medical expenses, and deduction for donations) as amounts deducted from income..

If there is no separate taxable income, the tax amount is calculated by applying the tax rate to the taxable gross income after deducting the income tax credits ("taxable gross income"). If there is separate taxable income, it is calculated in the third table in addition to the gross income, and the amount of income and tax are posted in the first table. Various tax credits were deducted. Specifically, the amount of tax credit, such as dividend income tax credit for adjusting double taxation on dividend income at the corporate and individual levels, special credit for housing loans, special credit for donations to political parties, and special credit for earthquake-proofing houses, is deducted.[5] Finally, the amount of tax already paid to the foreign government is deducted as the foreign tax credit. If there is any withholding tax on declared income, then the withholding tax amount is deducted from the declared tax amount.

2.2.Advantages and Considerations of Using Tax Data

The tax data provided in collaboration with the National Tax Agency include detailed items for calculating the amount of tax due to each reported income tax bracket. In addition, the availability of tax data over a given year (from 2014 to 2020), rather than sample surveys, allows for the coverage of a large number of taxpayers, in excess of 20 million, in a single year[6]. Table 1 shows the number of tax returns for income tax. FTR data are also unbalanced panels because they FTR data is assigned an ID to each taxpayer and are classified. This includes very high-income taxpayers who are probably not well represented in the survey data. Unlike survey data, a certain degree of accuracy is ensured, and the data is highly reliable because, additional taxes and, in the most egregious cases, penalties are imposed on taxpayers who file untruthful tax returns.

However, the tax data on reported income taxes have several limitations. First, the coverage is limited to data on reported income taxes that involve filing tax returns. In Japan, there are two forms of taxation: taxable income taxation (i.e., the taxpayer is required to file a tax return) and taxable income taxation (i.e., the taxpayer is required to file a tax return and pay taxes at the source). Therefore, most interest taxation is not declared and is not included in the tax data presented here. (The "interest income" subject to comprehensive taxation included in the First Schedule of the tax return is limited to income not subject to withholding tax in Japan, such as interest on deposits, etc., paid outside Japan). In addition, since an elaborate year-end adjustment system for employment income was introduced in Japan, many salaried workers with no income other than salary have completed the tax payment procedure by withholding taxes and have not filed an income tax return. However, because tax returns are now required for salaried workers with salary income exceeding 20-million-yen, tax data for salaried workers with salary income exceeding 20 million yen are included in the data provided in this report. In particular, the former caveat makes it difficult to extract the "true" capital income and capital income tax amounts of

[5] If the Disaster Reduction and Exemption Law is applied, the amount of disaster reduction and exemption will be stated. In addition, the amount of special income tax for recovery will be the standard income tax amount after deducting the disaster exemption amount, multiplied by 2.1%.

[6] Following Kunieda and Yoneta (2023), the number of filing the tax return is 21,812,717 and average income is 3,437,917 in 2014. Aggregate income in FTR data is approximately 75 trillion yen which is approximately 19% of national income in SNA. In this paper, we do not use the FTR data in 2020 because the gender information of each (assigned an ID and anonymized) taxpayer is not avairable.

tax filers. Therefore, in this study, we analyze a macro model that includes heterogeneity in labor income (labor productivity) by estimating labor income and labor income tax amounts for each income quintile.

2.3. On Other Administrative Data

Regarding empirical analysis of the income process using administrative data, Hoffman et al. (2022) analyzed disparity trends using administrative data from the Italian National Institute of Social Security from 1985 to 2016. Halvorsen et al. (2022) estimated the income risk using demographic data from 1967 to 2010, covering the entire Norwegian population.

In the United States, the Office of Tax Analysis (OTA) of the U.S. Department of Treasury and Compliance Data Warehouse (CDW) of the Internal Revenue Service compiled tax return information. In addition, the Statistics of Income Section (SOI), a statistical division of the Internal Revenue Service, publishes a Public Use File for the general public that excludes personal information and provides only fully anonymized and partially sampled data for a fee. In the United Kingdom, tax data are provided by Datalab, His Majesty's Revenue, and Customs (HMRC). In Denmark, the personal number system allows tax data to be collated and analyzed with other administrative data (e.g., (Danish Integrated Database for Labor Market Research), and Chetty et al. (2014) and Kleven and Schultz (2014) use this dataset. In Japan, the University of Tokyo's Center for Research and Education in Program Evaluation (CREPE) conducts an analysis of income and local taxes using municipal tax data, such as inhabitant taxes.

3. Estimating Labor Income Tax Function Using FTR

This section estimates the labor income tax function using Final Tax Return (FTR) data in Japan. We define the nonlinear income tax function, constructs labor income and tax data from the FTR records and estimates the disposable income function. The analysis covers aggregate data and income quintiles from 2014-2019 for working-age males.

3.1.Labor Income Tax Function

Following Feldstein (1967), Benabou (2002), Heathcote et al. (2017), and Borella et al. (2023), we model the nonlinear (labor) income tax function as follows:

$$T(Y) = Y - (1 - \lambda)Y^{1-\tau},$$

where $T(Y)$ is the (labor) income tax, and Y is the (labor) income. Parameter τ represents the degree of progressivity. Income tax is progressive if $1 > \tau > 0$. We estimate the following disposable income function:

$$Y - T(Y) = (1-\lambda)Y^{1-\tau}.$$

The marginal tax rate is obtained by $T'(Y) = 1 - (1-\lambda)(1-\tau)Y^{-\tau}$ and the average tax rate is obtained by $1 - (1-\lambda)Y^{-\tau}$.

3.2. Data Construction of Labor Income and Labor Income tax

This study uses data from the National Tax Agency's "Information on Administrative Records Held by the National Tax Agency on Income Tax Returns in Japan (hereinafter referred to as "tax data")," which includes all tax returns from 2014 to 2019 (an average of approximately 23 million for a single year).[7] The advantage of using tax data is not only that the sample size is much larger than previous data but also that we can obtain highly comprehensive data, including data for sole proprietors and salaried workers with incomes exceeding 20 million yen. In addition, the inclusion of very high-income earners, who are not often included in survey data, makes it possible to analyze the impact of very high-income earners on overall income inequality. However, it should be noted that data for salaried workers who have already paid taxes through the year-end adjustment system are not included. In addition, it is difficult to strictly define and analyze labor income because some of the reported income includes "business income (business income and agricultural income)," "miscellaneous income," and "occasionally income," which are a mixture of labor income and capital income. In addition, information on family structure is difficult to analyze rigorously because each individual files his/her own tax return. Therefore, it is only possible to infer which individuals are married couples, and the family structure can only be inferred from the existence or non-existence of deductions for dependents.

This study calculated the labor income tax rate using income under labor income in the reported income tax (*Table 1* (*Dai 1 pyou*)). However, to define labor income, we use Gunji and Miyazaki's (2011) definition of prorated labor income and Eq. (1) to predict labor income.

