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Basic Income Stalls the Economy: Economic Conditions Affecting the Effects of Basic Income and the Response to Relative Income

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Abstract

Basic income (BI) is a social welfare policy idea that has recently received much attention. BI implementation requires extensively transforming social and economic systems, possibly resulting in significant, unforeseeable impacts. This study focused on the impact of BI in terms of its effectiveness based on relative income and economic conditions at the time of its implementation. We analyzed the impact using a simulation approach with a macro artificial economy model that incorporates multilayered feedback paths and encompasses a complete flow of funds mechanism. The analysis revealed conditional impacts depending on the BI implementation period. A boom can stagnate or a recession can recover, depending on the public's work motivation. Particularly, when work motivation is high and the economy expands, BI implementation may slow down economic activities.

Keywords: agent-based modeling, basic income, work motivation, simulation, business cycle

1 Introduction

Basic income (BI) has been recently attracting attention as a system that permanently provides people with an income that unconditionally guarantees a living standard. As Van Parijs and Standing emphasized, BI helps those who have fallen into a poverty trap [1, 2]. Standing's study [3] in the poorest regions, where the amount of money in circulation is a constraint on economic activity, showed that BI is one of the most effective means to avoid destitution.

BI has negative as well as positive opinions. They include financial difficulties [4], being less effective than unemployment insurance [5], and being a financial burden and negatively impacting gross domestic product (GDP) [6]. One of the most important problems is the issue of labor supply [7, 8]. BI is a permanent, fixed income and thus may reduce the incentive to work and create social system issues if widely implemented throughout society. Many BI proponents are aware of this issue, which is often mentioned as a rebuttal to criticisms when discussing BI. BI supporters claim that labor supply has no problems based on an analysis of the results of empirical experiments with BI and a similar system of negative income taxation [9, 10, 11, 12,

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13, 14]. However, these empirical experiments have issues, such as institutional problems [15], a possible Hawthorne effect [16], and the failure to consider interactions that could occur if the target is set at the level of the entire population [17]. Thus, the societal impact of BI implementation remains unknown.

In addition, unlike the thriving empirical experiments, theoretical research remains scarce [18]. A quantitative macro analysis [19], a study using a micro perspective and a behavioral economics standpoint [20], and analyses using a microsimulation perspective [21, 22] have been conducted, but only a few. In Chrisp's survey [17], nine studies had used macroeconomic models as of 2022, with the first being conducted in 2016. The slow progress of theoretical research is due to the difficulty of building models because of the large-scale market changes. Additionally, the impact of BI is difficult to predict because workers' labor supply decisions have no precedent. Forget mentioned that BI's educational impact is manifested in a household's behavioral changes in response to the behavior of surrounding households caused by BI [23]. Similarly, employee motivation, which determines labor supply, may be influenced by surrounding workers. However, only a few studies have considered the influence of others on employee motivation, although one analysis used a work/leisure model focusing on envy and blame [24].

In contrast, we focused on Clark's point about the efficacy of income relative to others [25] and analyzed the impact of BI using an agent-based computational economics model. Results revealed that the impact of BI exhibits a complex behavior due to multilayered feedback, including not only work motivation but also workforce changes depending on work motivation, changes in the use of government spending, and firms' capital investment decisions [26].

These results suggest that when BI is implemented in society, emergence through multilayered feedback may lead to corresponding changes. Economic conditions during implementation can greatly affect change-oriented policies, particularly for large societies where multilayered interactions occur. However, to our knowledge, no study has analyzed how the impact of BI varies under different economic conditions, extending the scope to complex interactions arising from multilayered feedback. Thus, this study focuses on the economic cycle behavior that endogenously emerges in this model and the BI impact on a model that includes multilayered feedback. We experimented and analyzed the impact of BI in each economic situation.

This study uses a middle-range agent-based model (ABM) [27] with limited economy-wide components and performs simulations under conditions of large fluctuations to observe endogenously emergent economic cycle behavior. Although several studies have analyzed the impact of BI using ABM [28, 29, 30], only a few were conducted in the context of the macroeconomy, as mentioned above. In addition, these studies do not assume a multilayered feedback mechanism, which may limit the BI impact.

Therefore, the gap concerning dynamic interactions and economic fluctuations in the context of BI implementation must be addressed. Although existing studies have explored the macroeconomic impact of BI and used ABM, mult-agent interactions under fluctuating economic conditions and relative income effects are often overlooked.

This study is novel in that it focuses on economic conditions at the start of BI implementation and relative income impact, which has not been considered in previous BI studies. The study also simulates endogenous economic cycle movements that may result from BI implementation and multilayered feedback mechanisms as they exist in reality. Through this experiment, this study contributes to the literature by providing the first realistic and objective feedback-based analysis of the BI impact on the macroeconomic system. Results showed that BI has the exact opposite effects, either stagnating a strong economy or improving a sluggish one, depending on work motivations. In relation to the experimental attempt in the previous study [31], this study extends the experimental conditions to further explore the impacts of BI.

This paper is organized as follows. Section 2 outlines the model, and Section 3 describes the experimental conditions of the study. Section 4 presents the results, and Section 5 discusses the results. Finally, Section 6 presents the conclusions.

2 Model

The model details are described below. Although this study adopts the same model as that of the previous study [31], certain components are explained in greater detail.

2.1 Agent-Based Computational Economics Construct

An agent-based computational economics model is built to govern five types of autonomous agents: household, firm, government, bank, and equipment maker. Households provide labor supply for firms; they earn wages and consume to maximize their utility. Firms produce consumer goods, employ household agents, and invest in capital. The government collects taxes from households and firms and then redistributes the funds as government spending. Banks manage fund circulation, household savings collection, and loan offerings to firms. Equipment-makers manufacture the capital goods needed by firms. Among these agent types, households and firms employ varying parameters, whereas the government, bank, and equipment maker are represented by an agent, respectively.

In this model, household income sources include wages paid by firms and BI provided by the government. Firms' income is acquired through the sale of goods to households, other firms, and the government. Tax revenue is collected from households and firms, and the volume of circulated money within the system fluctuates based on bank loans and repayments. This model does not include mechanisms for replacing agents during business failures, thus maintaining a fully circulating capital structure without the unnatural emergence of money in the market, as recommended by Caiani [32].

