Dynamic Cash Management Models with Loans

Zimian Zhang

Lancaster University

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Outline

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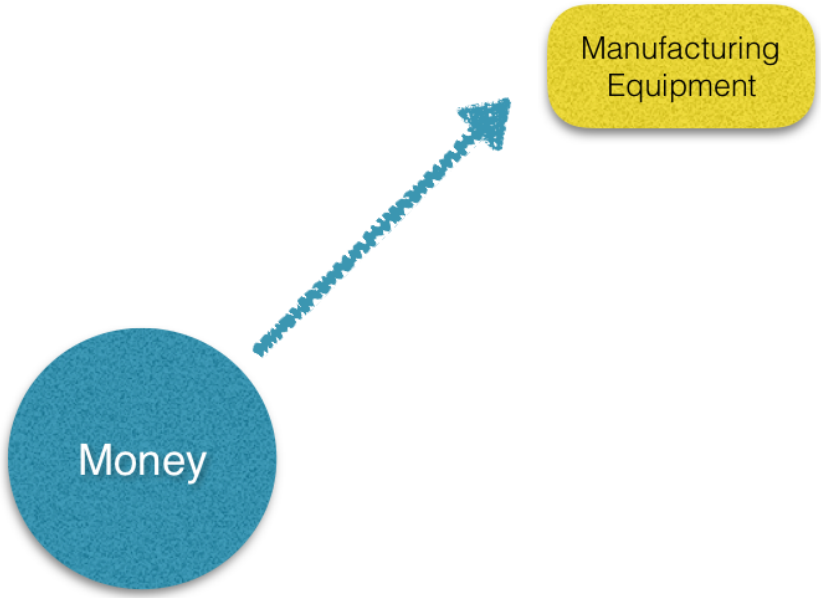

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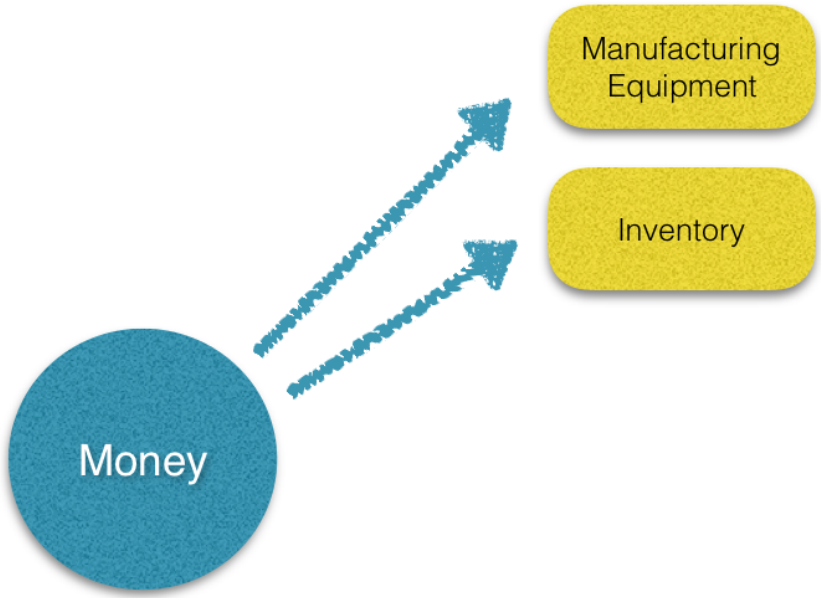

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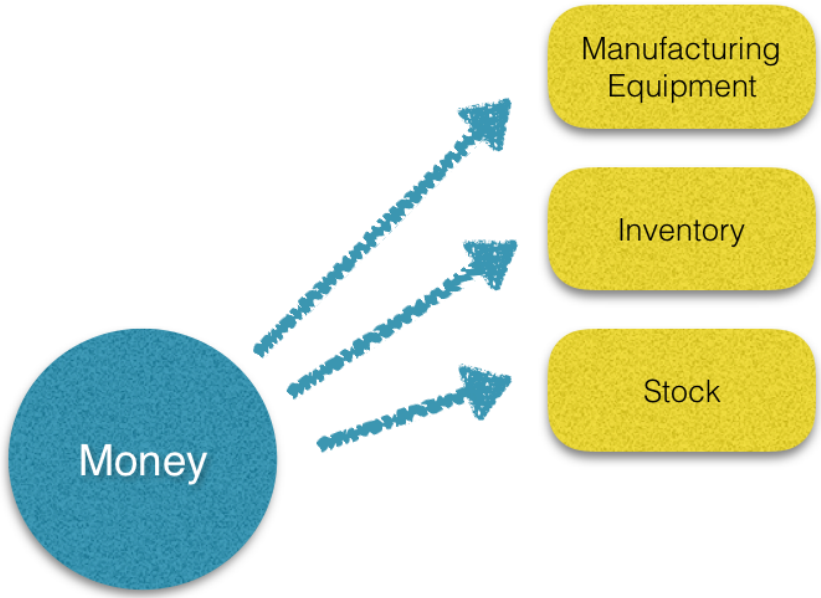

