

Effect of Progressive Taxation on Wealth Inequality and the Economy in an Agent-based Artificial Economic System

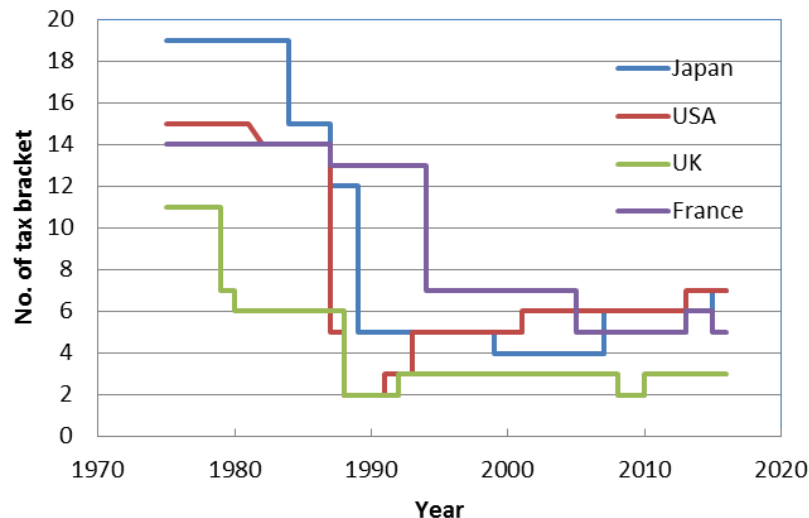
Shigeaki Ogibayashi, Kousei Takashima
Chiba Institute of Technology
Nov. 11-13, 2016

Introduction

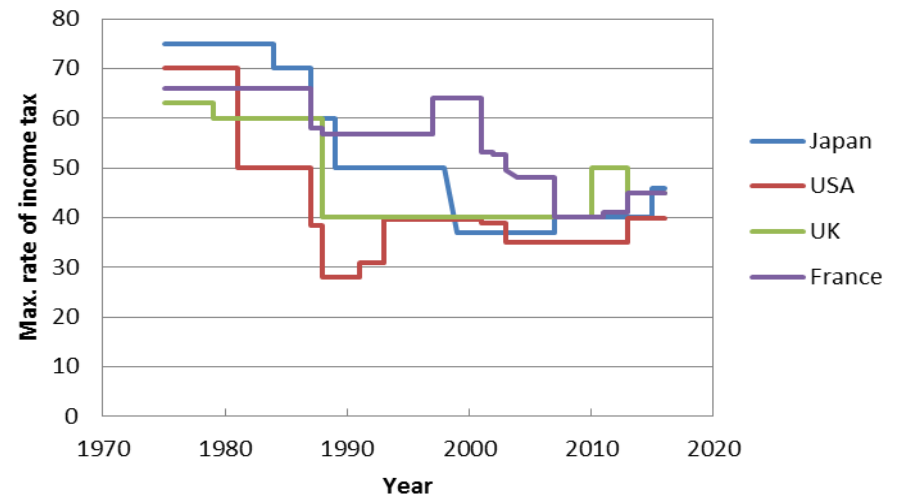
Wealth inequality is increasing during several recent decades, which is currently one of the major policy issues for nations to address.

One of the reasons for this increase in wealth inequality seems to be due to the decrease in progressivity in the progressive taxation during 1970 to 2010 in many OECD countries, in the form of reducing both the number of statutory tax brackets and maximum tax rate.

The number of statutory tax brackets



The maximum tax rate



Previous works on the effect of progressive taxation on GDP

The policy of reducing progressivity seems to stem from the idea that progressive taxation decreases GDP because it reduces the economic efficiency due to the inefficient allocation of resources, by reducing the incentive to invest, to take the risk, etc. by high-income earners.

(c.f. Stiglitz, J.(1986), Economics of the Public Sector,p.846)

One typical example of the evidence for this idea is the OECD's statistical analysis using the database for 21 OECD countries over the period 1971-2004, concluding that

progressivity of income taxes negatively affects economic growth.

(Arnold, J, (2008): Economics Department Working Papers, No.643)

However, this relationship could not reflect real causality, because GDP steadily increased during the period of reducing progressivity.

On the other hand, there is a study which argues that trade-off between equality and economic efficiency is not inevitable because of the effect of the labor market and wage settings.

(Knut.R and Steiner, S (1999), Progressive taxes and the labor market)

Thus, the effect of progressive taxation on GDP seems to be still under arguments, the reason of which is considered that since statistical data include various scatter factors, it is not easy to extract actual causality from the chronological data.

The aim of the present study

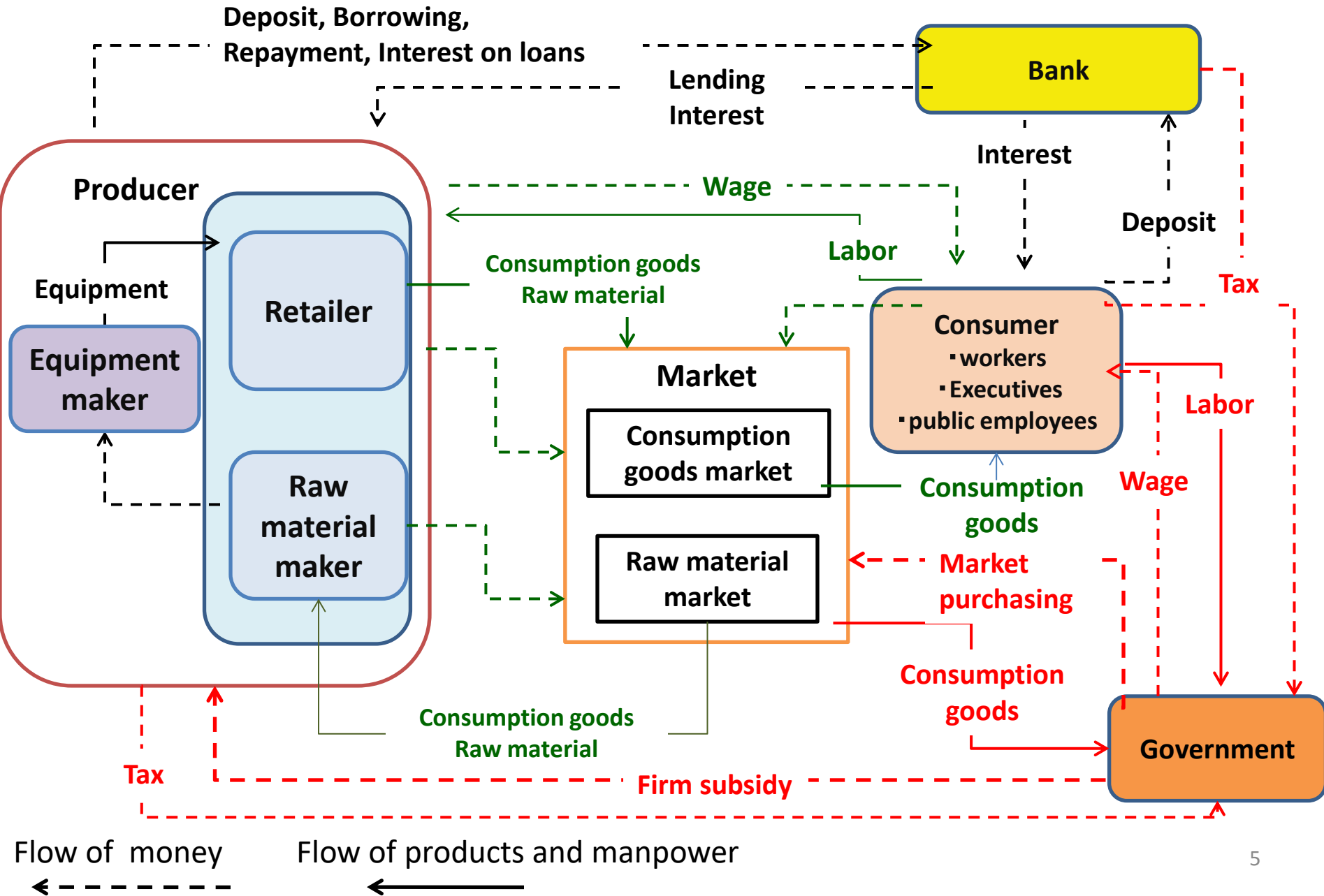
is to clarify the influence of progressive taxation on both wealth inequality and GDP, by agent-based modeling approach.