Figure 1 illustrates the model structure, and Table 1 lists the monetary relationships in an accounting chart [33]. The left side of the table tracks active agents, and the right side tracks passive agents. It depicts monetary increases and decreases caused by the actions of active agents and the corresponding changes for passive agents. Agents' actions occur in monthly real-time cycles based on the following steps:

1. Each agent determines its budget for taxes, consumption, wages, and benefits based on the previous period's financial results. Firms plan their production based on sales performance, and households set their work motivations based on income.
2. Firms produce goods based on their production plans. However, their employees' productivity may vary due to work motivation changes, and production may not proceed as planned.
3. Households and the government make purchases according to their budgetary limits and respective purchasing rules.
4. Firms invest in capital equipment if they perceive a high demand for their products. Thus, loans are taken, and repayments are made to the bank in installments with interest. Additionally, banks pay interest on households' deposits.
5. Each agent pays salaries, bonuses, and BI according to a budget set at the beginning of the period.

The model makes the following assumptions regarding goods and preferences:

- The market has consumption goods, and each firm produces two goods at the beginning of the simulation. Thus, one type of good may be produced by more than one firm.
- Households are assigned a random number of three recognizable consumption goods.
- Production equipment has a constant function at a constant price, regardless of the state of the firm or the product produced.

Table 1: Accounting-related tables for this model [26]

ID	Sender's journal entry						Accounting Relation	Receiver's journal entry					
	Sender	Type (debit)	Subject (debit)	Abstract	Subject (credit)	Type (credit)		Type (debit)	Subject (debit)	Abstract	Subject (credit)	Type (credit)	Receiver
H1	Hou	Liabilities	Accrued Income Tax	Accrued Income Tax Payment	Cash	Assets	Income Tax Payments	Assets	Cash	Income Tax Received	Income Tax Received	Revenue	Gov
H2	Hou	Expenses	Supplies_R	Buying Supplies_R	Cash	Assets	Buying CtoR Supplies (O)	Expenses	Cost of Sales	Product Sales C_Supplies	Products	Assets	FirCo
								Assets	Cash	Product Sales C_Supplies	Product Sales C_Supplies	Revenue	
H3	Hou	Assets	Deposits	Deposits	Cash	Assets	Deposits	Assets	Cash	Deposits Under Custody	Deposits Under Custody	Liabilitie	Ban
H4	Hou	Assets	Cash	Deposit Withdrawal	Deposits	Assets	Deposit Withdrawal	Liabilities	Deposits Under Custody	Deposit Withdrawal	Cash	Assets	Ban
F1	Fir	Liabilities	Accrued Fixed Salaries	Fixed Salary Payment	Cash	Assets	Fixed Salary Payment	Assets	Cash	Fixed Salary Received	Fixed Salaries Received	Revenue	Hou
F2	Fir	Liabilities	Accrued Bonuses	Bonus Payment	Cash	Assets	Bonus Payment	Assets	Cash	Bonus Received	Bonuses Received	Revenue	Hou
F3	Fir	Liabilities	Accrued Corporations Tax	Accrued Corporation Tax Payments	Cash	Assets	Corporations Tax Payment	Assets	Cash	Corporations Tax Received	Corporations Tax Received	Revenue	Gov
F4	Fir	Assets	Cash	Short-term Loans	Short-term Loans	Liabilities	Short-term Loans	Assets	Short-term Loan Receivables	Short-term Cash Loans	Cash	Assets	Ban
F5	Fir	Liabilities	Short-term Loans	Short-term Loan Repayments	Cash	Assets	Short-term Loan Repayments	Assets	Cash	Receive Short-term Repayments	Short-term Loan Receivables	Assets	Ban
FC1	FirCo	Assets	Cash	Long-term Loans	Long-term Loans	Liabilities	Long-term Loans	Assets	Long-term Loan Receivables	Long-term Cash Loans	Cash	Assets	Ban
FC2	FirCo	Liabilities	Accrued Interest (Facilities and Equipment)	Interest Payment	Cash	Assets	Interest Payment	Assets	Cash	Loan Interest Received	Interest Received	Revenue	Ban
FC3	FirCo	Liabilities	Long-term Loans	Long-term Loan Repayments	Cash	Assets	Long-term Loan Repayments	Assets	Cash	Receive Long-term Repayments	Long-term Loan Receivables	Assets	Ban
FC4	FirCo	Assets	Capital_E	Capital Buying_E	Cash	Assets	Buying RtoE Capital (O)	Expenses	Cost of Sales	Product Sales R_Capital	Products	Assets	FirEq
								Assets	Cash	Product Sales R_Capital	Product Sales R_Capital	Revenue	
G1	Gov	Expenses	Corporate Subsidies	Corporate Subsidies Payment	Cash	Assets	Corporate Subsidies Payment	Assets	Cash	Subsidies Received	Subsidies Received	Revenue	FirCo
G2	Gov	Expenses	BI	BI Payment	Cash	Assets	BI Payment	Assets	Cash	BI Received	BI Received	Revenue	Hou
G3	Gov	Expenses	Supplies_R	Buying Supplies_R	Cash	Assets	Buying CtoR Supplies (O)	Expenses	Cost of Sales	Product Sales G_Supplies	Products	Assets	FirCo
								Assets	Cash	Product Sales G_Supplies	Product Sales G_Supplies	Revenue	
B1	Ban	Expenses	Interest Expense (Interest)	Deposit Interest Payment	Cash	Assets	Deposit Interest Payment	Assets	Cash	Deposit Interest Received	Interest Received	Revenue	Hou

Hou: Household Gov: Government Ban:Bank Fir: Firm & Equipment maker
FirCo: Firm (Consumer goods manufacturing)

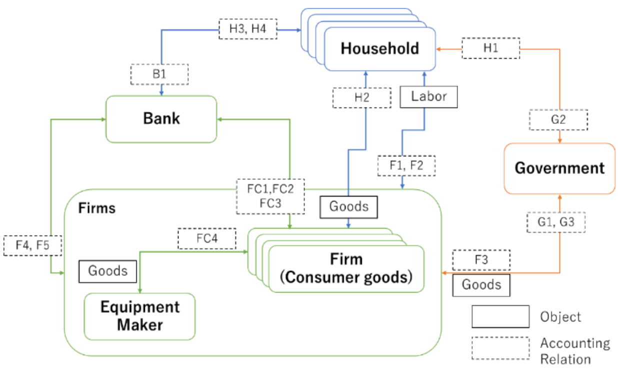

Figure 1: Model structure [26]