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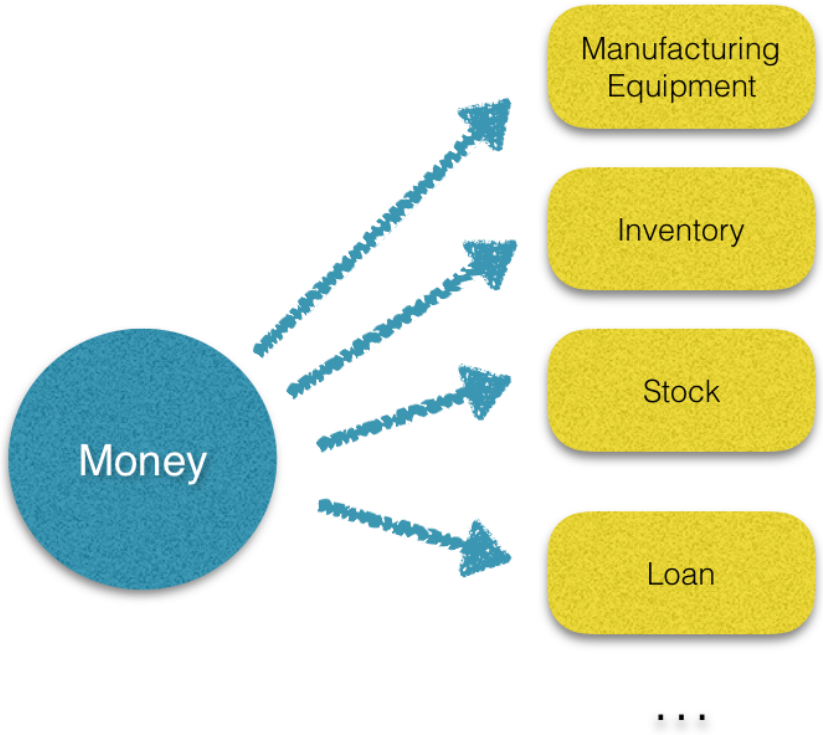

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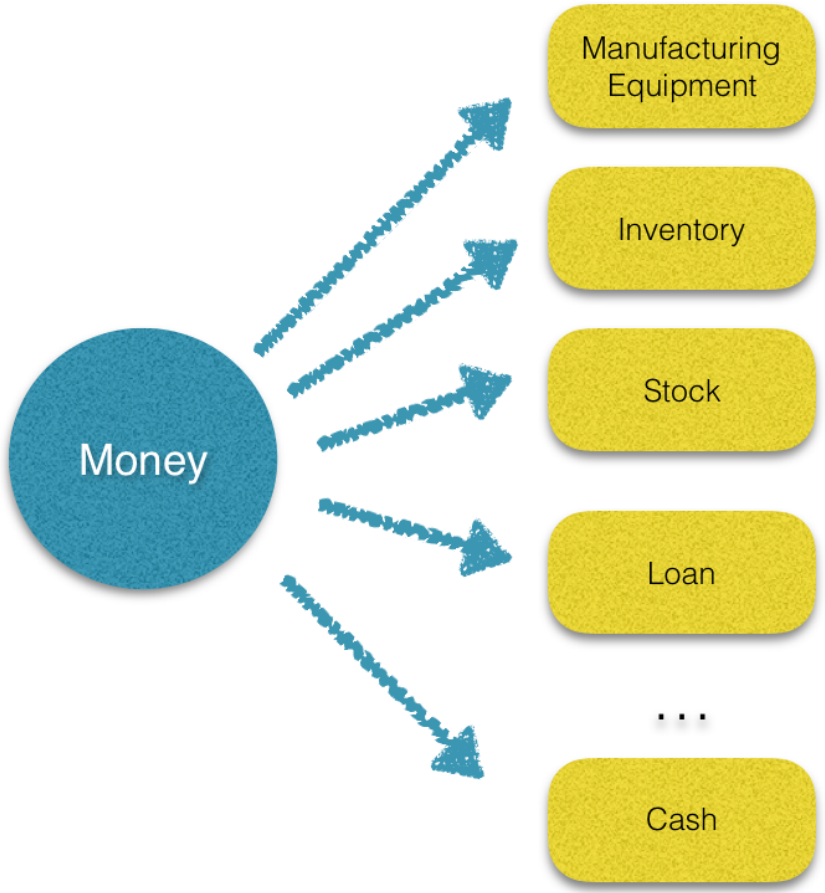