The agent-based model used in the present study comprises 150 consumers, 37 producers, a bank and a government, and includes essential system structure for reproducing the fundamental behavior of macro economic system, such as

- fund circulation, ▪ price equilibrium ▪ supply chain
- firm's investment as well as bank financing ▪ business cycles,
- the positive effect of the reductions in income tax and corporate tax.

The transaction between agents is recorded using double-book keeping method, GDP is calculated from the input-output table at every period.

Outline of the model



Outline of the behavioral rules of agents

1. Each consumer purchases consumption goods at every period to maximize the utility within the limit of budget restriction.
If the goods of the same type exist in the market at different prices, the consumer purchases the cheapest one.

Budget E = Keynesian consumption function + withdrawal of deposit

$$E_c^{(t)} = a + bI_c^{(t-1)} + r_{wd}^{(t)}D_c^{(t)} + C_c^{(t-1)}$$

where, I_c : after tax income, D_c : deposit,

Utility $\max u = \sum_{i,\alpha} C_c : \text{cash at hand} \quad s.t. \quad \sum_{i,\alpha} w_i x_i \quad rwd : \text{withdrawal ratio}$

2. Producers determine the price and quantity of products at every period based on the amount of goods in stock and total sales.
Production capacity is given by Cobb-Douglas function.

$$Y_i(K, L)_P^{(t)} = A_{iP} K_{iP}^{(t)\alpha} L_P^{(t)(1-\alpha)}$$

$L_P^{(t)}$: Number of employees

$K_{iP}^{(t)}$: Number of equipments for class of goods i

3. Producers decide to invest in equipment to increase production capacity, in which
- 1) investment is decided based on demand in previous 10 periods.
 - 2) funds required for investment is financed by both the bank and internal funds.
 - 3) Investment is restricted due to credit rationing
 - Upper limit of the number of loans is 3.
4. Government collects corporate and income taxes, pays wages and spends the surplus by mixing 2 types of public expenditure.
- Public expenditure
- $$= \text{Market purchasing} * \eta + \text{firm subsidy} * (1 - \eta)$$
- η : inefficiency in public expenditure
- = ratio of firm subsidy to total spending.
- Market purchasing : Buy products at market price.
- ⇒ Extreme case of efficient public spending
- Firm subsidy: Deliver funds to firms randomly without any limitation of its use.
- ⇒ Extreme case of inefficient public spending

Experimental conditions

No. of agent	Consumer	150			
	Retailer	30			
	Raw material maker	6			
	Equipment maker	1			
	Bank	1			
	Government	1			
No. of class of product	Retailer	6			
	Raw material maker	6			
	Equipment maker	1			
Rules of government	Income tax rate	Progressive		Fixed 20%	
	Corporate tax rate	Fixed 20%			
	Inefficiency in government expenditure	0~100%			
Rules of consumers	Withdrawal ratio of deposit	Income-dependent	constant	Income-dependent	constant
		Small/middle/large	0~r, r=0.25,0.5,0.75	Small/middle/large	0~r, r=0.25,0.5,0.75
Rules of producers	Rule for investment	Based on demand in previous 10 periods			
	Rule for financing	Loan and internal funds(50%each)			
	The upper limit on the number of loans	3			
Market	Goods market	With			
	Stock market	Without			
	Labor market	Without			

Experimental Conditions

--Factors systematically changed in the experiment

1. Inefficiency in government expenditure

0, 0.1, 0.2,.....0.8, 0.9, 1.0

2 Tax rate for income

- Constant tax rate: 20%

- Progressive tax rate: Income-dependent

as defined by the following equation

$$T_{income} = T_0 + D \log_{10}(I_i^t / I_{ave}^t) \quad (\text{Lower limit is 0.1})$$

where, T_0 = standard tax rate (= 0),

D : Degree of progressivity (= 0.5),

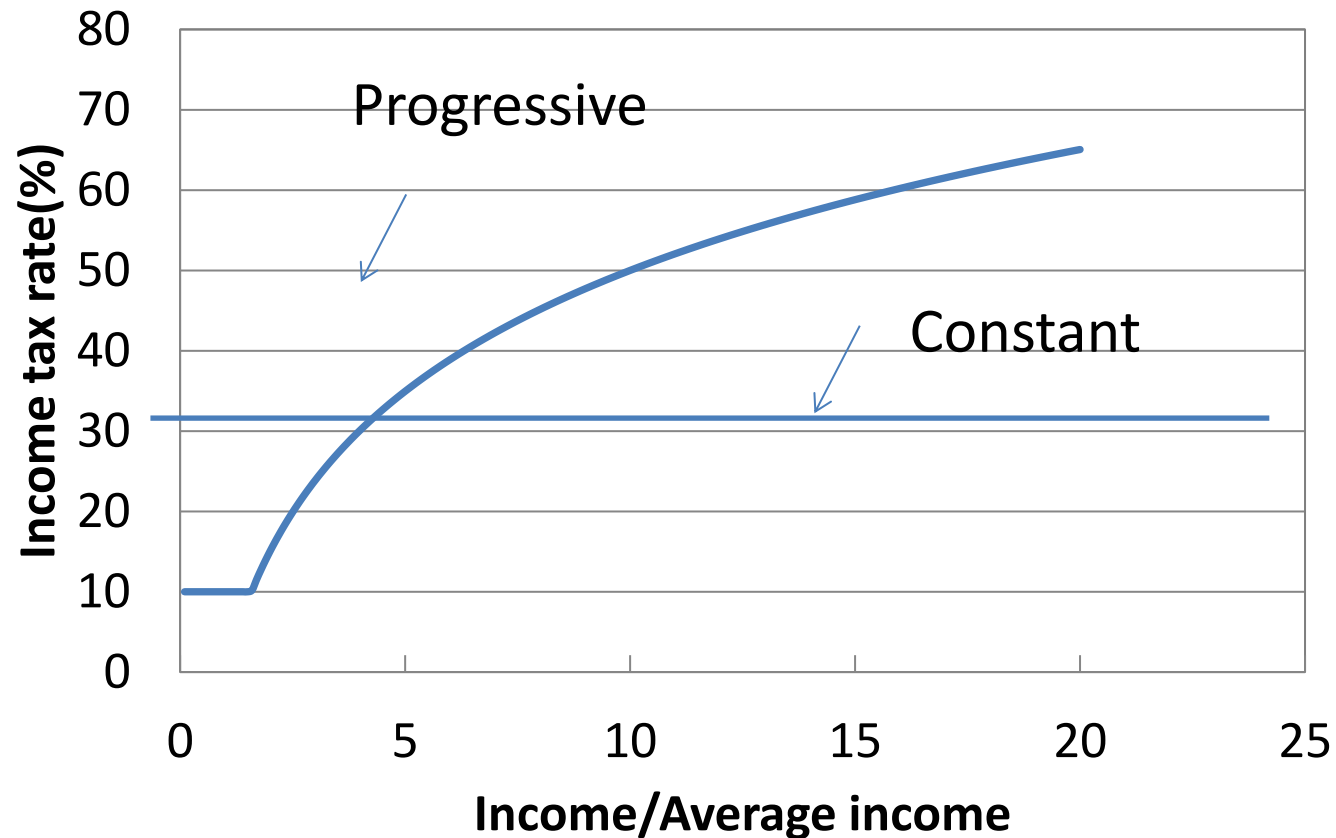
I_i^t : income of agent i at t_{th} period