2.2 Individual Agent Behavior

2.2.1 Households

Household h determines its consumption budget $C_{[h]t}$ for period t based on disposable income $Y_{[h]t-1}$ from the previous period. The current period's disposable income $Y_{[h]t}$ is calculated as follows:

$$Y_{[h]t} = W_{[h]t}\left(1 - r_{i\_tax}\right) + BIR_t + DI_{[h]t}, \quad (1)$$

where $W_{[h][t]}$ is the wage paid by firms to household h in period t, r_{i_tax} is the income tax rate applied to the wages, BIR_t represents the BI received in period t, and $DI[h]_t$ is the deposit interest accrued by household h in period t based on the amount deposited in the bank. In addition, the model does not assume unemployment, and each household has two sources of income: salary and BI.

This formula incorporates households' primary income sources, including wages after income tax, BI, and interest on deposits. These elements form the disposable income that determines the household's consumption budget for the next period. Considering the extensive use of variables in this model, subscripts such as [h] for household, [f] for firms, and [i] for product types are reused to denote specific entities and categories within the model.

Consumption $C_{[h]t}$, or the total amount of consumption by household h at time t, is determined as follows:

$$C_{[h]t} = bc + \left(Y_{[h]t-1} - bc\right)mpc + D_{[h]t}wd, \quad (2)$$

where bc is the basic consumption, mpc is the marginal propensity to consume, and wd is the withdrawal rate from savings $D_{[h]t}$. The formula reflects that households consume a fixed basic amount, plus a portion of the remaining income after basic needs, and additionally withdraw from savings.

Savings D is adjusted for each period as follows:

$$D_{[h]t} = (Y_{[h]\mathrm{t}} - bc) \cdot (1 - mpc) - D_{[h]\mathrm{t}} \cdot wd. \quad (3)$$

This equation reflects how unconsumed income is added to savings, whereas a portion of existing savings is withdrawn.

Each household h purchases consumer goods to maximize their utility within income constraints, guided by the Cobb–Douglas utility function.

The labor motivation $M_{[h]t}$ changes with income as follows:

$$M_{[h]t} = \frac{\boldsymbol{\delta}}{\boldsymbol{\delta} + \mathbf{exp}\left\{-\varepsilon\left(\frac{Y_{[h]t}}{Y_t^*} - 1\right)\right\}}, \quad (4)$$

where δ and ϵ are the parameters affecting labor motivation's response to the relative income difference $Y_{[h]t}/Y^*_t$, where Y^*_t represents the average income level.

2.2.2 Firms

Firms adjust their production quantities and prices based on their products' sales performance. The maximum production capacity is represented by the upper limit of inventory $Qlim_{[f][i]t}$, indicating the maximum number of products of type iii that firm f can hold. This inventory ceiling is determined using a Cobb–Douglas production function based on the number of facilities K, labor input L calculated from employed workers, and a firm-specific coefficient a as shown below:

$$Qlim_{[f][i]\,t} = a_{[f]}\, K_{[f]t}^{\alpha} L_{[f]t}^{(1-\alpha)}, \quad (5)$$

where α is the distribution rate parameter indicating the share of output attributed to capital and labor inputs and $a_{[f]}$ is a firm-specific technological capability randomly assigned to each firm, affecting their production efficiency. Labor force $L_{[f]t}$ per firm sums the labor motivations of all employed workers (households) *fh* at firm *f* during period *t* as defined below:

$$L_{[f]t} = \sum_h M_{[f][h]\,t}. \quad (6)$$

This formulation assumes that a firm's effective labor input is proportional to the total motivation of its employees, regardless of skills and other attributes.

Firms determine their target production quantities $Qaim_{[f][i]t}$ in each period using a regular ordering method based on sales data up until the previous period as follows:

$$Qaim_{[f][i]t} = \frac{1}{ti}\sum_{j=t-ti}^{t-1} Qsel_{[f][i]j} - \mathrm{ST}_{[f][i]t} +$$

$$\left\{ sa\sqrt{\frac{1}{ti}\sum_{j=t-ti}^{t-1}\left(Qsel_{[f][i]j} - \frac{1}{ti}\sum_{ji=t-ti}^{t-1} Qsel_{[f][i]j}\right)^2} \right\} \quad (7)$$

where the forecasted demand over the forecasting period *ti* (i.e., the number of past periods used for averaging) is assumed to be the average sales during this period. Safety stock is calculated with a procurement period of 0 and a reorder interval of 1. $Qsel_{[f][i]j}$ represents the sales volume of product *i* by firm *f* during period *j*, and $ST_{[f][i]t}$ represents the inventory on hand before production. The parameter *sa* is the safety factor that determines the safety stock size by scaling the standard deviation of past sales. If $Qaim_{[f][i]t} + ST_{[f][i]t}$ exceeds the production limit $Qlim_{[f][i]t}$, then $Qaim_{[f][i]t}$ is adjusted to $Qlim_{[f][i]t} - ST_{[f][i]t}$.

This study assumes that prices are adjusted based on the proportion of the previous period's inventory $ST_{[f][i](t-1)}$ relative to the production limit $Qlim_{[f][i]t}$. Thus, if $ST_{[f][i](t-1)}/Qlim_{[f][i]t} < 0.2$, then prices are increased by 2%; if the ratio exceeds 0.8, then prices are reduced. However, any price reduction must not fall below the production cost, which is calculated from labor costs, depreciation, and interest on loans incurred during investment periods. This pricing strategy ensures that firms remain economically viable while adapting to market demands and inventory levels.

Furthermore, persistent inventory shortages, monitored through a cumulative investment flag, trigger capital investments to enhance production capacity. Thus, capital investment increases *K* in Eq. (5), enhancing production capacity. Capital investment decisions are made by adding the investment flag variable in the period when $Qaim_{[f][i]t}$ exceeds $Qlim_{[f][i]t}$ and subtracting the investment flag variable in the period when $Qaim_{[f][i]t}$ falls below the current inventory $ST_{[f][i]t}$. In this study, capital investment is made when the investment flag variable exceeds 20. Half of the capital investment is financed by the firm's funds, and the remaining by a long-term loan from a bank.