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- **Why cash?**: Cash demand: Salaries, Utility bills, Shareholder redemption, etc.

Cash Management Problem

What is the strategy of allocating money to this asset 'cash'?

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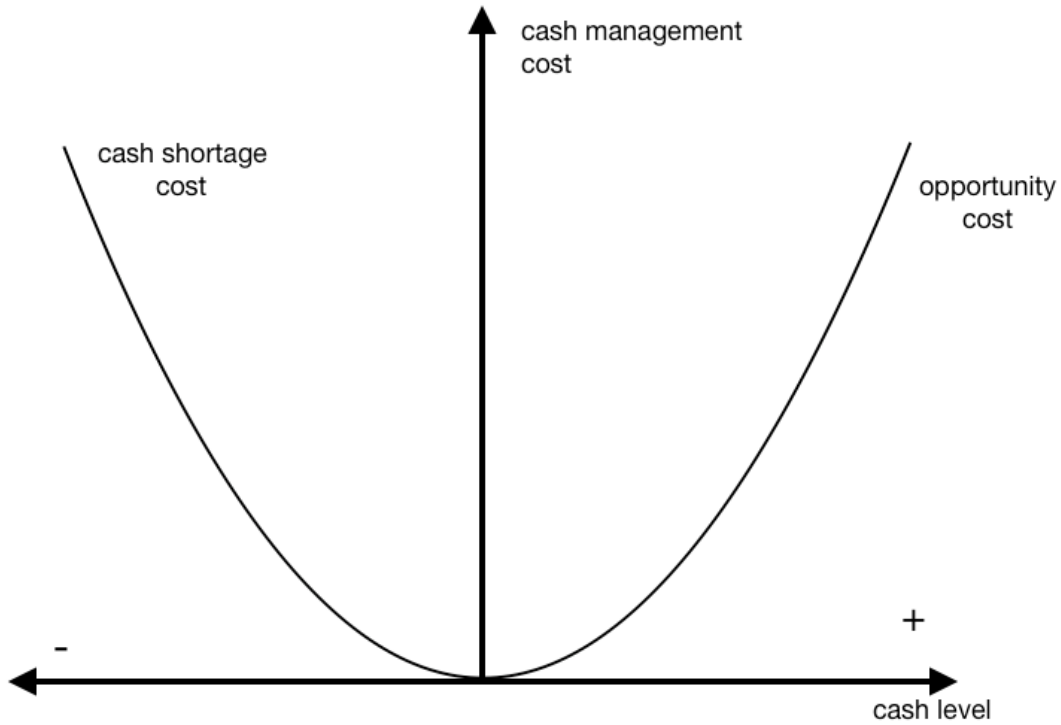