I_{ave}^t : Average income of N agents at t_{th} period

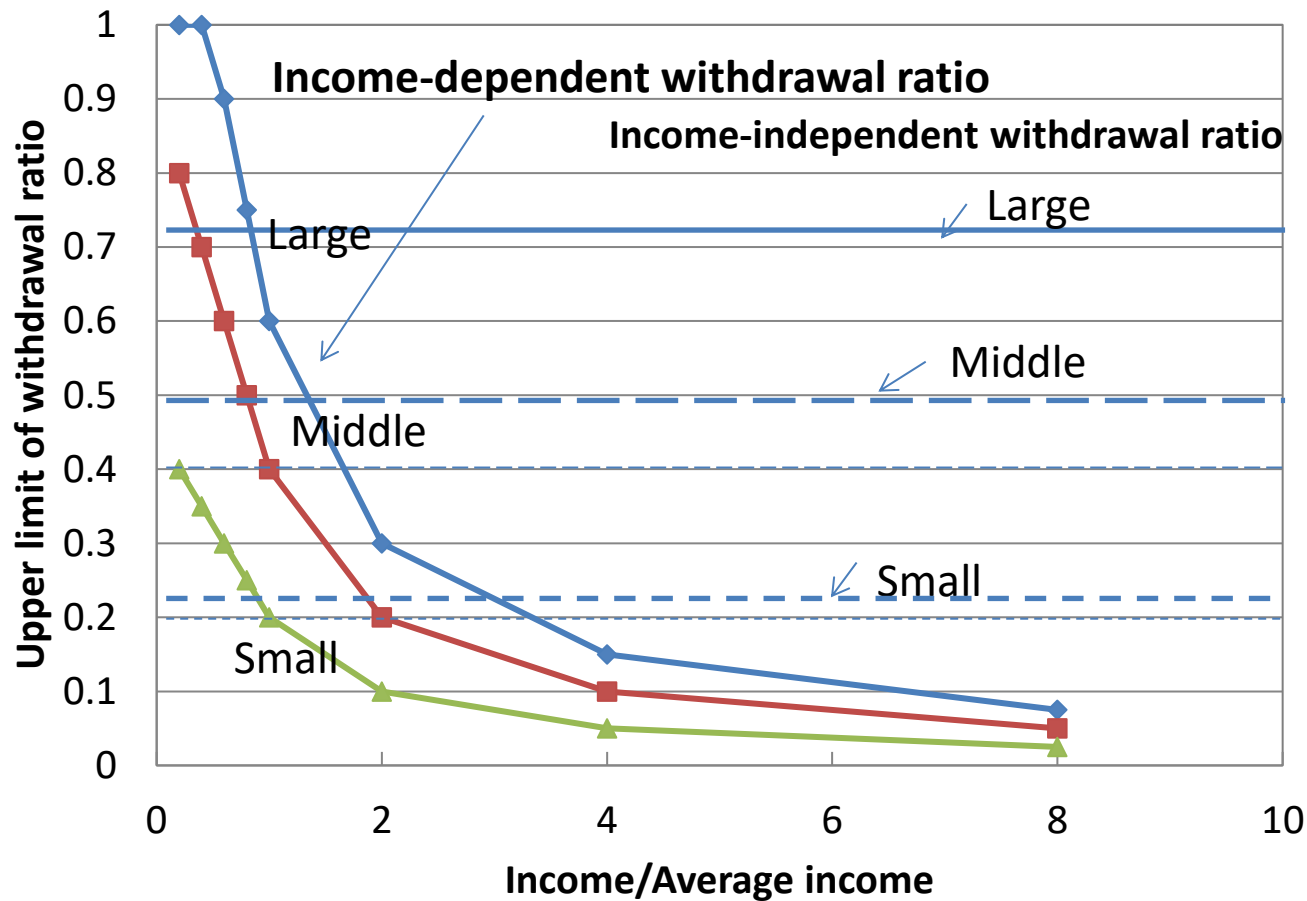
3. Withdrawal rate of deposit which is assumed to corresponds to the consumption of capital goods.

- Income-dependent, or Income-independent
- small/ middle/ large

The tax rate as a function of income level for progressive taxation was determined so that tax revenue would be almost same for both cases of taxation.

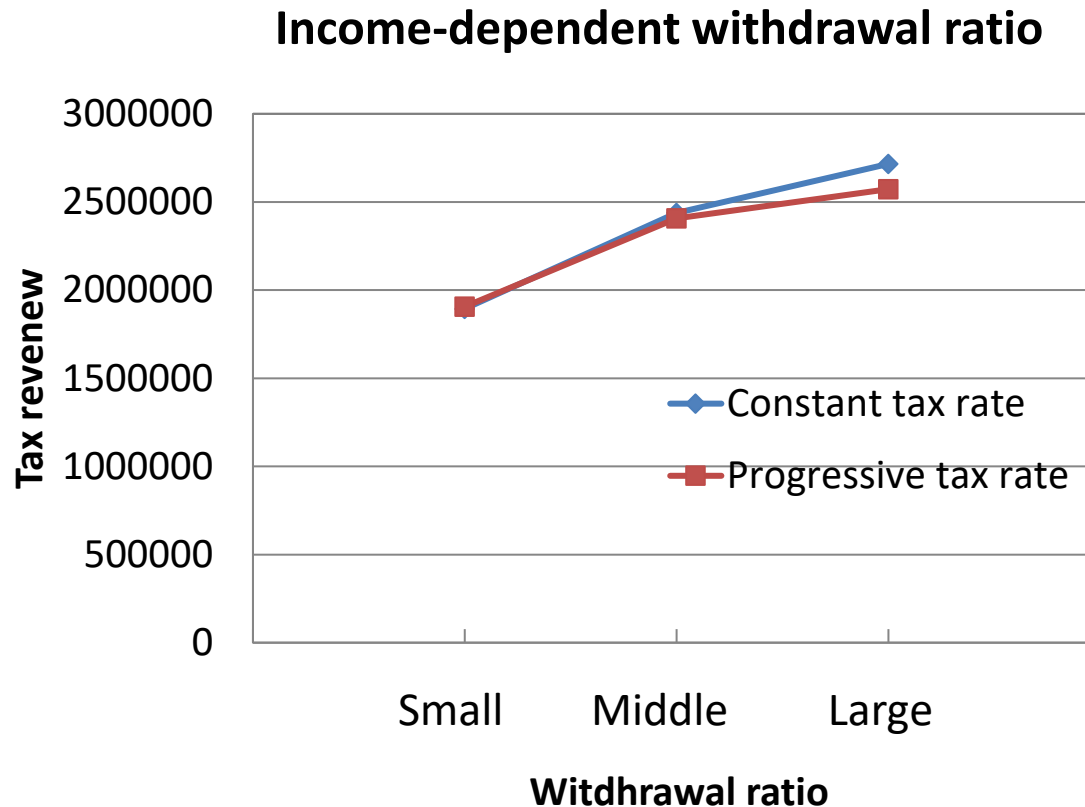


Income tax rate for progressive and constant tax rates used for calculation.