Labor income = salary income + retirement income + labor share × (operating income + agricultural income + forestry income + miscellaneous income+ occasional income), (1)

Considering that retirement income, forestry income, and temporary income are classified in Gunji and Miyazaki (2011), the labor share is calculated from employer compensation divided by national income in the factor cost representation in the System of National Accounts. The third

[7] Kunieda and Yoneta (2023) explains the detail of data characteristics and management.

schedule, subject to separate taxation, the labor income tax promotion method, is defined in Eq. (2).

$$
\begin{aligned}
&\mathit{Labor\ Income\ Tax} \\
&= \mathit{Comprehensive\ Taxation} \\
&\times \frac{\begin{array}{c}\mathit{Employment\ Income} + \mathit{Labor\ Share} \times (\mathit{Agrecultural\ Income} + \mathit{Operating\ Income} \\ + \mathit{Miscellaneous\ income} + \text{occasional income})\end{array}}{\mathit{Income\ for\ Comprehensive\ Taxation}} \\
&+ \mathit{Separate\ Taxation} \times \frac{\mathit{Retirement\ Income} + \mathit{Labor\ Share} \times \mathit{Timber\ Income}}{\mathit{Income\ for\ Separation\ Taxation}} \qquad (2)
\end{aligned}
$$

In Eq. (1), for income that includes both labor and capital income, the portion corresponding to labor income is divided by the labor share in the SNA (compensation of employees/national income expressed as a factor cost). In Eq. (2), labor income tax is divided by the share of labor income defined in Eq. (1) for total taxation and separate taxation (expressed as a fraction).

In addition, this study assumes a household model. Therefore, we referred to Guvenen et al. (2021) and restricted our sampling to the male working age group (younger than 66 years), thus narrowing the sample size to approximately 6.87 million persons in each year of the analysis. Restricting the data to men aged is less than 66 years resulted in a sample size of approximately 40 million.

Table 2 shows the summary statistics of the aggregate labor income and tax data, and Tables 3 and 4 show the subsample statistics for each year (Table 3) and the five income quantiles (Table 4).[8]

Next, we briefly focus on the analysis of the income process. Figure 1 shows the log difference in labor income, and we can see that its distribution seems normal. Figure 2 shows the AR (1) persistence of logarithmic labor income in both aggregate and age groups.[9] Figure 2 shows that there is no significant change in the magnitude of labor income AR (1) persistence, with the exception of the under-19 cohort.

3.3. Empirical Estimation of Labor Income Tax Function

[8] Note that the ratio of zero income is approximately 8% in our data, while the full-sample data is approximately 25% (which includes women and retires).

[9] Summary statistics and transition matrix are shown in Appendix.

We estimate the following log-linearized equation:

$$\ln(Y_{i,t} - T_{i,t}) = \theta_0 + \theta_1 lnY_{i,t} + \alpha_i + \alpha_t + \nu_{i,t}, \quad (3)$$

where $\theta_0 = \ln(1-\lambda)$ and $\theta_1 = 1-\tau$ in Eq. (2), and α_i and α_t are the components of two-way fixed effects.

Table 5 presents the estimation results for the aggregate data. The disposable income function using aggregate data suggests that it is approximately linear; however, the assumption that it is log-linear is strong. Therefore, it is analyzed separately for each income quintile, and the results are shown in Table 6. In Table 6, tax progressivity is almost linear ($\tau \fallingdotseq 0$), despite the previous literatures such as Holter et al. (2020) estimates it which is larger than 0.1. One reason for this low progressivity is that taxpayers (especially business owners filing blue returns) receive various tax credits, resulting in lower actual tax payments by higher-income taxpayers.

3.4.Calculating Transition Matrix of Income Quantile

We calculate the transition matrix of labor income (or labor productivity) mobility to regress the income quantiles in the previous year, as shown in Table 7. Table 7 shows that the diagonal elements of each income quantile are largest in the row. In particular, the diagonal elements of the fifth income quantile are much larger than the others, which implies that higher-income groups are more likely to remain in the same income bracket.

4. Heterogeneous-Agent Model with Progressive Income Tax

FTR data are not a population of taxpayers in Japan and cannot be used to analyze the Japanese economy as a whole. However, we analyze disparities in tax return data in this section and beyond to capture the characteristics of the tax return data theoretically. We use the well-used heterogeneous agent model of Aiyagari (1994), which applies to five states with respect to labor productivity and introduces progressive (labor) income tax.[10] We compare two types of models exogenous and endogenous labor supply, as in Heer and Trede (2003), Marcet et al. (2007), and Zhu (2020).

4.1. Exogenous Labor Supply model

[10] Aiyagari (1994) uses two-states (employment or unemployment) heterogeneous model.

As a benchmark model, we analyze a model in which the labor supply is exogenous. The specific model extends Aiyagari's (1994) model to five states and introduces a progressive (labor) income tax system.

4.1.1. Households

The expected utility function of an individual equally distributed in the interval $j \in [0,1]$ is as follows:

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma}}{1-\sigma}, \quad (4)$$

where c_t is consumption, β is the discount factor, and σ is relative risk aversion.

Each household has an inelastically efficient labor supply, ε_{it} under idiosyncratic risk to labor efficiency. In this study,ε_{it} is independent across households, but faces one of the five labor efficiencies in each period in the form of conditional probabilities of labor efficiency in the previous period. Specifically, we follow a Markov process with 5-state transition probability $\pi(\varepsilon'|\varepsilon)$, where ε' denotes efficient labor in the next period[1 1]. The labor income of households in state j is $\varepsilon_{jt}w_t$ and after-tax labor income is expressed as $\left(1-\tau(\varepsilon_{jt})\right)\varepsilon_{jt}w_t$the wage per efficient labor). Considering that the income tax system in our country is progressive, we identify and analyze the following post-tax income functions used by Benabou (2002), Heathcote et al. (2017), and Holter et al. (2019):[1 2]

$$ya_{jt} = \theta_0\left(\varepsilon_{jt}w_t\right)^{\theta_1}, \qquad (5)$$

where ya_{jt} is disposable income (which is equal to $\left(1-\tau(\varepsilon_{jt}w_t)\right)\varepsilon_{jt}w_t$). In the calibrations described below, Eq. (3) is log-linearized to estimate θ_0 and θ_1.

Labor efficiency is denoted by s. The budget constraint equation for households is expressed as

$$s_t = j, \qquad c_{jt} + a_{jt+} = \left(1-\tau(\varepsilon_{jt}w_t)\right)\varepsilon_{jt}w_t + (1+r_t)a_{jt}, \qquad (j = 1,2,3,4,5) \quad (6)$$

where a_{jt} is asset holdings and r_t is the rate of return. In addition, households face the

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[1 1] The order of labor efficiency is assumed to be $\varepsilon_{1t} < \varepsilon_{2t} < \varepsilon_{3t} < \varepsilon_{4t} < \varepsilon_{5t}$. While Aiyagari (1994) and Krussel and Smith (1998) assume the two-state case of employment and unemployment, in this paper we analyze the two cases separately by income quintile.