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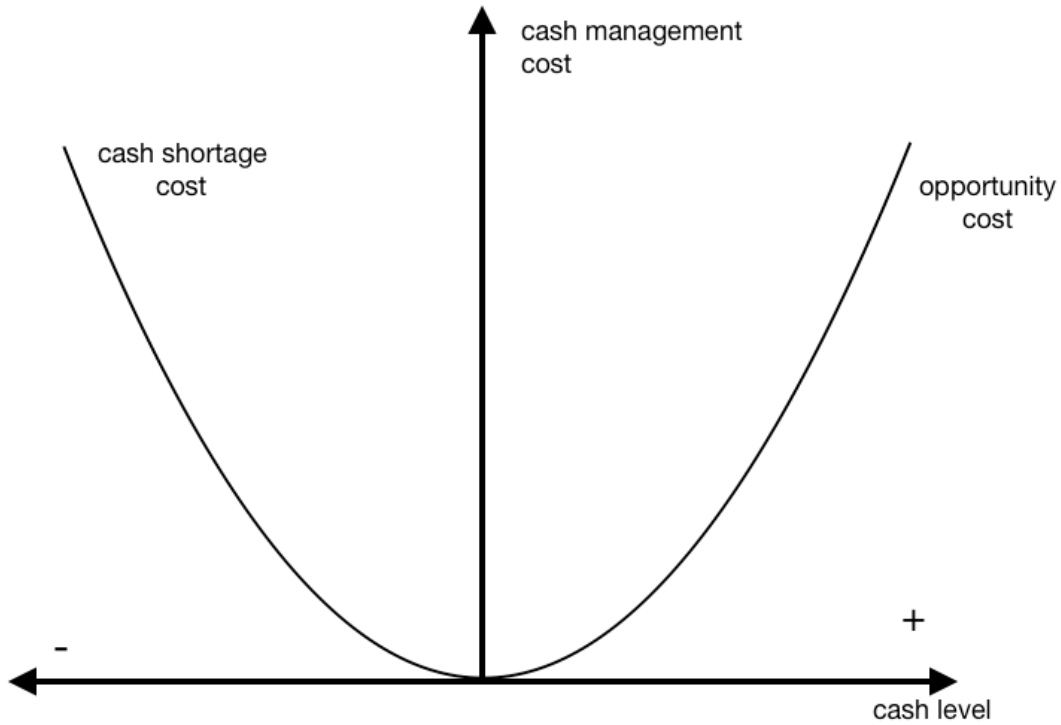

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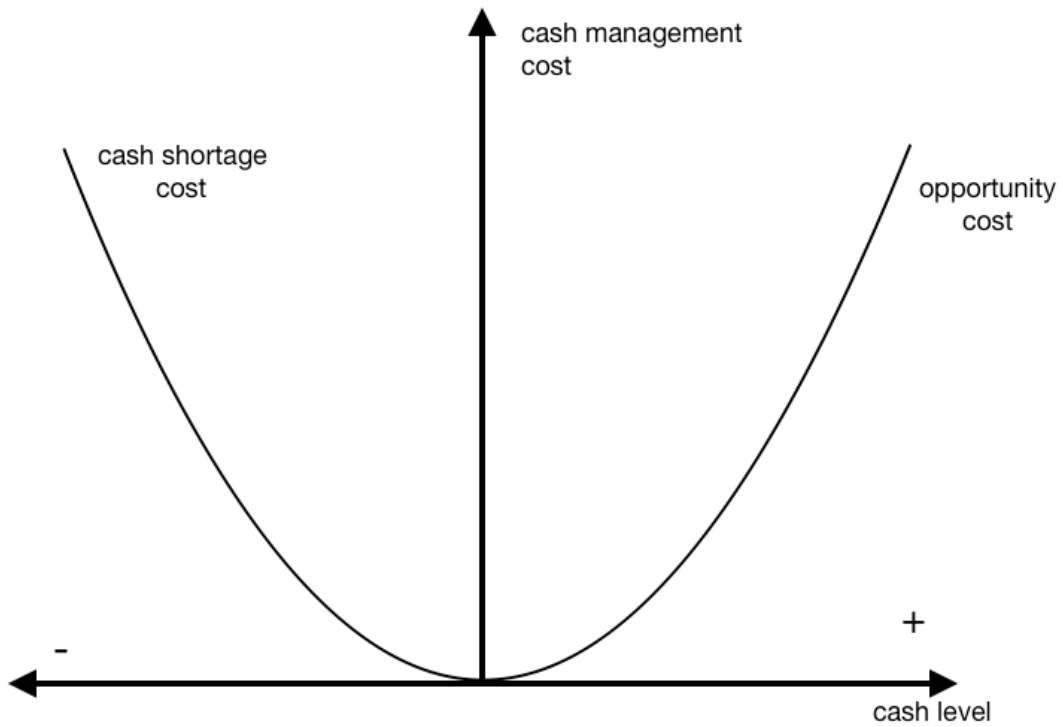
- On the other hand, a high cash-holding level normally means the inefficient use of firm's resource, which would constrain firm's future profitability.