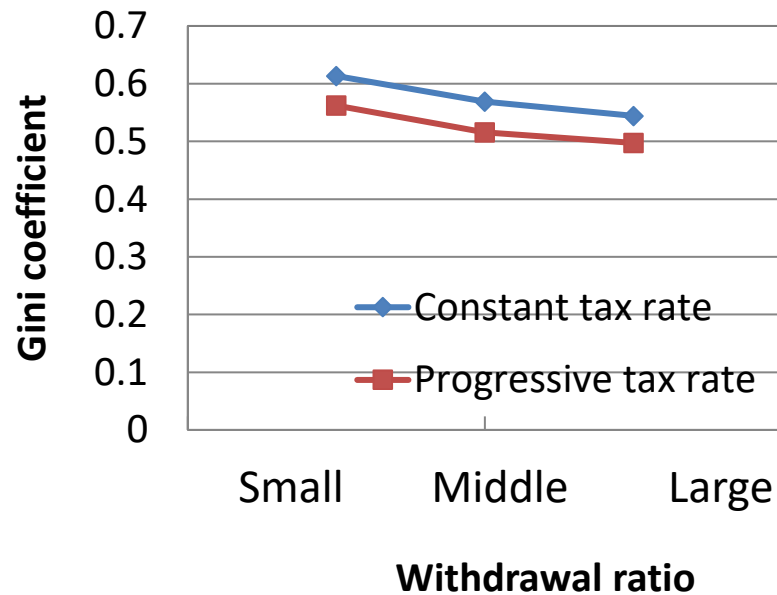
Upper limit of withdrawal ratios used for experiment which are either income-dependent or income-independent.

Calculated results

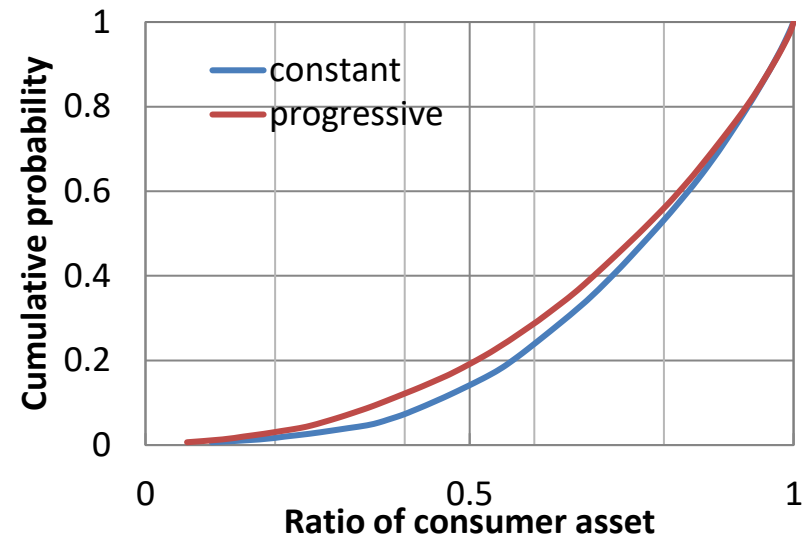


Comparison of tax revenue between progressive and constant tax rates for various levels of income-dependent withdrawal ratios, showing the neutral effect in tax revenue.

Income-dependent withdrawal ratio

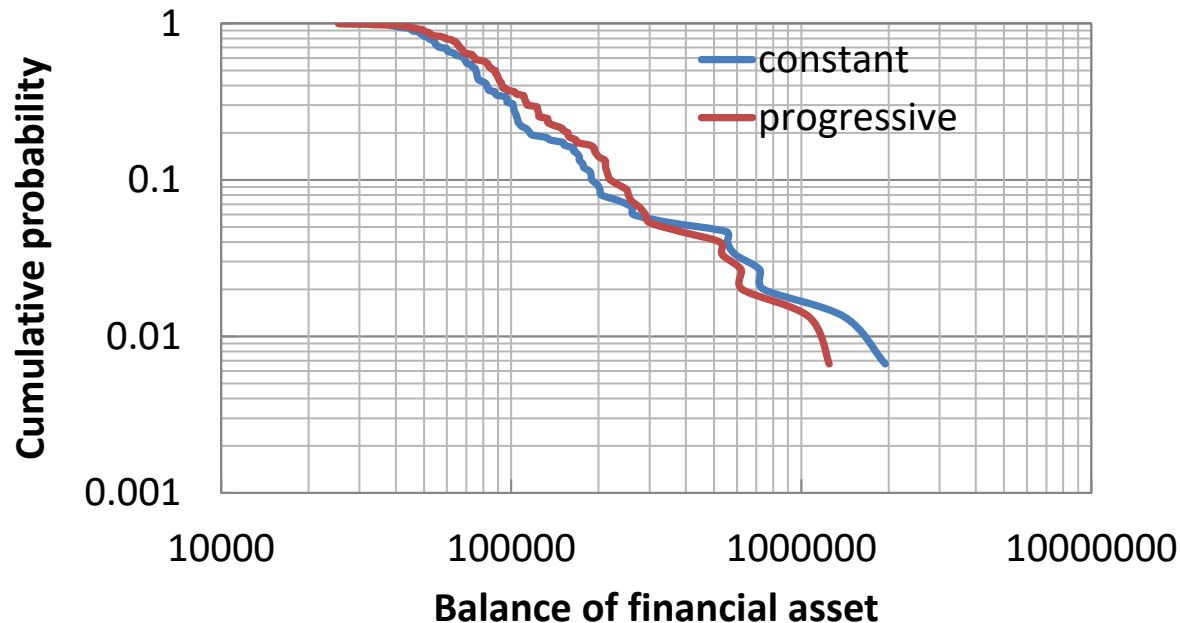


Top percentage of asset holders	Top percentage of asset share	
	Constant	Progressive
2	21.5	15.1
4	31.2	23.7
6	37.4	28.7
8	41.1	32.8
10	44.2	36