The salary $W_{[f][h]t}$ paid by firm *f* to each worker *fh* has two components: a fixed salary and a performance-based bonus. The fixed salary $W_{[f][h]}$ is randomly assigned at the beginning of the simulation to reflect individual differences in ability. The actual amount paid in each period is scaled by the worker's current motivation $M_{[f][h]t}$, where M = 1 results in 100% of the base salary being paid, and lower values reduce the amount proportionally. The performance-based bonus is calculated as the firm's profit in the previous period $E_{[f]t-1}$ multiplied by the bonus rate r_b, forming the total bonus pool. This pool is distributed among workers based on their relative labor contribution in the previous period. Specifically, each worker's share is determined by the proportion of their adjusted fixed salary (i.e., $W_{[f][h]} \cdot M_{[f][h](t-1)}$) to the total adjusted fixed salaries of all employees in that period.

Thus, the total salary received by each worker is calculated as follows:

$$W_{[f][h]t} = WF_{[f][h]}M_{[f][h]t} + E_{[f]t-1}r_b\left\{\frac{WF_{[f][h]}M_{[f][h]t-1}}{\sum_h WF_{[f][h]}M_{[f][h]t-1}}\right\}. \quad (8)$$

From the household's perspective, this salary is recorded as $W_{[h]t}$, which is identical to $W_{[f][h]t}$ from the firm's perspective.

2.2.3 Government

Taxes are used for government expenditures, which represent public spending, subsidies to firms, and BI to households. Government acquisitions include consumables purchased equally from each producer in the market. These acquisitions are within the budget based on the government's purchase rate g_{rp}. Alternatively, enterprise subsidy is calculated from tax revenues according to the enterprise subsidy budget rate g_{rs} and is distributed equally to enterprises.

The BI grant distributes funds equally to all households. In this case, the per capita subsidy amount BIR_t is calculated by dividing the average household income by the standard BI rate gr_{bi}. In the experiment, when BI is implemented, securing budget for BI is prioritized, and the remaining amount is used to determine the budget for market purchases and subsidies according to g_{rp} and g_{rs}. In contrast, if the BI is not granted, the full amount of the budget is used according to g_{rp} and g_{rs}.

2.2.4 Banks and equipment makers

Banks collect deposits from households and extend long-term loans when firms make capital investments and short-term loans when the working capital is insufficient. Long-term borrowing accumulates interest based on a given rate, and repayment is made in equal installments of the principal and interest. For short-term borrowings, interest is not charged for simplicity as the borrowings are repaid in the subsequent period. In this model, the bank does not employ workers and thus has no source of interest payments. Profits accumulate in the banking sector, which negatively impacts the flow of funds.

The equipment manufacturer produces equipment based on the orders of individual firms. Because equipment manufacturing firms provide employment, they pay fixed wages and bonuses to their employees in proportion to the sales they generate.

3 Experimental Conditions

When the model is simulated under the conditions shown in Table 2, an endogenous economic cycle emerges as shown in Section 4.1 below. This result is caused by the expansion and contraction of the flow of funds resulting from corporate investment. When firms perceive a tight demand, they make capital investments financed by bank borrowings, and the inflow of funds into the market results in economic expansion. In contrast, when corporate investment runs its course, the economy shrinks because funds flow out of the market as borrowings are repaid [26].

In this study, we first compared GDP and work motivations at various phases of the economic cycle with (BI[T0]) and without BI (NoBI) implementation. Then, we analyzed the impact of implementing BI in each of the upswing or downswing phases of the economic cycle with no BI implementation.

For these experiments, work motivation ε is defined by three conditions of very high (VH), high (H), and low (L) work motivation. This parameter was established based on a previous study [26]. Conditions of very low work motivation are possible but are excluded in this study because they can cause an equilibrium flow of funds in the system, showing results unrelated to the BI impact. The experiments were conducted using 21 patterns of BI initiation conditions: 0, 10, and 20 periods. Each initiation is delayed by 10 periods, up to 200 periods. Therefore, when the NoBI condition is added, 22 patterns are utilized, and the simulations were implemented for each of the three work motivation conditions, constituting 66 simulation patterns. For each of the 66 experimental patterns, 10 random numbers were used. Unless otherwise mentioned, the following results are based on the average of 10 random number patterns. Table 3 shows the experimental conditions.

This paper does not include a dedicated sensitivity analysis. Nevertheless, previous studies using earlier versions of the macroeconomic ABM framework (before the integration of BI and relative labor motivation) have examined the effects of varying tax rates [34]. Furthermore, in a refined version of the model developed in earlier studies (e.g., [34]), sensitivity to labor motivation parameters and BI levels (0%, 20%, 40%) has been tested. These earlier results provide preliminary robustness insights into the key mechanisms addressed in this study [26].

Table 2: Basic parameters for simulation

Simulation period *T*	360	Fixed wage *WF*	4000~5000
Number of item type *I*	10	Basic consumption *bc*	1000~1500
Number of household *H*	500	Marginal propensity to consume *mpc*	0.5
Number of firm *F*	60	Withdrawal rate *wd* (random, each period)	0.5~0.8
Initial cash of household	3000~5000	Number of product types that can be produced	2
Initial cash of firm	100,000	Initial equipment K_t	1
Initial cash of government	100,000	*a* of Cobb–Douglas type production function	10~12
Initial cash of equipment maker	1,000,000	Capital distribution ratio α	0.8
Initial cash of bank	40,000,000	Forecasted period *ti*	10
Budget rate for government purchases gr_p	0.5	Safety coefficient *sa*	1.65
Budget rate for firm subsidies gr_s	0.5	Initial price of every firm's goods	1000~1500
Income tax rate	20%	Bonus ratio of firm r_b	0.5
Corporation tax rate	40%	Repayment period of long-term loans	100
Equipment price	500,000	Maximum number of long-term loans	2
Maximum production of equipment per period	10	Interest rate of loans	0.01