[1 2] In the calibration of this paper, the tax rate is determined in a way that corresponds to labor efficiency.

following borrowing constraints.

$$a_{jt+1} \geq 0. \quad (7)$$

In Eq. (5) and (6), each household considers its consumption and savings plan in its own state for each period, without borrowing.

4.1.2. Firm

The production function of (representative) firm is expressed as follows:

$$Y_t = z_t K_t^{\alpha} L_t^{1-\alpha}, \quad (8)$$

where z_t is the total factor productivity and assume $z_t = 1$ and $L_t = 1$ because labor is exogenous.

Solving the profit maximization problem, we obtain the following conditions with respect to the factor prices:

$$\begin{aligned} w_t &= (1-\alpha) z_t \left(\frac{K_t}{L_t}\right)^{\alpha} \\ r_t &= \alpha z_t \left(\frac{K_t}{L_t}\right)^{1-\alpha} - \delta \end{aligned} \quad (9)$$

where δ is depreciation rate.

We define the aggregate capital stock K_t as follow:

$$K_t = \sum_a \sum_\varepsilon a g_t(a, \varepsilon),$$

$$L_t = \sum_a \sum_\varepsilon \varepsilon g_t(a, \varepsilon),$$

where $g_t(a, \varepsilon)$ is probability density function with respect to a and labor efficiency ε.

4.1.3. Government

This study assumes that the government levies a progressive labor income tax to finance consumption, G_t, as shown in Eq. (10):

$$\sum_a \sum_e \tau(\varepsilon_{jt}) \varepsilon_{jt} g_t(a_{jt}, \varepsilon_{jt}) w_t = G_t. \quad (10)$$

For tax revenue, we can apply alternative methods such as redistribution or fiscal consolidation. While the use of taxes can be applied to a variety of policy analyses, including the use of taxes for redistribution and fiscal consolidation, as a benchmark model, this study only analyzes the case in which taxes are used only for balanced budgets and government consumption.

4.1.4. Computation of the Model

In this study, we used Winberry's (2018) method to derive stationary equilibrium.[13] The procedure involves the following two steps to derive steady-state equilibrium:

- Step 1. Approximate the equilibrium using Finite-dimensional objects.
- Step 2. Derive a stationary equilibrium (without aggregate shocks, but with remaining intrinsic shocks) from the approximate equilibrium conditions.

For the parameter values in the model, we use the values of logarithm function with respect to consumption and quadratic disutility with respect to labor supply. We use the average tax rate which estimates the disposable income function in Table 5 as the tax rate for each income quantile. For the transition matrix of the income quantile, we use the transition process shown in Table 7 and the relative income in each quantile. For labor productivity in each quantile, we set the average income for 3rd income quantile to the total average income ratio for each income quintile: $(\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}, \varepsilon_{4t}, \varepsilon_{5t}) = (0.13411, 0.55175, 1, 1.66863, 4.28953)$. The rest of the parameters were set as listed in Table 8.

We obtained the results of the numerical simulation as follows. Figure 3 shows the asset (deposit) holding distribution at stationary equilibrium in each income quantile.[14] Figure 4 shows the aggregate assets, consumption, and labor supply (set as one in the exogenous labor supply model) at the stationary equilibrium. Figure 4 shows that households in the first, second-, and third-income quintiles face more liquidity constraints, that is, zero assets are the mode, whereas households in higher income quintiles hold more assets.

4.2. Endogenous Labor Supply model

Next, we extend the model to the endogenous labor supply. A change from section 4 is that the utility function in Eq. (4) can be rewritten as (11):

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{1-\sigma}}{1-\sigma} - \chi \frac{h_t^{1+\eta}}{1+\eta} \right), \quad (11)$$

where h_{jt} is the labor supply in household j, χ is the disutility parameter of labor supply, and η is the inverse of the labor supply elasticity with respect to wages.

For each state $s_t = j$, the household's budget constraint is also rewritten as follows:

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[13] This algorithm includes aggregate shocks, whereas this study only estimates stationary distributions using Chebyshev polynomials. It is therefore common to the algorithm used in Sims et al. (2022).

[14] The values of assets on the horizontal axis in Figures 4 through 7 are theoretical values based on numerical calculations, and the level values themselves are not meaningful (although relative comparisons are possible.

$$c_{jt} + a_{jt+1} = \left(1 - \tau(\varepsilon_{jt})\right)\varepsilon_{jt} w_t h_{jt} + (1 + r_t) a_{jt}. \ (j = 1,2,3,4,5) \quad (12)$$

Eq. (11) includes h_{jt} as a control variable for the household optimization problem.

We define the aggregate labor supply L_t as follow:

$$L_t = \sum_a \sum_\varepsilon \varepsilon_t h_t g_t(a, \varepsilon),$$

The government budget constraint is rewritten as:

$$\sum_a \sum_e \tau(\varepsilon_{jt}) \varepsilon_{jt} h_{jt} w_t g_t(a_{jt}, \varepsilon_{jt}) = G_t.$$

By Marcet et al. (2007) and Zhu (2020), it is shown that in a macroeconomic model of an incomplete market with endogenous labor supply, due to differences in the income effect of the impact on endogenous shocks, the self-insurance function acts more than in the labor exogenous model, as income and assets. This is due to the fact that households facing higher labor efficiency reduce the amount of labor due to the positive income effect, while real wages increase the amount of labor due to the substitution effect caused by the increase in real wages, both of which are present. In this study, individuals facing higher labor income due to a progressive income tax system experience both a substitution effect from taxation and a negative income effect.

We also used the same parameter as in the previous section and obtained the results of the numerical simulation as follows: Figure 5 shows the asset (deposit) holding distribution at stationary equilibrium in each income quantile.[15] Figure 6 shows the aggregate assets, consumption, and labor supply (set as one in the endogenous labor supply model) at the stationary equilibrium. The endogenous labor supply model suggests that an increase in the labor supply of individuals facing high productivity (fifth income quintile) increases their labor income, which in turn encourages consumption.

4.3. Further Extension of the Model: Inducing Capital Income and Consumption Taxes

In this subsection, we further expand the model, i.e.

$$(1 + \tau_C) c_{jt} + a_{jt+1} = \left(1 - \tau(\varepsilon_{jt})\right)\varepsilon_{jt} w_t h_{jt} + (1 + (1 - \tau_K) r_t) a_{jt}. \ (j = 1,2,3,4,5)$$

We set $\tau_C = 0.1$ and $\tau_K = 0.2$ and simulated the stationary equilibrium.

[15] The values of assets on the horizontal axis in Figures 4 through 7 are theoretical values based on numerical calculations, and the level values themselves are not meaningful (although relative comparisons are possible.

The government budget constraint can be rewritten as follows:

$$\sum_a \sum_e [\tau(\varepsilon_{jt})\varepsilon_{jt}h_{jt}w_t + \tau_C c_{jt} + \tau_K r_t a_{jt}] g_t(a_{jt}, \varepsilon_{jt}) = G_t.$$

Figure 7 and 8 show the asset distributions and policy functions for one period ahead of the assets, consumption, and labor supply. Figure 7 and 8 indicate that adding consumption tax or capital income tax makes little difference to the qualitative conclusions.