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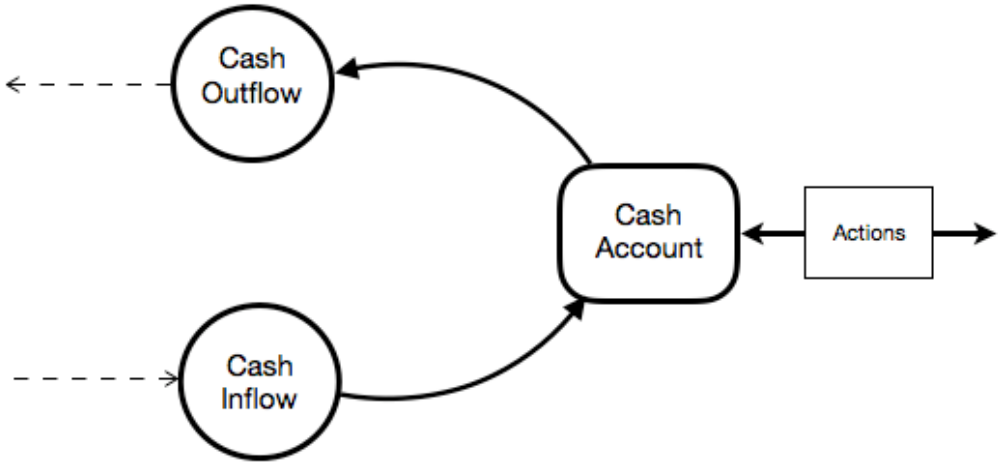

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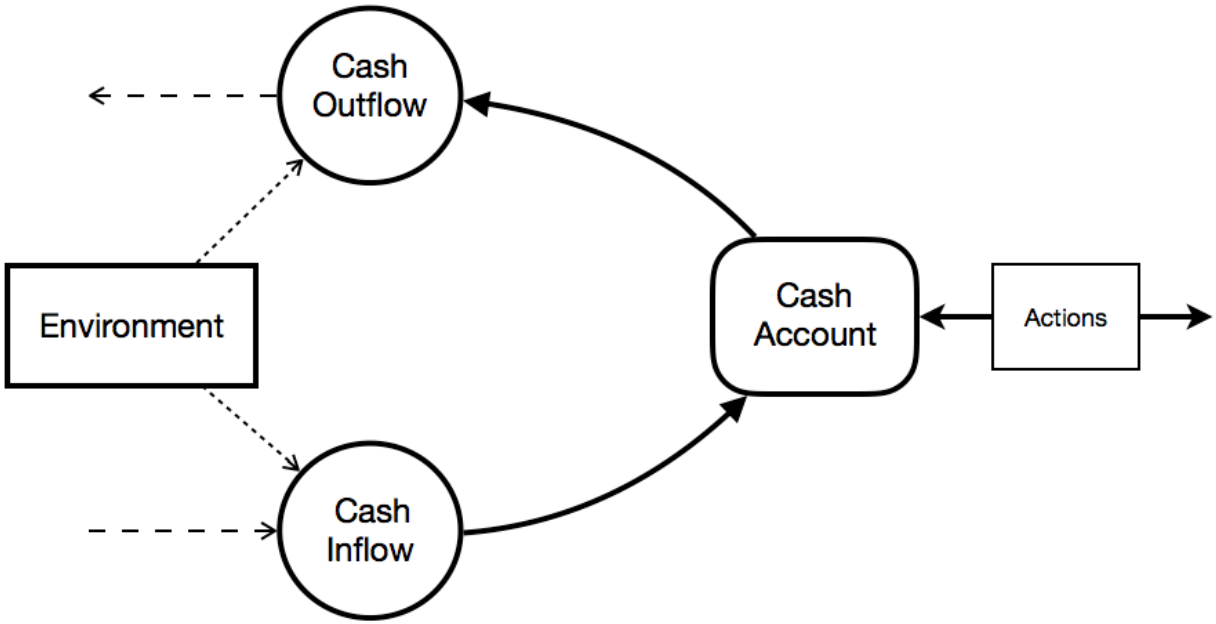