Table 3: Experimental levels

ε	BI	BI start period	Condition
−0.01	No	—	NoBI_VH
(VH)	Yes	0~200 (10-period interval)	BI(T0)VH, BI(T10)VH, ･･･BI(T200)VH
−0.02	No	—	NoBI_H
(H)	Yes	0~200 (10-period interval)	BI(T0)H, BI(T10)H, ･･･BI(T200)H
−0.15	No	—	NoBI_L
(L)	Yes	0~200 (10-period interval)	BI(T0)L, BI(T10)L, ･･･BI(T200)L

4 Results

4.1 Basic Behavior of NoBI and BI(T0)

Work motivation significantly affects BI. Thus, we first reviewed the results on the relationship between relative work motivation and BI. In the NoBI condition with a random number pattern in this model, under the condition of ε = −0.02 (NoBI_H), where work motivation is relatively hard to decline, the average work motivation during the 360 periods was 95.2% against 1 when the worker worked completely. In contrast, in the ε = −0.15 condition (NoBI_L), where work motivation is likely to decline, the average work motivation was 87.8%. Figures 2(a) (NoBI_H) and 2(b) (NoBI_L) show the change in GDP over a 360-period interval averaged over 10 different random number conditions.

As shown in Figure 2(b), the third wave of the economic cycle does not occur under the NoBI_L condition, where work motivation tends to decline. The reason is that under this condition, a decline in work motivation leads to a decline in income. As a result, demand decreases and firms cannot recognize the need to make capital investments.

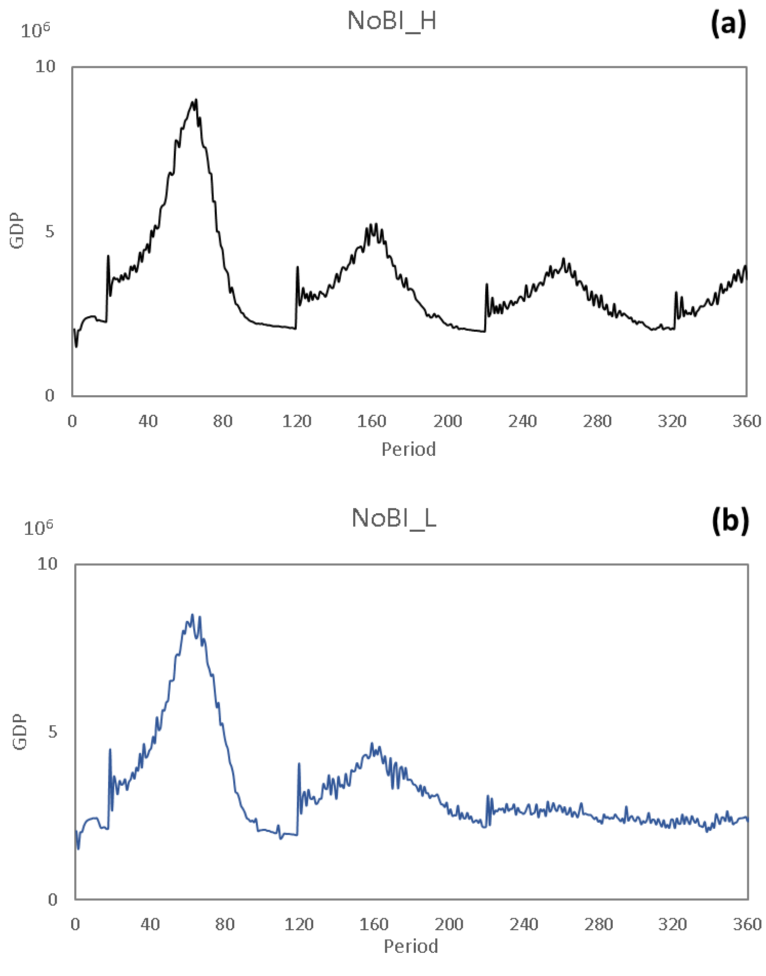

Figure 2: GDP trajectories over 360 periods under NoBI conditions, averaged over 10 random number seeds. (a) Sustained cyclical behavior in GDP under relatively stable labor motivation (NoBI_H). (b) Gradual flattening and stagnation under more volatile labor motivation (NoBI_L).

Note: The disappearance of the third and later cycles in panel (b) shows how persistent declines in work motivation dampen investment and stall macroeconomic recovery. (GDP is shown in model units without real-world equivalents.)

In contrast to this situation, in the BI(T0)_H and BI(T0)_L conditions, where BI was implemented from the beginning, the economic situation improves regardless of the work motivation status as shown in Figure 3. This phenomenon results from preventing government spending from becoming corporate profits and accumulating as corporate surplus. Under the assumptions of this model, although corporate surplus funds are necessary for capital investment, they will continue to accumulate and not be expended if the situation is not suitable for investment. Therefore, under conditions where many workers have low work motivation, income will decline, negatively affecting household consumption. In other words, the existence of corporate surplus funds will stagnate the funds circulating in the market, causing economic shrinkage.

BI would cause government spending to be routed through households rather than directly to firms. This situation increases the proportion of funds for buying and selling goods as the ultimate destination of funds circulating in the market at the end of a given period. Therefore, firms will recognize demand and make capital investments. Regarding GDP trends, under the condition of $\varepsilon = -0.02$, the 360-period average of GDP is 3413050 for NoBI_H and 4113840 for BI(T0)_H, which is approximately 20% higher. In contrast, under the condition of $\varepsilon = -0.15$, which tends to reduce work motivation, the 360-period average of GDP for NoBI_L is 3229039 and 4385847 for BI(T0)_L, an increase of approximately 35%. Under the conditions where work motivation tends to decline, the economic cycle due to the flow of funds effect of BI has a significant impact, particularly on creating a third economic upturn phase. This phase shows a high effect of increasing GDP.

Comparing the average work motivation over a 360-period for a given random number, the change in work motivation for BI relative to NoBI was 99.83% for BI(T0)_H and 102.58% for BI(T0)_L. This result is caused by factors that workers consider relative income.

The willingness to work is affected by relative income and thus increases when low-income individuals have lower incomes compared with others. Therefore, under the conditions where work motivation is less likely to decline, the equalization of BI earnings will improve the low-income situation relatively. As a result, low-income workers' work motivation will be reduced. In contrast, under the conditions where work motivation is likely to decline, when high-income individuals earn higher incomes relative to others, they are likely to be satisfied with the status quo, thus reducing their willingness to work. In this situation, the equalization of BI prevents high-income individuals from decreasing their work motivation, resulting in a work motivation difference as described above.