4.4.On Inequality Measures in the Model and Comparison with the Data

Table 8 lists the Gini coefficients obtained from numerical simulations of the model. The asset gap widens more than the income gap because entities facing higher labor income can save more (financial) assets. However, the consumption gap is smaller than the income gap because consumption smoothing is dominated by the borrowing constraint. The following three points can be noted regarding the differences between the exogenous and endogenous labor models: First, disposable aggregate income inequality increases because higher (lower) labor productivity encourages (discourages) labor supply, and the labor income gap is much larger. Second, consumption inequality increases slightly because aggregate disposable income inequality increases. Third, asset inequality decreases slightly. This is because lower labor productivity groups (e.g., the 1st income quantile) decrease the probability of binding liquidity constraints.

Next, we compared the results of our data-based Gini coefficient estimates with those of survey data-based analyses in Japan, including Kitao and Yamada (2019), who used a national consumption survey from 1984 to 2014, and Kitao and Yamada (2024), who used a household survey from 1981 to 2021. Kitao and Yamada (2019) find that the Gini index rises from 0.32 to 0.35 for income and from 0.58 to 0.64 for wealth over the same period. Kitao and Yamada (2024) find that the Gini index ranges from 0.22 to 0.26 for disposable income while moderately increases from 0.22 to 0.275 for total consumption. Compared with the results of the model simulation, the income and consumption Gini index of the simulated result is larger than that of Kitao and Yamada (2019,2024), although asset inequality is consistent with Kitao and Yamada (2019). This implies that the higher-income quintiles in the FTR data (especially the fifth income quintile) tended to report higher Gini coefficient values than the other survey data, partly because of their higher relative mean income. This suggests that susceptibility to liquidity constraints, not only in the first income quintile but also in the second- and third-income quintiles, may have increased consumption and asset inequality. Again, it should be noted that the FTR data do not include information on withholding-only salaried workers; therefore, the Gini coefficient was estimated as an issue.

5. Discussion and Concluding Remarks

This study presents a numerical analysis of the consumption, capital distribution, and labor supply of the Japanese economy in aggregate and income quintiles, using Japanese tax return data from 2014 to 2019. Additionally, this study numerically simulates an incomplete market model with individuals of different incomes or labor productivity. We discuss the characteristics of administrative data and tax return data, and what should be considered when comparing them with administrative data from other countries. In the calibrations for obtaining the model parameters, we use labor income tax data from the FTR to estimate the transition process of prorated labor income and the income tax rate function to analyze the macro model. Specifically, we compare the simulation results of a benchmark model with exogenous labor supply and an endogenous model with endogenous labor supply for consumption and asset distribution trends by income quintile in steady state. The results of the simulation analysis in this study show that consumption and income inequality are larger than those in Kitao and Yamada (2024). However, the results for asset inequality, which is implicitly derived from the model, are generally consistent.

Although the FTR has some limitations and restrictions, it has good potential for application in macroeconomic models. There are some areas for future research to make the FTR data more applicable to macro models. First, a more precise analysis of government expenditures and revenues is required. In terms of revenue, an additional examination of capital income and consumption taxes as well as social insurance contributions and inhabitant taxes that exist in conjunction with income taxes is required. Expenditures include subsidies, pensions, other income transfers, government debt, and consumption. Simultaneously, a heterogeneous life cycle model is also applicable. Because information on the age of each taxpayer is available in the FTR data, it is possible to break down the data within and between generations to analyze the various factors contributing to the disparity. Finally, to construct a dataset that approximates the population data for all taxpayers in Japan, the data for withholding-only taxpayers can be analyzed in a manner that complements the survey data.

Declarations

Conflict of interest: The authors declare that there are no conflicts of interest involved in this study.

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Table 1. Number of the Final Return for Income Tax in 2014 (Unit: Thousand people)

Number of final returns for income			21430
	Refund		12400
	Tax payment		6220
	Business income earners		1610
	Other income earners		4610
		Real estate income earners	1070
		Employment income earners	2360
		Miscellaneous income earne	840
		Other	340

(Source) National Tax Agency Annual Report 2015

Table 2. Summary Statistics of FTR Data (Observation : 43,102,909)

Variables	Mean	S.D.	Min
Labor Income (Unit: Ten thousand yen)	432.3815	808.9355	0
Labor Income Tax (Unit: Ten thousand yen)	40.15341	235.7961	0
Age	48.26217	11.81752	6

(Note) Restriction of data availability: We cannot show the maximum value of labor income and labor income tax.

Table 3. Summary Statistics of Aggregate Labor Income and Labor Income Tax in each year (Unit: Ten thousand Yen)

	2014	2015	2016	2017	2018	2019
Labor Income	409.3554	414.4554	424.4998	439.4529	451.3334	452.6367
Labor Income Tax	36.94173	38.54002	38.86815	40.42211	42.61359	43.21177
Observation	6,818,138	7,023,169	7,238,347	7,325,986	7,332,257	7,365,012

Table 4. Summary Statistics of Aggregate Labor Income and Labor Income Tax in five income quantiles (Unit: Ten thousand Yen)

	1st	2nd	3rd	4th	5th
Labor Income	37.92991	156.0467	282.8217	471.9248	1213.172
Labor Income Tax	0.329187	2.988413	7.791441	20.07331	169.5818
Observation	8,622,149	8,621,959	8,614,109	8,624,112	8,620,580

(Note) The incomes of persons in each income quintile for each year were divided and averaged by the income quintile.

Table 5. Result of Estimating Disposable Income Function using aggregate data

θ_0	θ_1	Marginal Tax Rate	Average Tax Rate
-0.007463	0.997583	0.0457	0.0219

Table 6. Result of Estimating Disposable Income Function using each income quantiles

Income Quantile	θ_0	θ_1	Marginal Tax Rate	Average Tax Rate
1	0.0009	0.9994	0.0065	0.0071
2	0.2583	0.9805	0.0381	0.0102
3	0.4877	0.9652	0.0621	0.0130
4	1.0008	0.9319	0.1096	0.0267
5	1.8336	0.8790	0.2353	0.0750

(Note) We calculate the marginal tax rate to substitute the average income for each quantile in the estimated disposable income function.