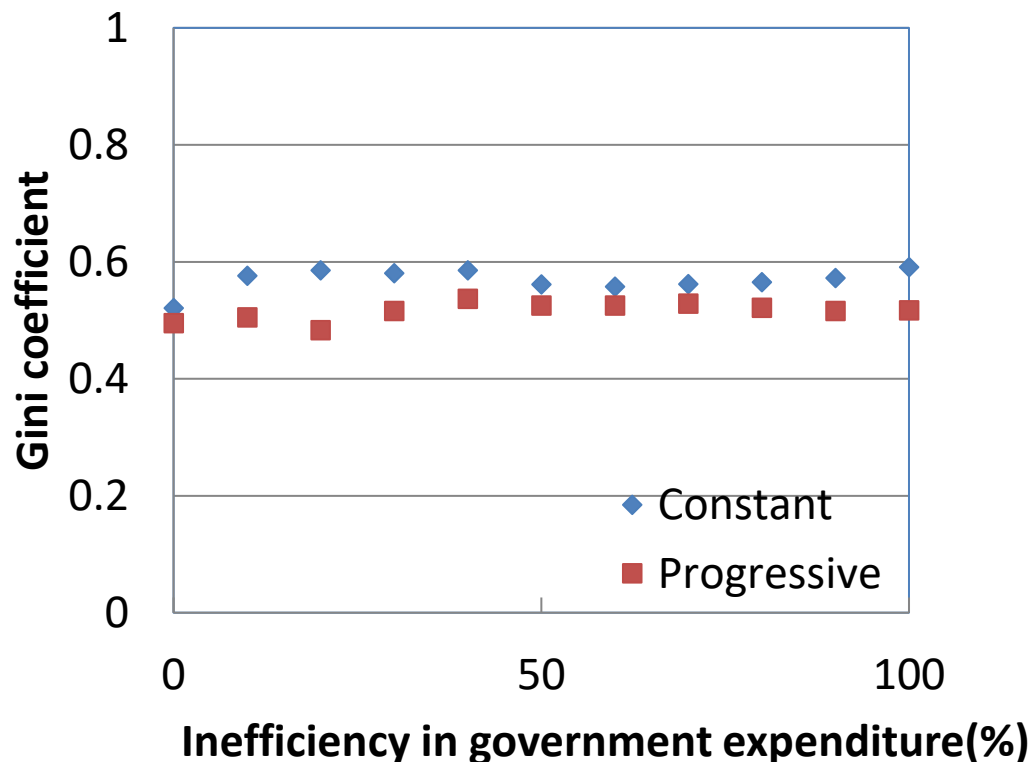
Effect of progressive taxation on Gini Coefficient for various levels of income-dependent withdrawal ratios.

income-dependent withdrawal ratio



Distribution of financial asset of individual agent, showing the asset of the rich decreases and that of the poor increases by progressive taxation.

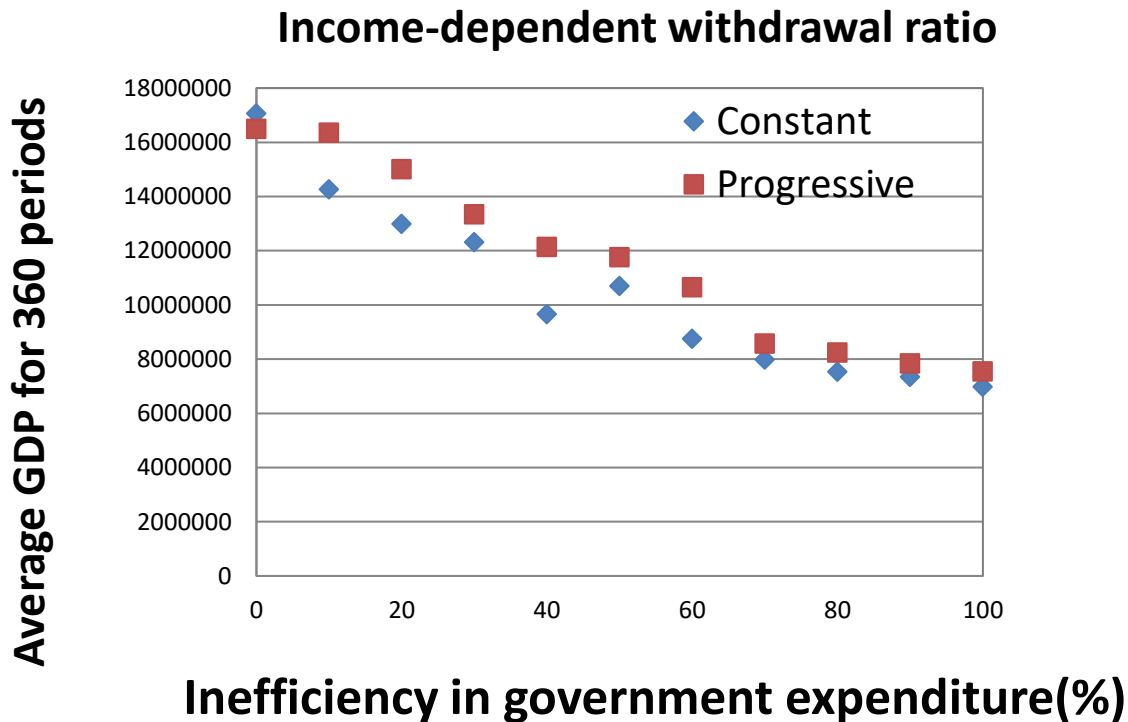
Gini Coefficient is independent of the inefficiency in government expenditure, showing the effect of progressive taxation on Gini Coefficient is independent of the way of public spending.



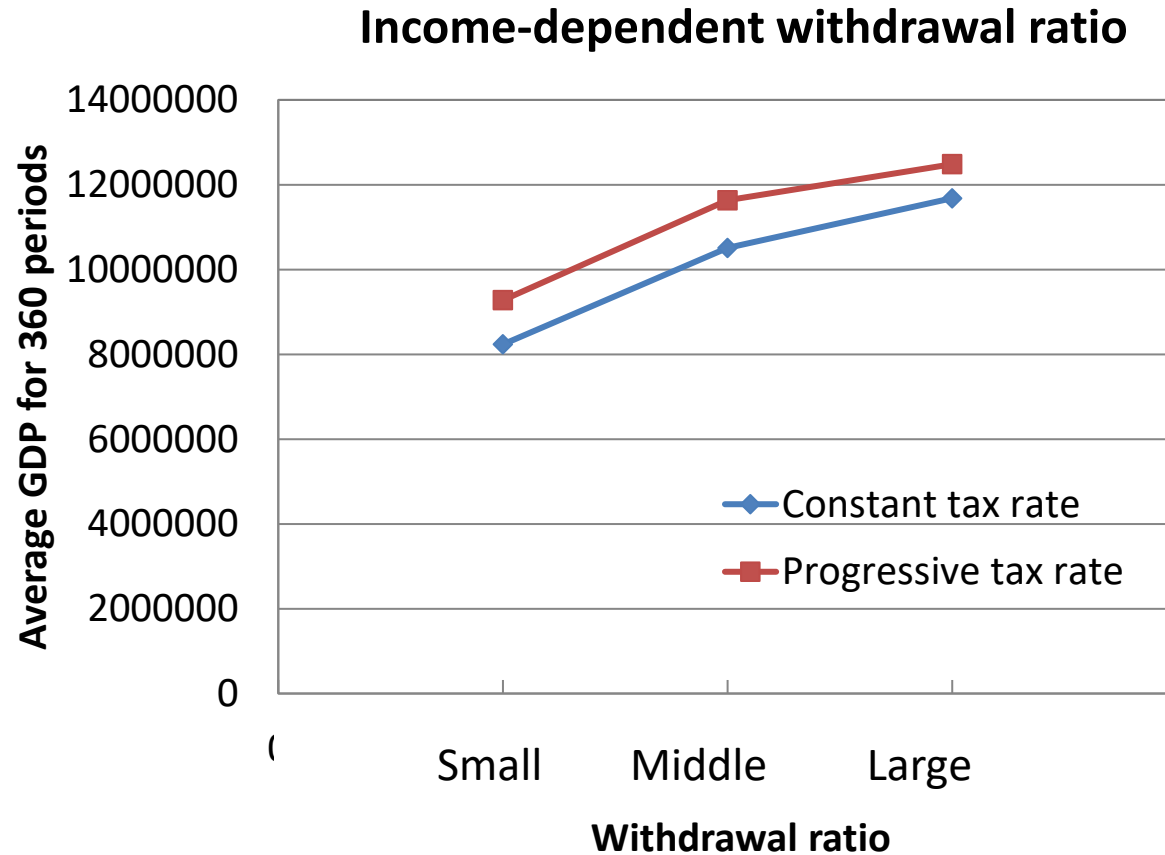
Gini coefficient as a function of Inefficiency in government expenditure (Withdrawal ratio is Income-dependent, middle level)

GDP depends on how government spends money.