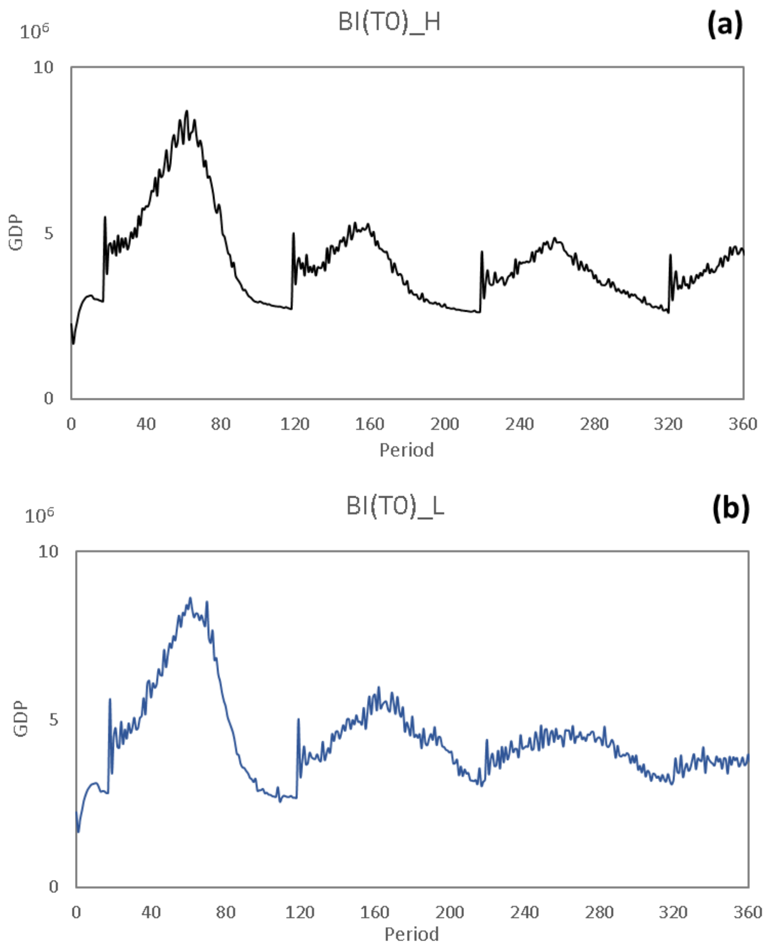

Figure 3: Simulated GDP transitions over 360 periods under BI(T0) conditions, where BI is implemented from the beginning. (a) Trend under relatively stable labor motivation (b) Lower labor motivation (BI(T0)_L). (BI(T0)_H).

Note: In both cases, GDP shows an overall increasing trend. Notably, under low labor motivation, BI contributes to the emergence of a third economic upturn, indicating a stronger cycle.

4.2 Impact of BI Implementation Timing

To analyze the impact of BI implementation under different economic conditions, we conducted simulations for each of the 10 periods from T0 to T200, shifting the timing of BI implementation. Simulations were also conducted for the VH work motivation condition in the same way as for the H and L conditions.

Figure 4 shows the geometric mean of the increase rate in NoBI and BI for the 150 periods after the period in which BI benefits begin. For example, for T100, BI benefits begin in period 100. Thus, the rate of change between the GDPs in period 100 of NoBI and period 100 of T100 is calculated, followed by periods 101, 102, and 250. Then, the geometric mean of these values is taken. As a result, under the H condition in Figure 4(a), a 12% increase is observed under the T100 condition.