Table 7. Transition Matrix of Five income quantiles (Unit: Percent (%))

$$\begin{bmatrix} 78.96 & 16.64 & 3.12 & 0.9 & 0.38 \\ 15.89 & 66.21 & 15.81 & 1.8 & 0.3 \\ 4.49 & 14.22 & 68.34 & 12.09 & 0.86 \\ 1.82 & 2.71 & 9.78 & 76.97 & 8.71 \\ 0.63 & 0.8 & 1.67 & 6.84 & 90.06 \end{bmatrix}$$

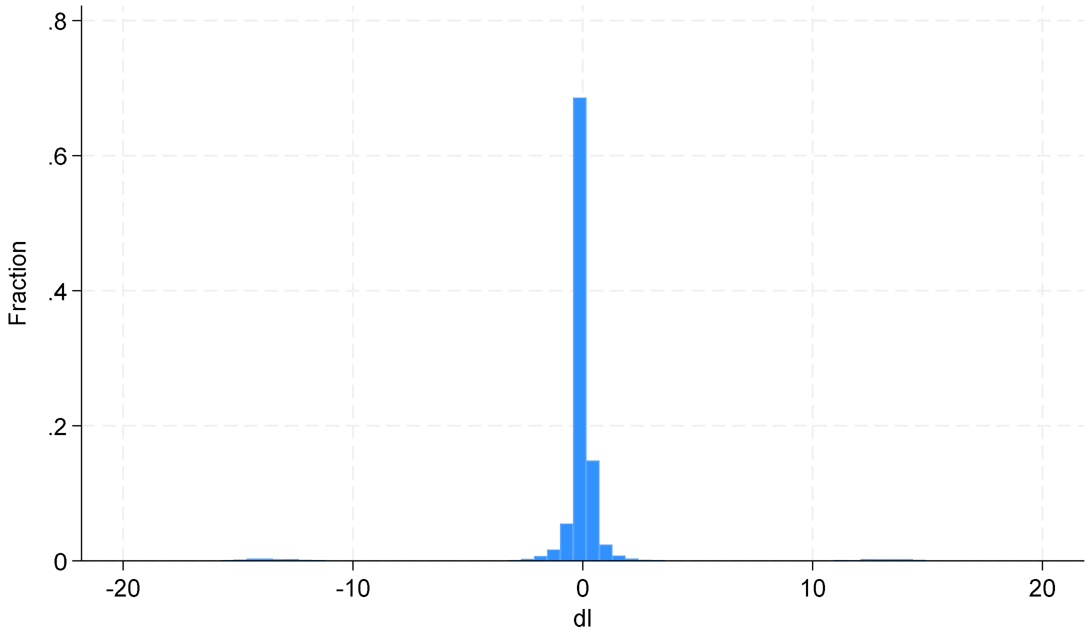
Table 8. Parameter value of the model

parameter	Meaning	Value
β	Discount factor	0.99
α	Capital Share	0.362
σ	Relative risk aversion	1
χ	Disutility of labor supply	1
η	Elasticity of labor supply	1

Table 9. Gini index of Labor Income, Deposit and Consumption in both exogenous and endogenous labor supply models.

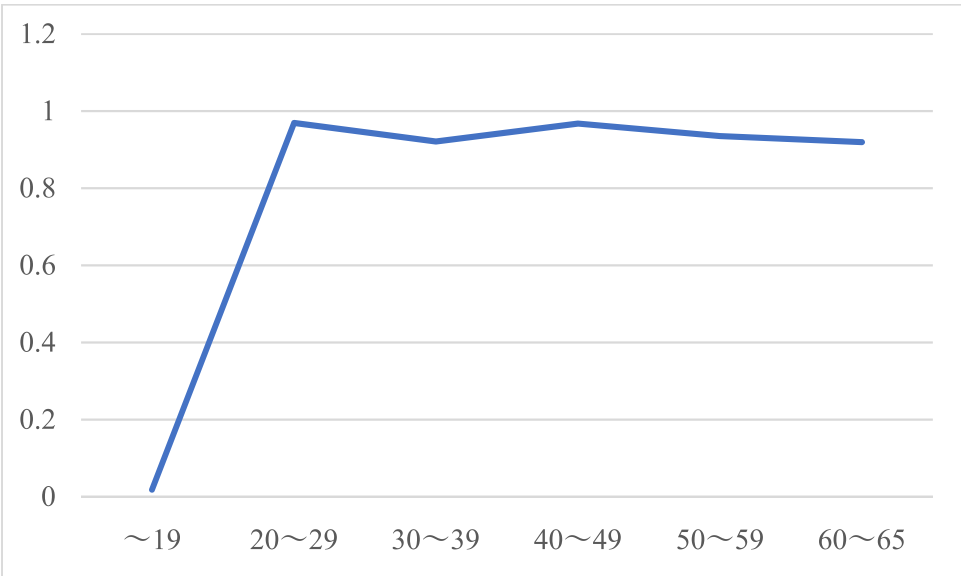
	Exogenous Labor Supply	Endogenous Labor Supply	Endogenous Labor Supply with capital income and consumption taxes
Disposable Labor Income	0.493	0.4711	0.4711
Disposable Labor and Capital Income	0.4711	0.6091	0.609
Asset	0.5023	0.4962	0.4984
Consumption	0.3746	0.4301	0.4294

Figure 1. Histogram of Log difference of Labor income



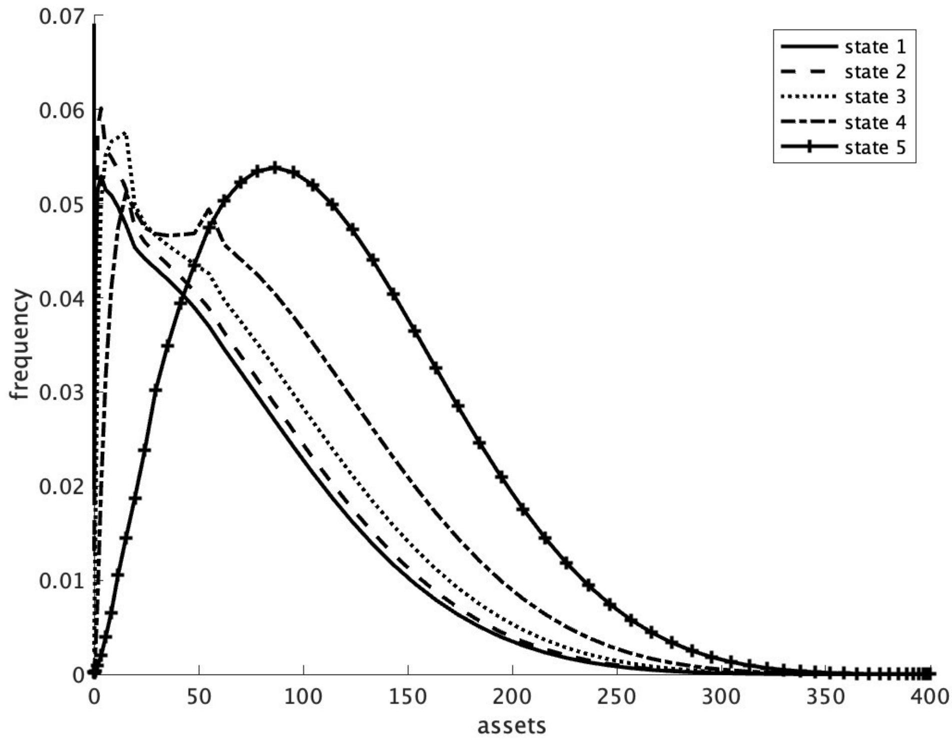
(Note) average growth rate is -0.0413, standard deviation, median is 0.008, skewness is -0.4143715, and kurtosis are-0.0413, 2.6637, 0.008,-0.4143715, and 24.9508, respectively. This calculation did not control for age or year dummy variables.