If government payment to firms for goods or services exceeds its economic value, the part of the surplus money is deposited in the bank, resulting in a decrease in the money stock in the market, thus reducing GDP.

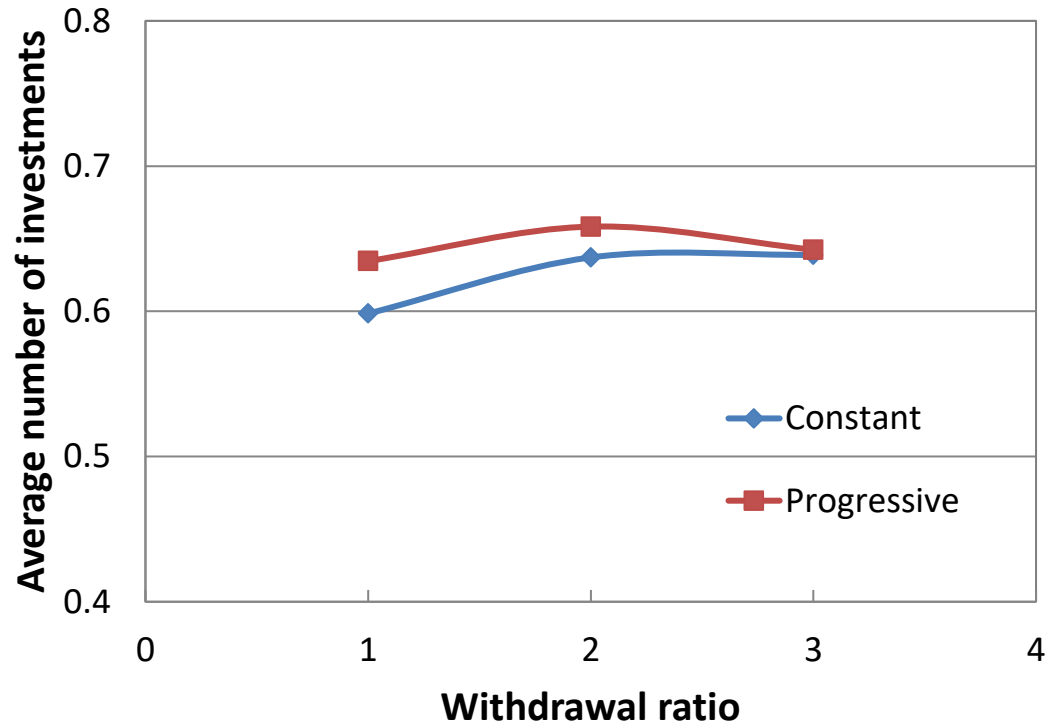


The effect of the inefficiency in government expenditure on GDP



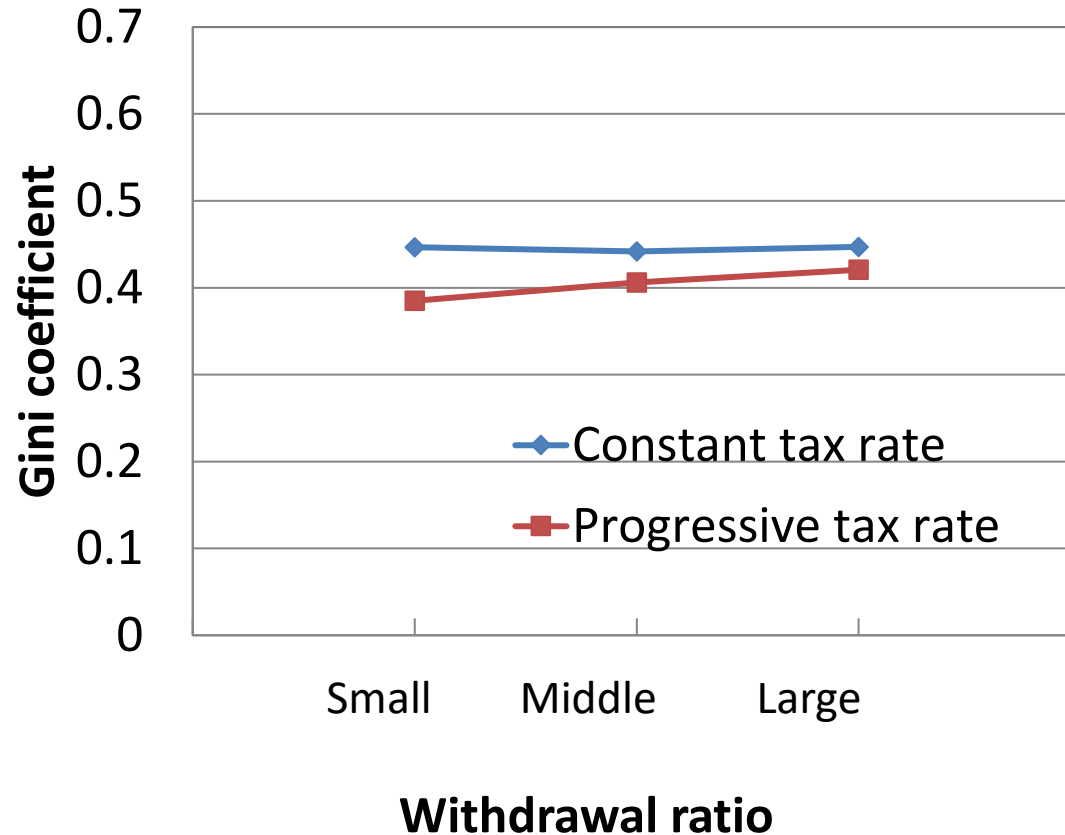
Influence of progressive taxation on average GDP for various levels of withdrawal ratios which are income-dependent.