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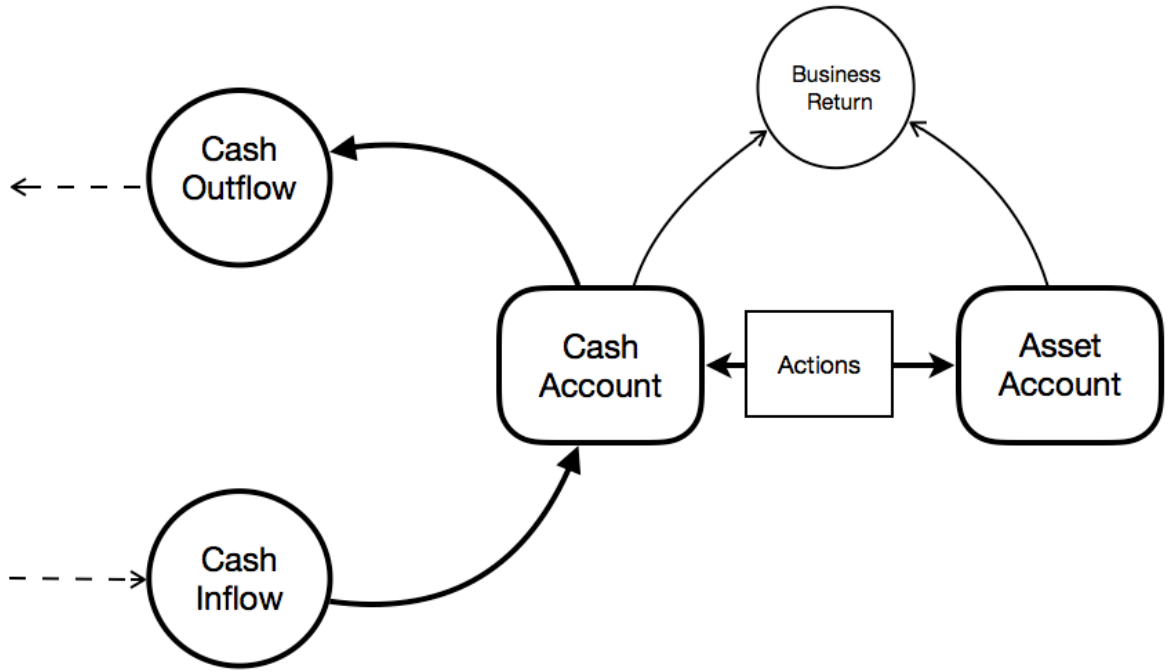

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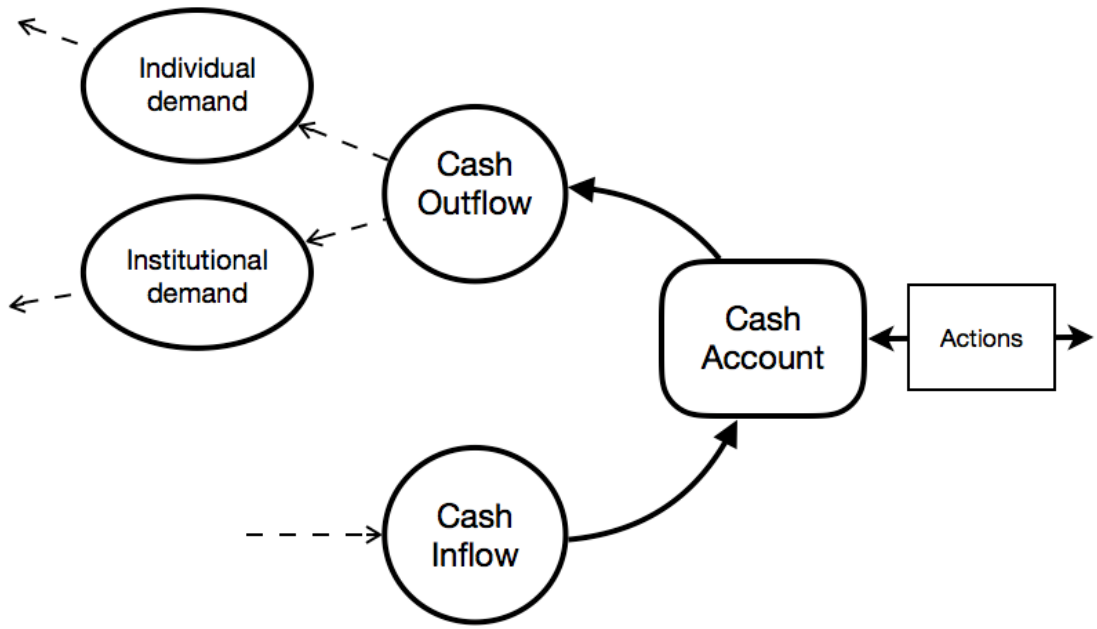