Figure 2. AR(1) persistency of Labor Income at each age groups



(Note) Aggregate AR(1) persistency is 0.9401.

Figure 3. Asset distribution in steady state of exogenous labor supply model



（Note） State i (i=1,2,3,4,5) represents the ith income quintile.

Figure 4. Aggregate assets (left), consumption (middle), and labor (right) at steady state in the exogenous labor supply model

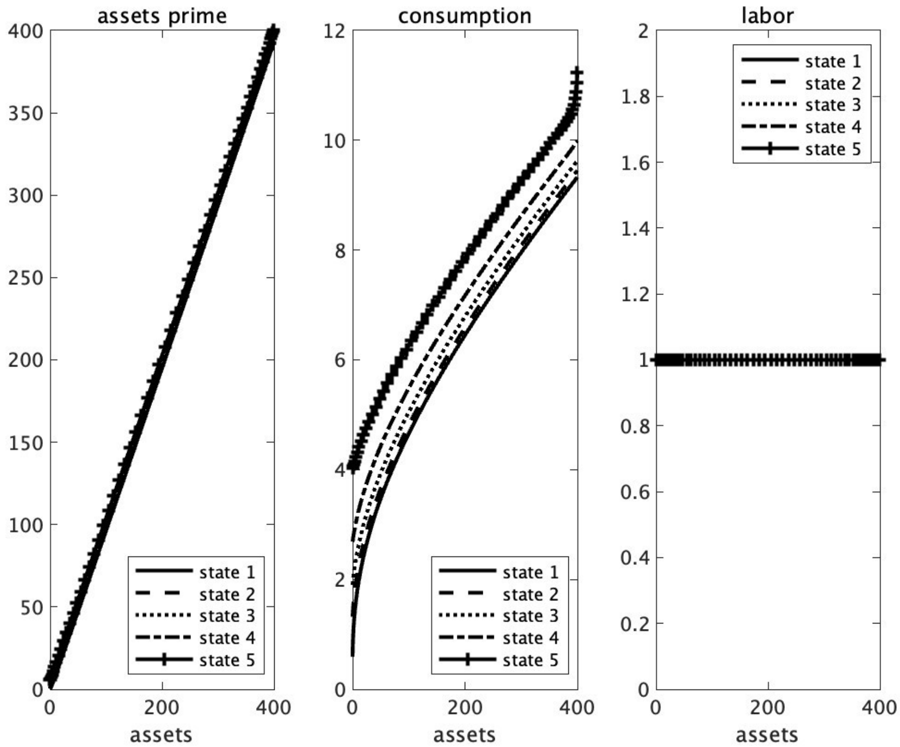
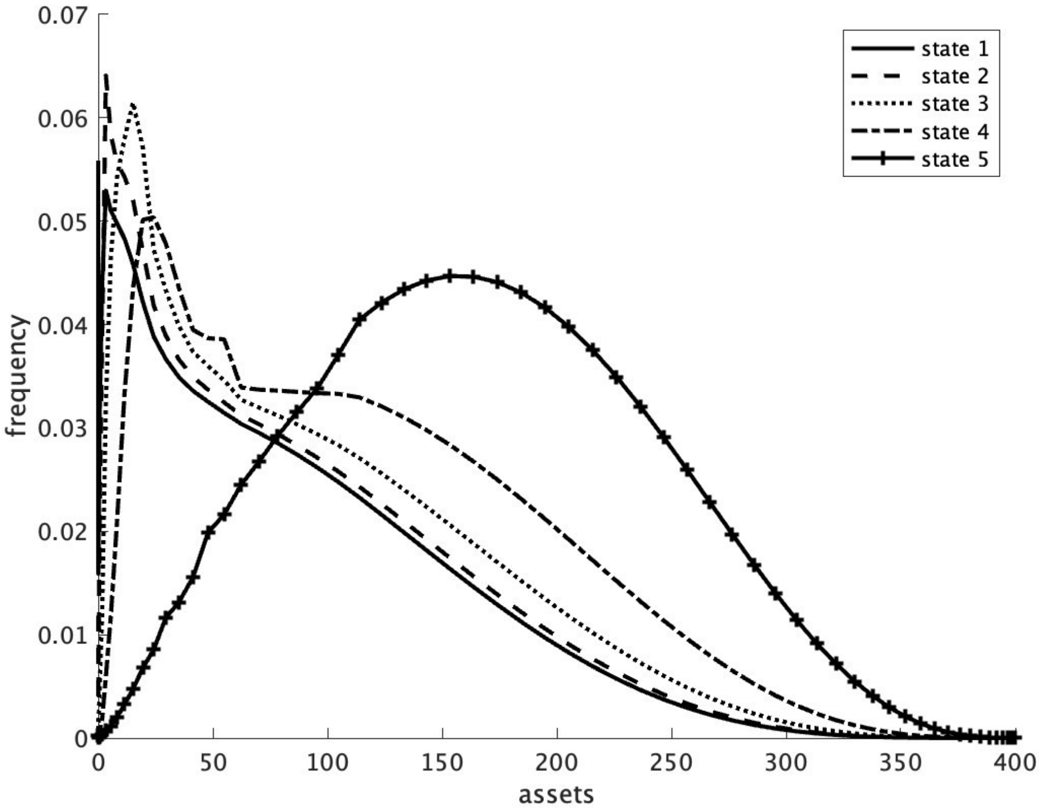


Figure 5. Asset distribution in steady state of endogenous labor supply model



（Note） State i (i=1,2,3,4,5) represents the ith income quintile.

Figure 6. Assets (left), consumption (middle), and labor (right) at steady state in the endogenous labor supply model