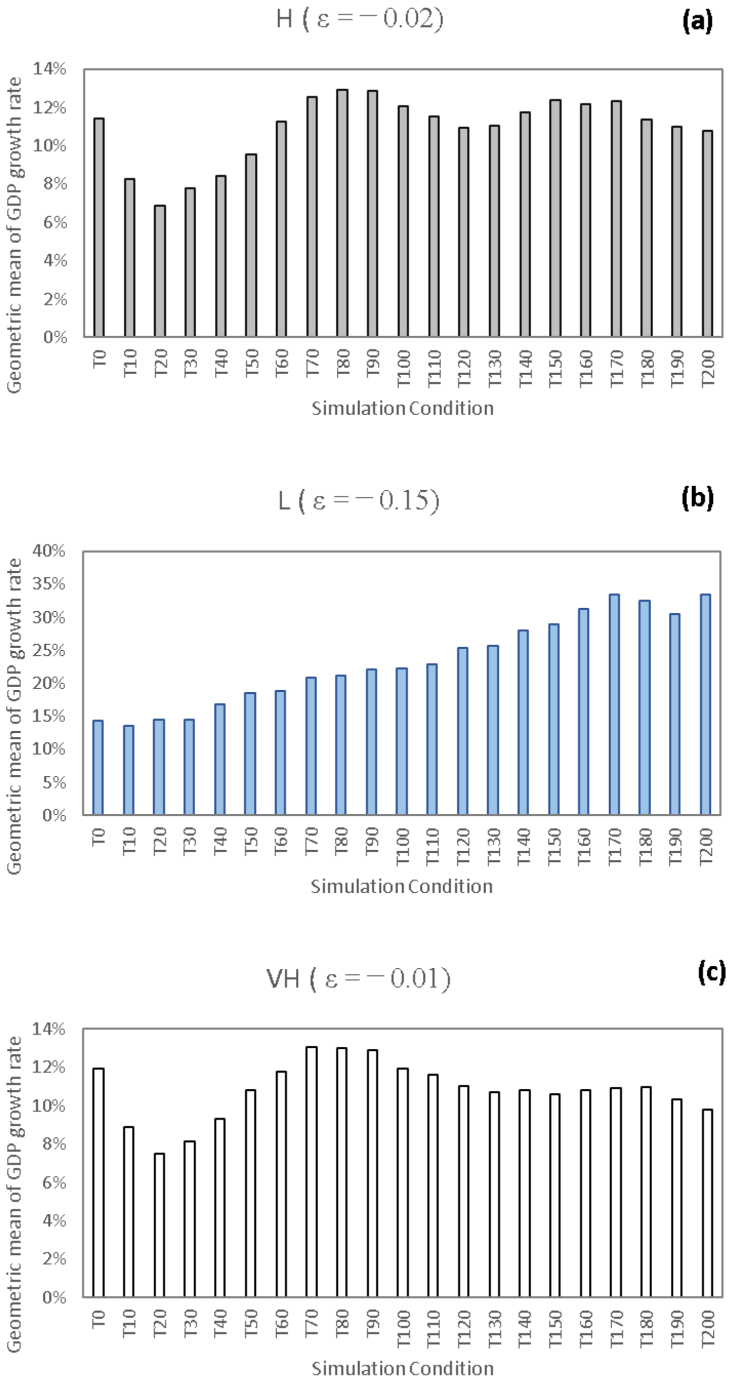

Figure 4: Geometric mean of GDP growth relative to the NoBI condition over 150 periods following the initiation of BI, across different BI start timings (T0–T200). (a) Results under high labor willingness (ε = −0.02), where the effectiveness of BI varies with timing, particularly improving during recessionary phases such as T70–T90 and T160. (b) Low labor willingness condition (ε = −0.15), where GDP gains increase steadily when BI is introduced later, with the highest effects observed when implemented after the second trough (T120+). (c) Similar trend to panel (a), confirming that under very high labor willingness (ε = −0.01), BI still promotes growth, but the timing remains critical.

A comparison between Figures 4(a) and 2(a) shows the following. When BI is implemented under the ε = −0.02 (H) condition, the GDP increase rate from the T10 to T50 (period of rising GDP) is lower than in the other conditions. In addition, when BI is implemented during the first economic downturn (T70~T90), GDP increases more effectively. Similarly, the GDP growth rate is low around T120 when BI is implemented during the second economic upturn, whereas it improves around T160, the recessionary phase. This trend also holds for the VH condition with higher work motivation as shown in Figure 4(c). Therefore, the overall trend remains the same under conditions of high labor willingness, that is, BI tends to increase GDP, as shown in Section 4.1. However, the effect of BI varies depending on its implementation period.

In comparison, Figure 4(b) shows that when ε = −0.15 (L) condition, the GDP increase rate does not decline significantly during the period of rising GDP. Moreover, if BI is implemented during an economic recession, GDP increases one level higher from T90 to T110 than it does before T80. Furthermore, as seen in T120, when BI is implemented after period 120, GDP increases significantly. This comparison is made for a period when the third economic peak has not occurred as seen in Figure 4(b). The economy peaked regardless of NoBI in periods such as T10. Thus, the GDP growth rate tends to be lower in the 150 periods that serve as the comparison period. In contrast, the comparison period after T120 is a period when the third economic peak did not occur with NoBI, and the economic peak was caused by BI, resulting in a significant increase rate.

Table 4 summarizes the key simulation outcomes described above.

Table 4: Summary of simulation outcomes under various labor motivation and BI implementation conditions

Experimental condition	Key observations	Notable dynamics
NoBI_H (ε = −0.02)	GDP exhibits three distinct economic cycles during the simulation period.	Baseline dynamics with stable labor motivation.
NoBI_L (ε = −0.15)	Cyclical GDP patterns are suppressed; the third peak does not emerge.	Declining labor willingness leads to reduced income, dampened demand, and fewer investments.
BI(T0)_H	Average GDP increases by 20% compared with NoBI_H, whereas labor motivation slightly declines.	Income redistribution boosts GDP but may reduce overall competitive incentives.
BI(T0)_L	Average GDP increases by 35% compared with NoBI_L; a third economic peak emerges.	Redistribution strongly stimulates a previously stagnant economy.
BI (H)	Implementing BI during an economic upswing causes stagnation; during a downturn, it promotes recovery.	The impact of BI varies depending on its timing within the business cycle.
BI (L)	No stagnation is observed when BI is introduced during growth phases.	Overall, BI implementation produces positive economic effects regardless of timing.

5 Discussion

The experimental results show that BI implementation leads to an overall increase in GDP. This trend is also observed in previous studies [26] because the destination of government spending is via households, which stimulates demand. This study shows that the behavior of BI implementation differs between the BI_H (labor willingness is less likely to decline) and BI_L conditions (labor willingness is more likely to decline).

As for the BI_H condition, GDP tends to decline more than in the other conditions from T10 to T50 during the economic upswing. We compared the averages of NoBI_H and BI_H from the BI implementation period to the economic peak in period 60. We found that the average of T10–T30 shows 79% for investment and 92% for GDP. During this comparison period, the increase rate was particularly low relative to the NoBI condition. In other cases, investment was 64% and GDP was 84% depending on the conditions of the random values. This result is due to the implementation of BI during the economic upturn. During this implementation period, labor willingness temporarily declined and then subsequently increased due to the income gap caused by the reduced labor willingness. This situation coincided with the timing of the firms' capital investment decision-making. The lack of supply capacity against demand is not recognized due to a temporary increase in the workers' willingness to work. The period of relatively easy investment during the economic upswing ends. Thus, investment does not grow, and the GDP does not rise. This phenomenon is also evident when BI is implemented from the beginning of the simulation at T0, showing a higher GDP increase rate than from T10 to T30. Therefore, the timing of BI implementation has an impact on the economic system.

In contrast, under the BI_L condition, the BI increase rate does not tend to decline significantly even during periods of economic upswing. Similar to the BI_H condition, the economy tends to be sluggish during the GDP and investment situation in the 60 periods from T10 to T30. However, unlike the BI_H condition, the decline is minor, with investment and GDP at 85% and 94% of the NoBI condition, respectively. In addition, the GDP increase rate is larger the later the BI starts. As discussed in Section 4.2, the impact of 150 periods is considered, showing a greater impact when BI is implemented in the latter half compared with NoBI. This study adopts an ABM in which funds circulate completely. Thus, a major change such as BI implementation will cause subsequent significant behavioral changes in the system over time, following different scenarios. This situation is particularly true when fluctuations such as economic peaks occur. Therefore, to consider the impact of the third peak, we take the GDP increase rate with NoBI from the BI implementation to period 360. This approach facilitates the comparison of the respective GDP increase rate as shown in Figure 5. The figure shows that GDP is increasing overall. However, unlike BI_H, the increase rate declines slightly at T80 (economic recession), and the GDP increase rate remains high around T120 during the economic upturn.