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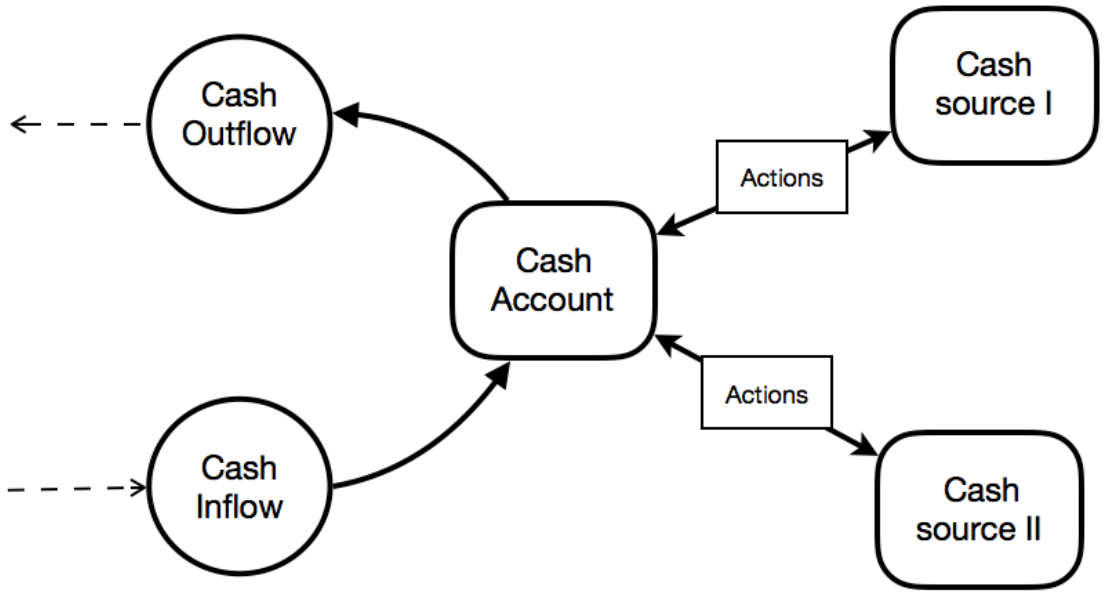