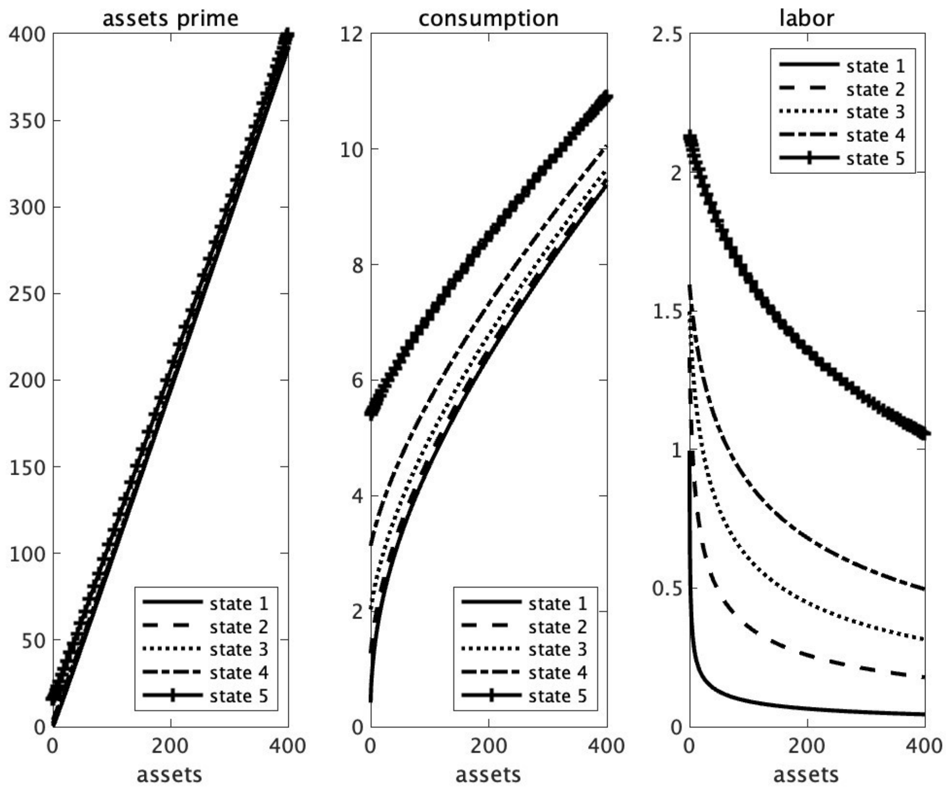


Figure 7. Asset distribution in steady state of endogenous labor supply model with capital income and consumption taxes

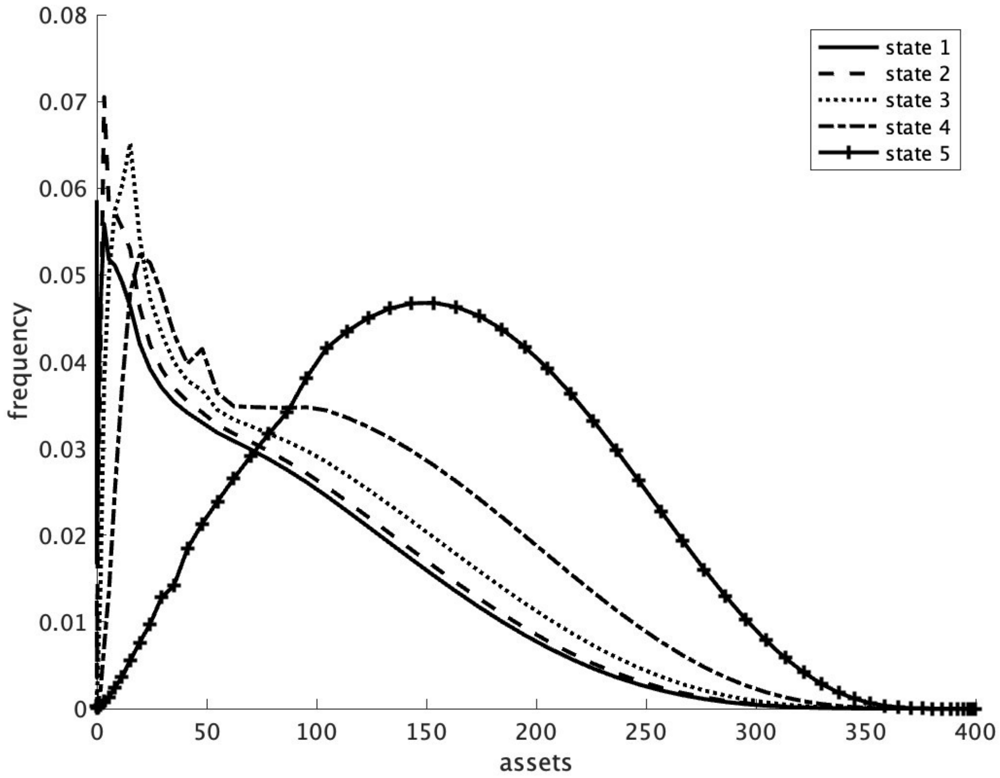
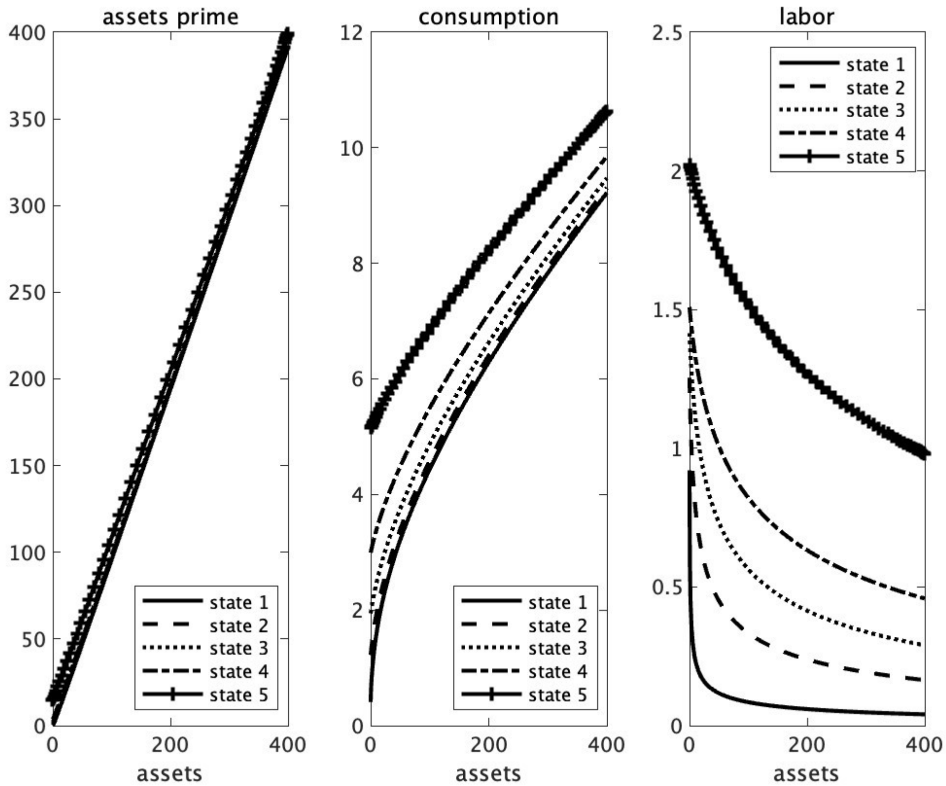


Figure 8. Assets (left), consumption (middle), and labor (right) at steady state in the endogenous labor supply model with capital income and consumption taxes



Appendix. Detailed features of the FTR data

In this appendix, we present some remarkable (but substantial) statistics on FTR data. In particular, we select more detailed (i.e. ten percentile) quantile and prefectural statistical data. Owingstudy

