ABM Report on Interactions between Stablecoin, CBDC and Cryptocurrencies

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This document is an individual report written to fulfill a requirement for *Interactions of Stablecoin, CBDC and Other Cryptocurrencies*, a group project conducted in Masahiro Fukuhara Reseaerch Seminar.

1 Agent-Based Model (ABM) Specification

1.1 Essential Model Setup

- **Time**: One tick in NetLogo simulation corresponds to one day.
- **Assets**: Bank deposits, JPYC, Bitcoin (BTC), and CBDC (when activated) are available for people to invest in.
- **Agents**:
  - 3 banks with heterogeneous transaction costs,
  - 1 JPYC issuer,
  - 19 risk-averse individuals,
  - 31 risk-loving individuals.

  The number of agents is adjustable, except for the JPYC issuer.
- **Agent Heterogeneity**: Risk preference type defines target weight for allocation of their net worth (subject to change over the course of simulation). Risk-averse people's income is generally lower than that of risk-loving people, but this relationship is not definite because the income is a random variable that is normally distributed. Certain numbers of people (changeable with a slider in NetLogo) are always unemployed; the employment status for each individual is subject to change every 2 years.

1.2 Daily Simulation Loop

Each simulation day consists of the following five steps. Individuals:

1. Accrue yields,
2. Observe BTC price,
3. Observe CBDC/JPYC-related market information,
4. Earn income, pay expenses, and allocate remaining funds
5. Rebalance portfolio toward the ideal allocation

1.2.1 Yield Accrual

Yields accrue to the following accounts at the rates indicated below:

- Bank interest: 0.1% annually on bank deposits and CBDC holdings,
- Risk-free rate: 2% annually on JPYC reserves,
- JPYC APY: 1% annually on JPYC holdings.

All annual rates are converted to daily yields and applied each tick. The JPYC issuer funds the APY from its reserves.

1.2.2 Bitcoin Price Process

BTC price data is using one of two methods (changable in a slider in NetLogo):

1. Historical prices fetched from CryptoCompare via API for 2,000 days, or
2. A GARCH(1,1) log-return process with mean return of 20% per year, parameters $\alpha = 0.1$, $\beta = 0.85$, satisfying $\alpha + \beta < 1$.

When using GARCH, the initial BTC price is set to 10 million JPY.

1.2.3 CBDC and JPYC Adoption Dynamics

Initially, 10 merchants accept CBDC and JPYC. The number increases by approximately one per year. As the number of adoption rises, the probability of privacy-related incidents (e.g., data breaches) increases. Such incidents raise agents' privacy concerns, and can affect their choice of asset allocation. The probability of incidents is halved for JPYC due to its blockchain-based infrastructure (assumed more immune to malicious attacks on the system).

1.2.4 Income, Consumption, and Allocation

Employed individuals allocate their income among bank deposits, JPYC, and CBDC for daily expenses (BTC is not available for daily transactions, consistent with the reality in most of the world). They always consume 80% of income and save the remainder. Unemployed individuals consume 0.05% of their net worth daily (since they do not have a source of income).

1.2.5 Portfolio Rebalancing

Individuals rebalance their portfolios across bank deposits, JPYC, CBDC, and this time including BTC using utility-based decision rules. Agents always take the following two steps in order:

1. Adjustment between bank deposits and stablecoins,
2. Adjustment toward target BTC weights using JPYC or bank deposits, and CBDC only when necessary.

Transaction costs follow intuitive ordering: JPYC/BTC trades are costless; bank–JPYC incur moderate costs; bank–BTC and CBDC–BTC incur high costs. The JPYC issuer's liabilities and equity are constrained to remain non-negative (maintaining consistency with the probable reality).

1.3 Simulation Results and Interpretations

See below for screenshots of 50+ years worth of simulations.

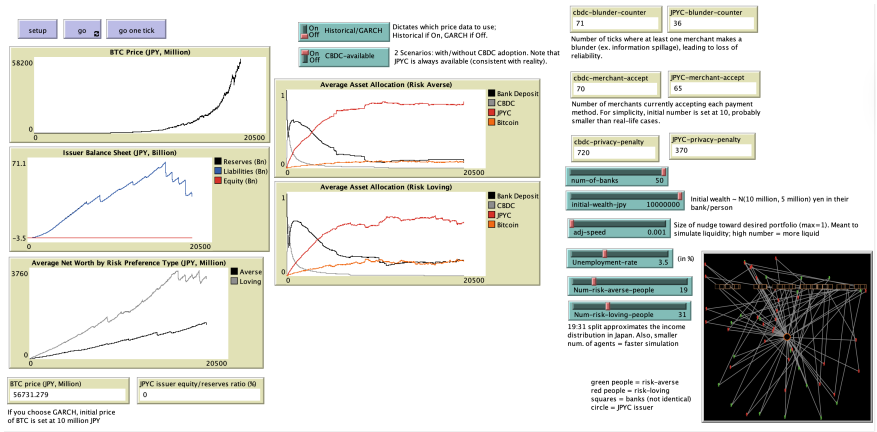

Figure 1: Simulation results with CBDC

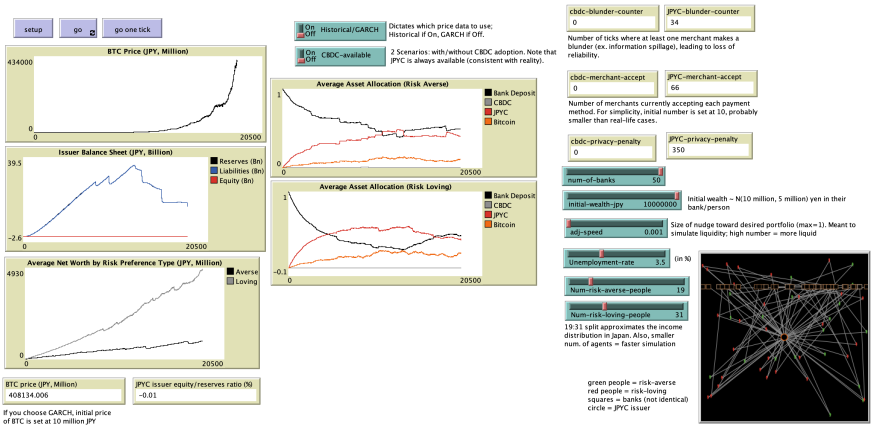

Figure 2: Simulation results with no CBDC

Simulations indicate that total JPYC supply occasionally exhibits sharp fluctuations, regardless of existence of CBDC in the market. The primary cause is BTC price hikes, which raises the demand (i.e. weight for BTC rises), creating the need to sell BTC back to either cash or stablecoin. If stbalecoin is chosen, it will be assigned a disproportionately high portfolio allocation weight, due to the spillover effects from the BTC price hikes. However, stablecoin cannot increase their market cap in a short term because they are (assumed to be) not allowed to borrow due to regulations that aim to prevent potential market crash caused by JPYC taking large debts and going bankrupt. Ironically, the remaining effects (intuitively, ones not mitigated by JPYC) will then spillover to bank deposits, creating large demand. Then, due to the portfolio rebalancing process illustrated in Section 1.2.5, agent will always use stablecoin to meet their need for portfolio rebalancing, leading to sharp drops afterwards.
To mitigate instability in JPYC supply, it is required for policies to encourage diversification in crypto-related transactions, aiming to curb the spillover effects on JPYC. Furthermore, the regulation on leverages taken by stablecoin owners should be relaxed to a certain extent to create a room for the spillover effects to be absorbed, while containing risks of sudden hikes in JPYC balance.