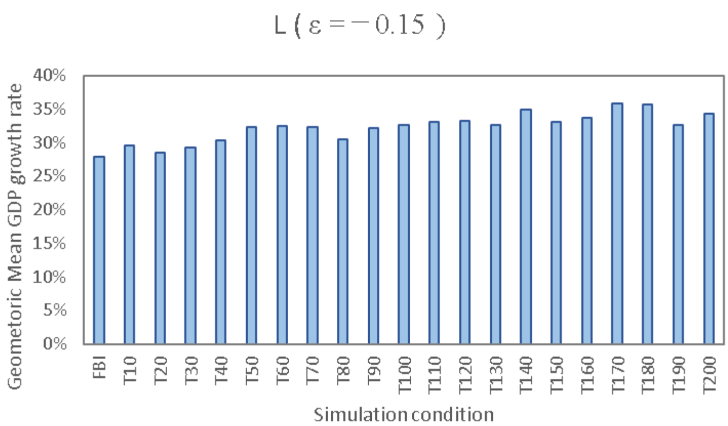

Figure 5: Average GDP from the BI implementation to period 360 for each condition under low labor willingness conditions

These differences are caused by the redistributive effects of BI and the emergence of market movements resulting from changes in labor willingness. In BI_L, because of low labor willingness, the redistributive effect is stronger than the economic slowdown effect caused by low labor willingness. On the other hand, in BI_H, the economy is well-cycled from the beginning, so the effect of income equalization on the decline in the willingness to work is more significant than the effect of redistribution. Furthermore, due to the disparities caused by the decline in labor willingness, the timing when overall labor willingness rises again coincides with the decision-making of others during the economic expansion period, slowing down economic growth.

In summary, the experiments in this study revealed two effects of BI. First, it has the effect of increasing demand by changing the quantity of funds in circulation through the income redistribution effect. This effect is similar to that of many economic policies such as unemployment insurance and social security. However, the scale of redistribution would be so extensive that it would be an economic policy that could have a greater effect than these policies if households and firms were considered as a simple function of consumption and production. In addition, as seen in Standing's study [3], other factors can have greater effects in the poorest areas.

Second, implementing BI during a period of economic expansion has the effect of stagnating the economy. This was made clear by the experiments in this study, which focused on the economic conditions under which BI is implemented, while taking into account changes in labor willingness resulting from differences in income relative to others. The results are particularly pronounced in groups composed of workers with a high willingness to work and are caused by changes in labor willingness due to the implementation of BI, resulting in firms' misperceptions of supply and demand. One of the most common arguments made by BI proponents is that the implementation of BI will not result in a decline in work motivation in the long run. On the other hand, some studies have observed that empirical experiments have resulted in a short-term decline in work motivation (in this case, it can be best phrased as labor supply rather than work motivation) because workers no longer need to continue working unwillingly and change jobs in search of learning and better workplaces [12, 13, 14]. Widerquist points out that these differences in opinion are not a matter of whether there is a decline or not but rather whether the amount of decline has an impact on society or not [16]. The second impact of BI identified in this study clarifies this issue. Whether proponents or deniers, they point out the possibility that BI may result in a temporary decline in labor willingness or labor supply. This study suggests that in such cases, the implementation of BI may have a negative impact on the economy under certain circumstances, if we extend our perspective on the impact on the economic market, not only to a simple decrease in labor supply but also to firms, or households as consumption entities, and the financial cycle and flow of funds.

The function of the flow of funds becomes more prominent during economic downturns, thus facilitating economic activities. In the long-term observation of the economy, this function has the effect of improving GDP compared with non-BI implementation under all conditions. However, because this model is simple regarding financial and labor markets, the adverse effects of implementing BI during a period of economic upswing could be more significant. In the event of a larger negative impact, a downturn in tax revenues could reduce the government's fiscal capacity to sustain BI. Therefore, economic conditions and the orientation of the target group's work motivation are critical factors when considering BI implementation.

This study focuses on the behavioral and systemic implications of BI implementation in a closed economy with balanced budgets. However, several structural limitations and extensions should be noted.

The current model corresponds to a closed economy within a single country. Thus, the findings in this study should be understood under the assumption of stable international trade and investment flows. Particularly, the growth-inhibiting effects of BI observed under the BI_H condition during economic expansion may be amplified in an open economy. Mismatches in demand recognition caused by BI may suppress economic growth driven by capital inflows from abroad. Additionally, if trade occurs between a BI and a non-BI country, the wealth of the BI country could be absorbed by the non-BI country. For instance, as shown in this study, if the productive capacity of the BI country weakens depending on the implementation period, imports from the non-BI country may increase. However, such outcomes remain speculative scenarios resulting from complex interactions. Simulation-based examinations have to be conducted. Thus, these possibilities should be regarded as future research directions.

Furthermore, in this model, the amount of BI is determined in each period based on the average wage, making it highly adaptive to inflation. In contrast, real-world systems would likely adjust BI payments annually at most. This discrepancy implies that rapid inflation and lagged BI adjustments could influence labor motivation and affect the economic system. Furthermore, this study focuses on the behavioral and systemic impacts of reallocating government spending under a closed economy with a balanced budget. Long-term fiscal dynamics, such as debt accumulation, remain outside the scope of this paper and are left for future research.

6 Conclusion

This study analyzed the impact of providing BI to people depending on its implementation period. We used a macroeconomic system with a mechanism that encompasses multilayered feedback as in reality and consists of agents whose willingness to work changes depending on the relative efficacy of their income.

The results showed that the impact of BI implementation differs between societies with workers whose labor willingness is less likely to decline and those with workers whose labor willingness is more likely to decline. In a society that is less likely to decline in labor willingness, BI implementation during a period of economic upswing may stagnate the economy. Although the focus is on one aspect of the timing of BI implementation, opposite results may be generated depending on the trends of change in work motivation of the workers who make up the society and the state of the economy. This study shows that the characteristics of the target country, region, or other group and the economic situation must be fully considered when evaluating BI implementation.

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