A1. 10^{th} quantile statistics of labor income and tax

Table A1. Summary Statistics of Aggregate Labor Income and Labor Income Tax in five income quantiles (Unit: Ten thousand Yen)

	1st	2nd	3rd	4th	5th
Labor Income	8.221529	67.62063	127.3881	184.6395	246
Labor Income Tax	0.026703	0.631385	2.106156	3.869004	6
Observation	4,310,288	4,310,897	4,308,214	4,311,897	4,309,719

	6 th	7th	8th	9th	10th
Labor Income	319.7707	410.9032	533.0432	718.8935	1707.46
Labor Income Tax	9.475469	14.98455	25.17056	49.96979	289.1961
Observation	4,310,818	4,310,327	4,310,107	4,310,329	4,310,249

Table A2. Transition Matrix of 10 quantile income process

$$\begin{bmatrix} 70.84 & 16.5 & 5.69 & 2.79 & 1.6 & 0.98 & 0.61 & 0.42 & 0.32 & 0.27 \\ 15.64 & 55.4 & 18.72 & 5.66 & 2.44 & 1.17 & 0.54 & 0.25 & 0.12 & 0.06 \\ 5.86 & 16.29 & 48.86 & 19.48 & 5.69 & 2.23 & 0.92 & 0.4 & 0.17 & 0.07 \\ 3.34 & 6.08 & 15.02 & 49.07 & 19.12 & 4.77 & 1.6 & 0.64 & 0.26 & 0.1 \\ 2.24 & 3.41 & 6.02 & 14.02 & 50.51 & 18.62 & 3.49 & 1.13 & 0.43 & 0.14 \\ 1.62 & 1.96 & 2.97 & 5.11 & 12.69 & 54.35 & 17.5 & 2.65 & 0.89 & 0.27 \\ 1.16 & 1.11 & 1.39 & 2.22 & 4.02 & 10.72 & 60.96 & 15.82 & 2.05 & 0.55 \\ 0.72 & 0.73 & 0.84 & 1.15 & 1.95 & 3.19 & 9.49 & 67.35 & 13.43 & 1.15 \\ 0.5 & 0.34 & 0.55 & 0.61 & 1.03 & 1.78 & 2.79 & 9.68 & 74.41 & 8.31 \\ 0.32 & 0.13 & 0.17 & 0.22 & 0.28 & 0.43 & 0.72 & 1.33 & 6.97 & 89.43 \end{bmatrix}$$

Table A3. Result of Estimating Disposable Income Function (10 income quantiles)

	$log\theta_0$	θ_1	Marginal Tax Rate	Average Tax Rate
1	0.0007	0.9997	0.0029	0.0032
2	0.1763	0.9862	0.0228	0.0093
3	0.2556	0.9806	0.0358	0.0165
4	0.2935	0.9782	0.0426	0.0210
5	0.3772	0.9726	0.0520	0.0248
6	0.5626	0.9603	0.0693	0.0296
7	0.7457	0.9485	0.0878	0.0365
8	1.1251	0.9241	0.1216	0.0472
9	1.4332	0.9045	0.1609	0.0695
10	1.8855	0.8759	0.2692	0.1694

Table A4(a). Prefectural sub-sample summary statistics

		Labor Income(Ten thousand yen)		Labor Income Tax(Ten thousand yen)	
	Observation	Mean	S.D.	Mean	S.D.
Hokkaido	1,745,151	376.6478	576.3856	33.09036	158.7586
Aomori	386,927	297.2374	473.3085	22.26267	135.6617
Iwate	376,465	297.9216	473.5738	19.73583	115.8439
Miyagi	821,453	373.531	538.9556	29.96194	157.7462
Akita	361,116	300.2624	418.2529	19.97002	100.3377
Yamagata	359,312	319.0928	463.957	23.4196	121.132
Fukushima	573,264	346.7505	535.9647	28.30787	149.1178
Ibaraki	1,012,950	370.3546	518.2938	27.81331	127.1469
Tochigi	657,817	374.8118	639.7677	30.1365	183.8706
Gunma	616,617	360.5776	636.2381	29.98688	168.9578
Saitama	2,508,597	414.1986	668.6376	33.74235	229.5452
Chiba	2,145,622	446.829	614.0134	38.84191	160.3808
Tokyo	5,753,862	632.5601	1480.212	76.09265	451.919
Kanagawa	3,431,609	515.8924	755.5108	49.37773	224.56
Niigata	692,454	336.3877	463.1725	24.15894	115.0859
Toyama	343,439	377.4323	574.4693	29.13069	176.5235
Ishikawa	372,159	372.252	1130.11	28.96308	234.5323
Fukui	249,812	374.584	608.0954	29.28544	153.8157
Yamanashi	309,445	345.2758	585.785	29.32625	182.406
Nagano	696,650	352.3922	532.0938	27.13213	136.9096
Gifu	548,594	373.676	510.7271	27.54594	134.8183
Shizuoka	1,114,534	392.8837	575.7805	32.83772	161.7479
Aichi	2,359,484	470.2266	702.1169	43.0312	193.24
Mie	489,984	392.3083	529.8182	30.50407	144.5925

Table A4(b). Prefectural sub-sample summary statistics (continues).

		Labor Income(Ten thousand yen)		Labor Income Tax(Ten thousand yen)	
	Observation	Mean	S.D.	Mean	S.D.
Shiga	496,034	398.6017	512.6227	30.33859	141.1294
Kyoto	887,659	415.6023	724.1851	37.99058	188.2056
Osaka	3,142,093	424.6695	731.9754	39.95057	202.1654
Hyogo	1,959,403	457.1707	859.1069	43.51296	267.0332
Nara	485,913	415.7701	575.2797	36.55556	149.4714
Wakayama	323,712	337.156	490.0354	27.19078	122.908
Tottori	154,685	309.4376	418.058	22.57705	102.8347
Shimane	211,313	321.4501	438.5764	22.57705	102.8347
Okayama	616,246	378.5335	554.7225	30.89347	144.8271
Hiroshima	928,093	403.6753	617.8518	35.50492	172.7331
Yamaguchi	395,861	354.2267	519.2232	28.02618	132.5931
Tokushima	231,590	348.5832	510.6139	27.21277	129.6189
Kagawa	293,547	374.7639	509.4792	30.96018	122.6381
Ehime	396,516	359.876	619.6299	31.16176	146.4689
Kochi	219,221	315.0811	479.9039	28.09583	119.6413
Fukuoka	1,682,779	384.4698	591.7372	34.29811	165.4004
Saga	292,976	313.4681	429.5042	21.97801	106.5074
Nagasaki	412,136	311.459	436.0713	24.13421	108.4439
Kumamoto	554,455	334.4907	521.3431	27.14573	134.3209
Oita	309,646	337.8887	553.1041	28.18756	168.4444
Miyazaki	330,186	306.5069	550.2943	25.58784	148.2287
Kagoshima	447,459	314.5739	499.9432	25.47933	122.1105
Okinawa	404,069	264.0181	452.0061	21.84188	111.8932