Income-dependent withdrawal ratio



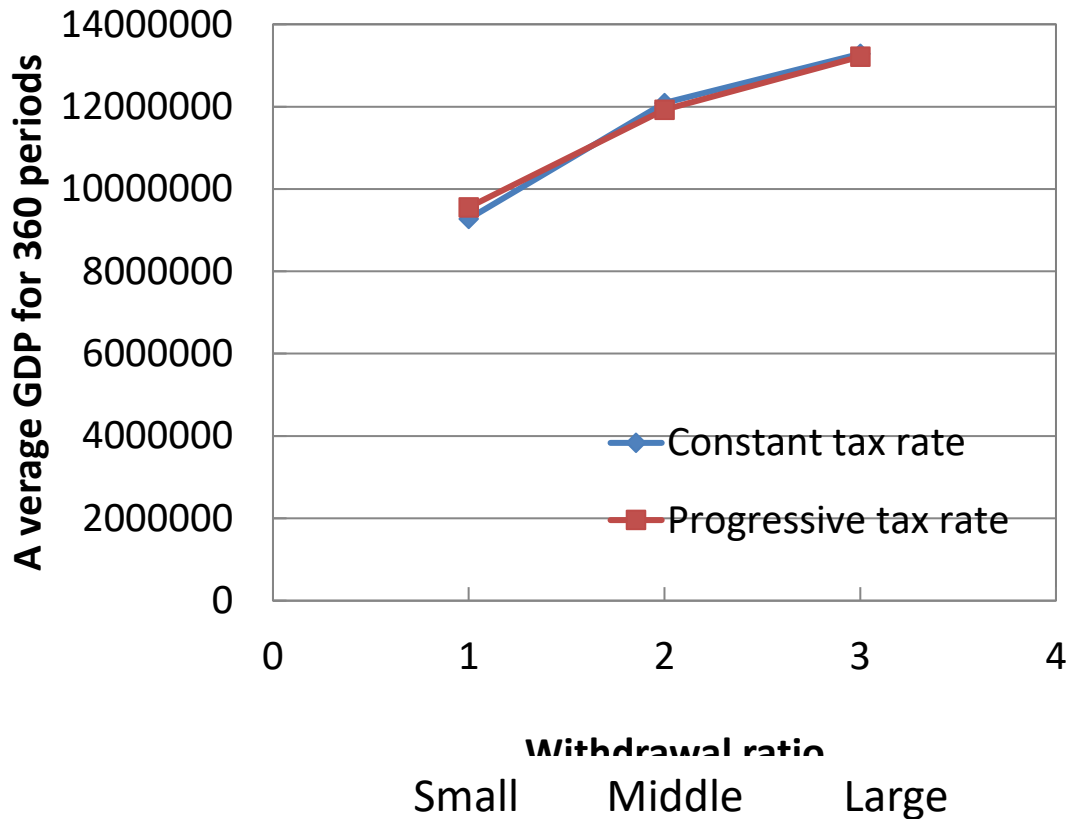
Influence of progressive taxation on the number of investment
For various levels of withdrawal ratios which are income-dependent

Income-independent withdrawal ratio

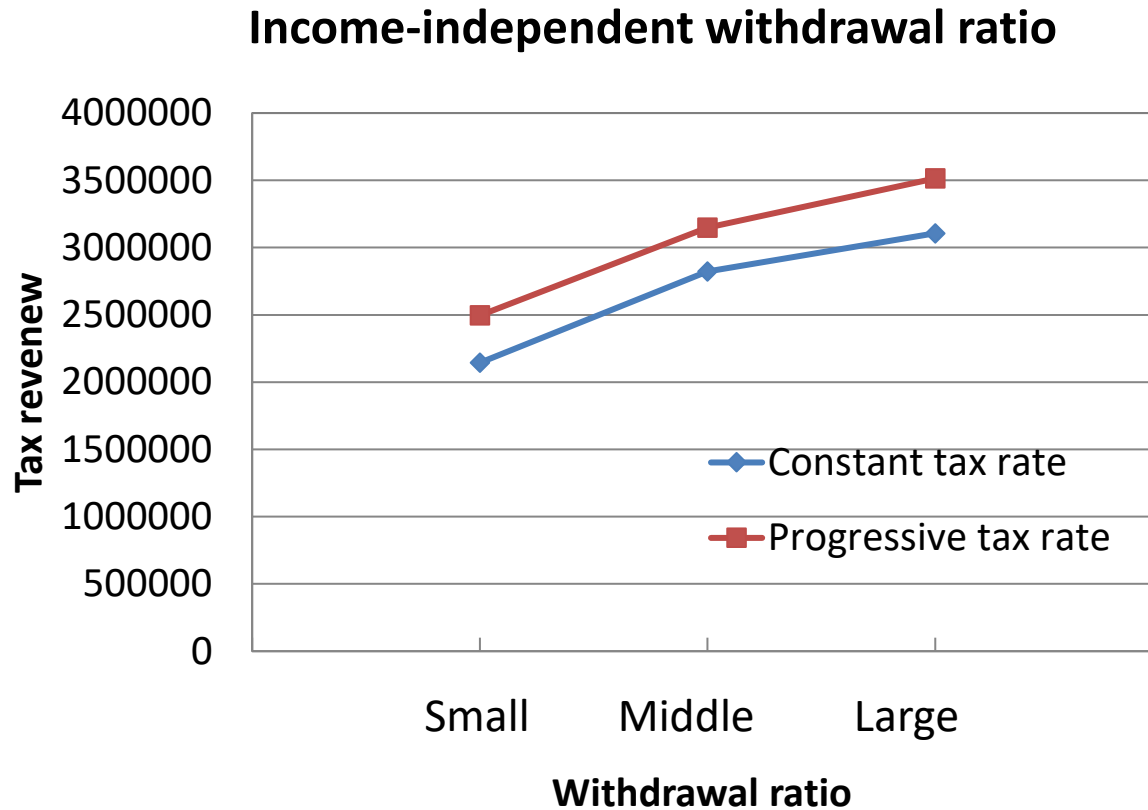


Effect of progressive taxation on Gini Coefficient for various levels of Withdrawal ratios which are income-independent.

Income-independent withdrawal ratio



Influence of progressive taxation on average GDP for various levels of withdrawal ratios which are income-independent.



Influence of progressive taxation on tax revenue for various levels of withdrawal ratios which are income-independent.

Brief summary

1. Progressive taxation is effective not only for decreasing wealth inequality but also for increasing GDP.

➡ The trade-off between wealth inequality and the economy is not inevitable.

2. Positive effect of progressive taxation on GDP holds even though there is no difference in the consumption behavior relative to income between the rich and the poorer people.

Note:

In reality, rich people saves larger part of the income compared to the poor people.

Discussions

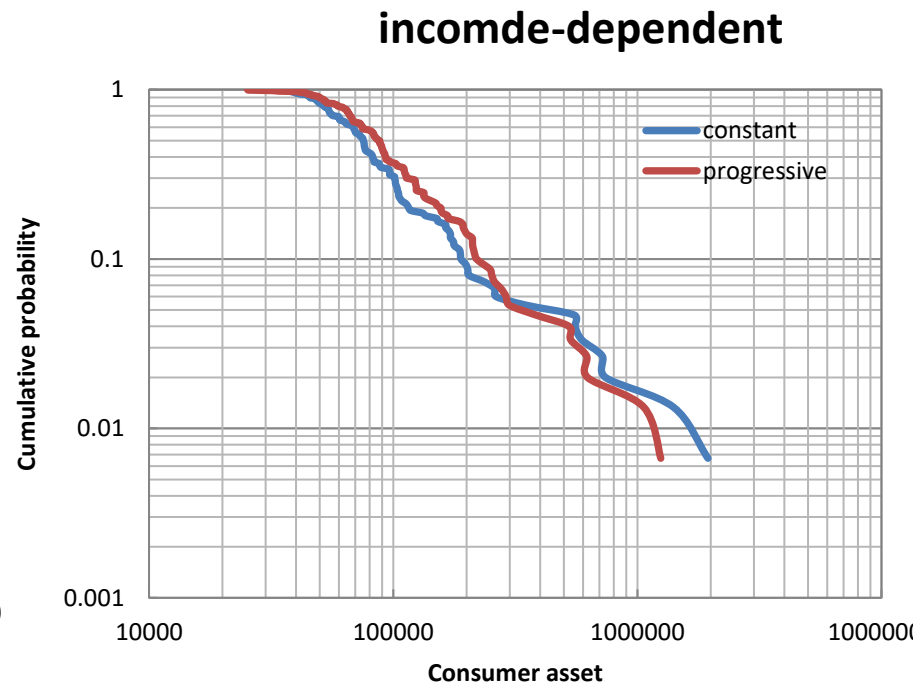
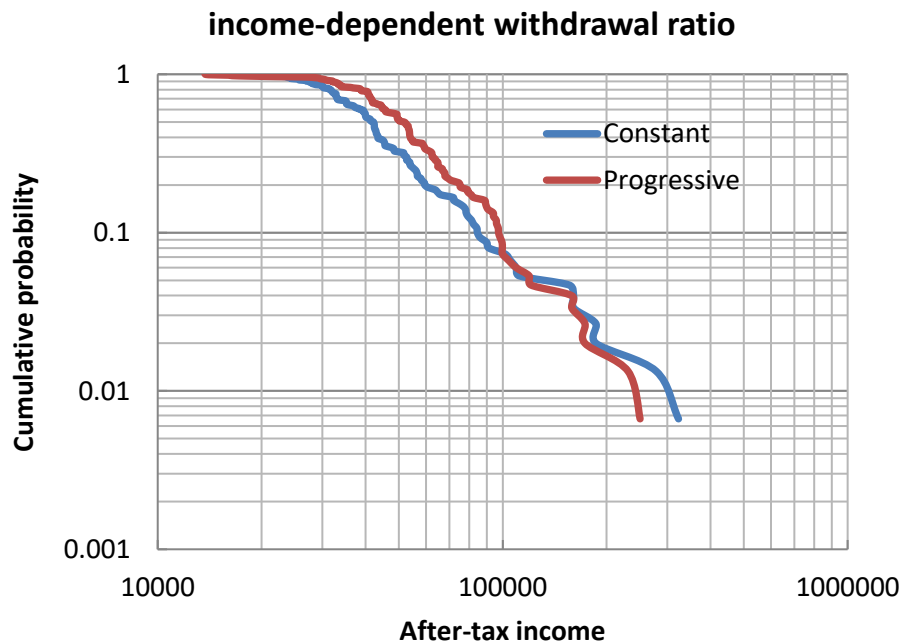
Why does the progressive taxation increase GDP?

Discussions

Why do the progressive taxation increase GDP?

- 1) Progressive taxation increases the income and asset of large number of people, while decreasing those of the rich of small number.

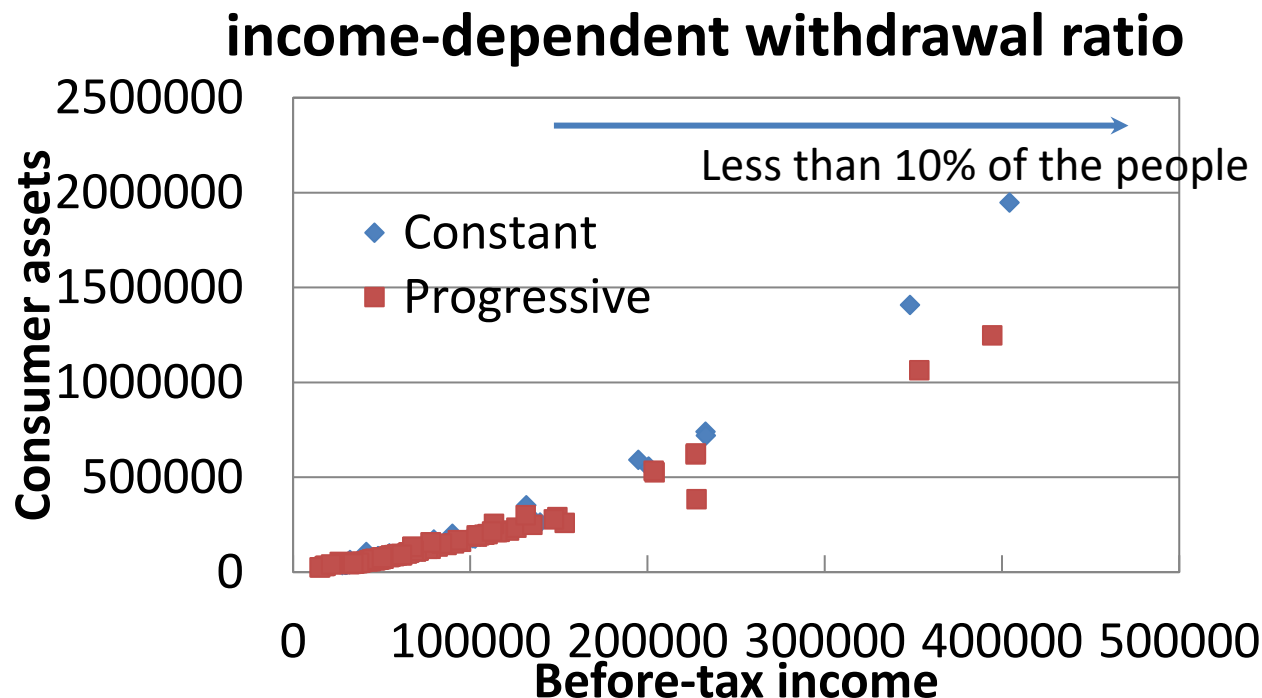
More than 90% of people who owns less acquire higher income and asset by progressive taxation.



2) The higher earner holds larger share of assets, meaning they save huge amount of money every period, even though consumption behavior relative to income is the same.



Progressive taxation transfers such money of the rich, deposited in the bank, to the majority of the people who owns less, making it being consumed in the market.



Mechanism of increasing GDP by progressive taxation is the money of the rich, which is to be deposited in the bank, is forced to be transferred to the majority of the people who owns less, thereby increasing the demand which in turn increases GDP.

Comparison between the model and the reality from the viewpoint of consumption behavior.

- The model of present study does not take into account the consumption of the rich for investment or tax evasion.
- If the effect of these factors are larger than the effect of increasing demand by the majority of people, then progressive taxation could result in negative effect on GDP.
- The detail remains as a future subject, but it might be considered that the policy for the incentive of investment etc. can be made in the level of corporate tax reduction.

Conclusions

The effect of progressive taxation on GDP was studied using ABM approach and we can conclude as follows.

1. Progressive taxation could increase GDP as well as having positive effect of decreasing Gini Coefficient.
2. The reason is that progressive taxation forces the money of the rich being deposited in the bank to be distributed to the majority of people who owns less.

This process results in the state that the positive effect of tax reduction for the majority who owns less is much larger than the negative effect of tax increase for the wealthy, thereby increasing the demand which in turn increases GDP.

3. The opposite phenomenon could occur If the rich people spend their money too much for investment, but it might be considered that the policy for the incentive of investment etc. can be made in the level of corporate tax reduction.