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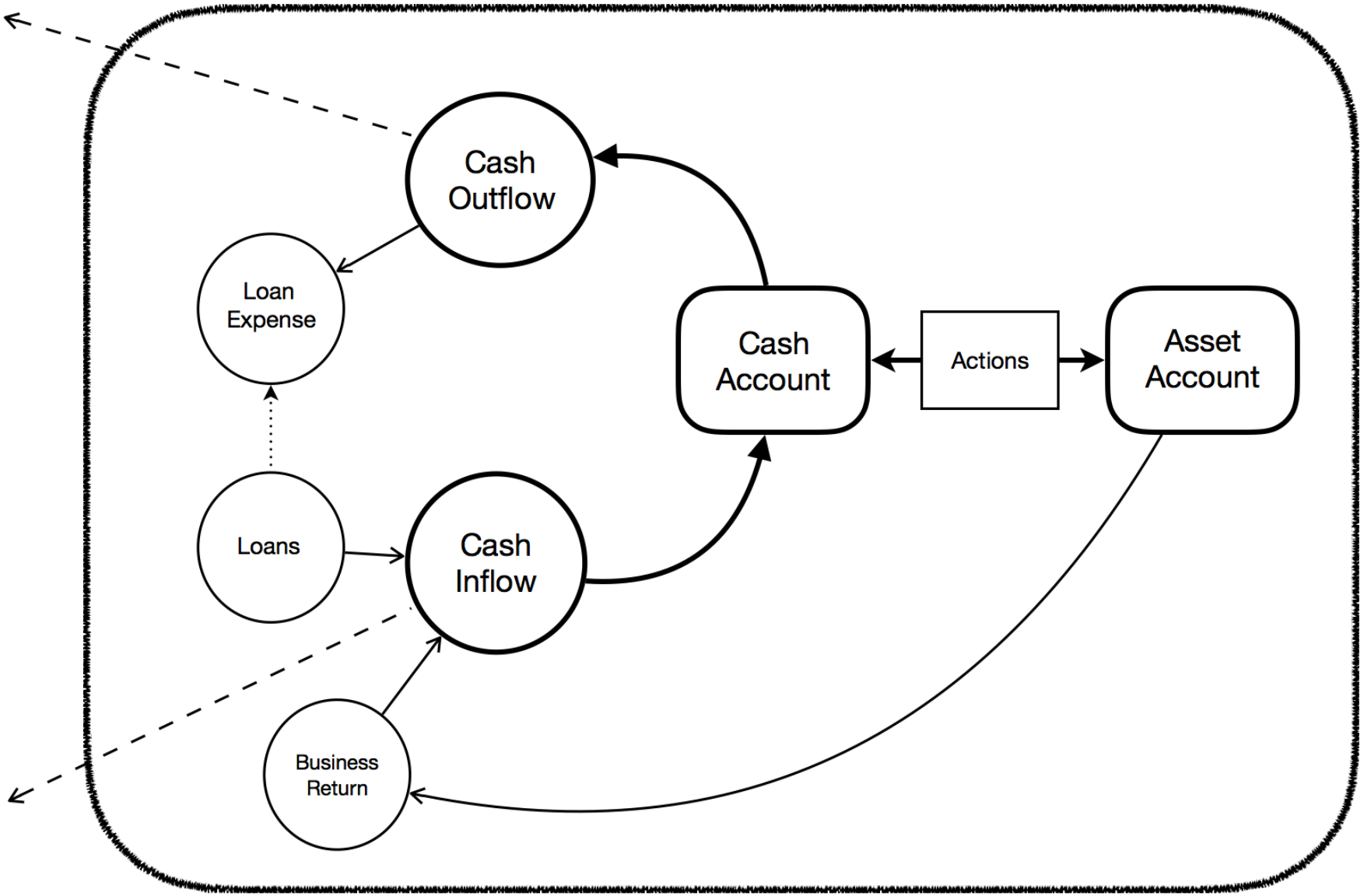
- We consider the scenario where the company can finance itself by taking loans.

Cash management model with loans



The two assets CM model

- Objective function: Maximising net profits

$$\max \sum_{t=0}^{\infty} \gamma^t \{rr \cdot y_t - D_t - \Gamma_t - SC_t\}.$$

- A partially fixed and partially proportional transaction cost function

$$\Gamma(a) = (K_c + k_c a) \cdot 1_{\{a<0\}} + (K_a + k_a a) \cdot 1_{\{a>0\}}$$

- Cash shortage cost:

$$SC(x_t) = 1_{\{x_t<0\}} \cdot \{SP + \Gamma(|x_t|)\}$$

- Options of declaring bankruptcy
- Loans unavailable.

States Transition

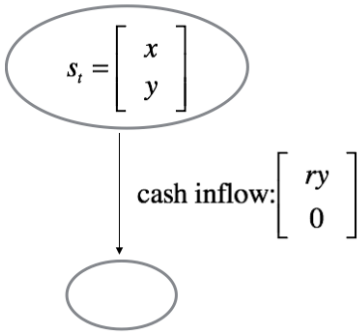
- Markov Decision Process

$$s_t = \begin{bmatrix} x \\ y \end{bmatrix}$$

- Discrete State:

States Transition

- Markov Decision Process



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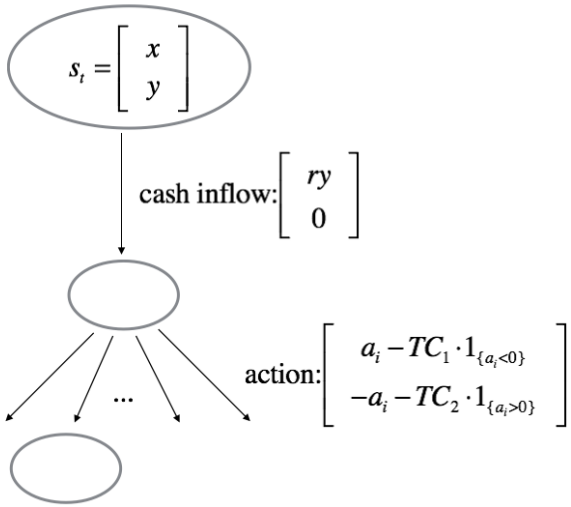

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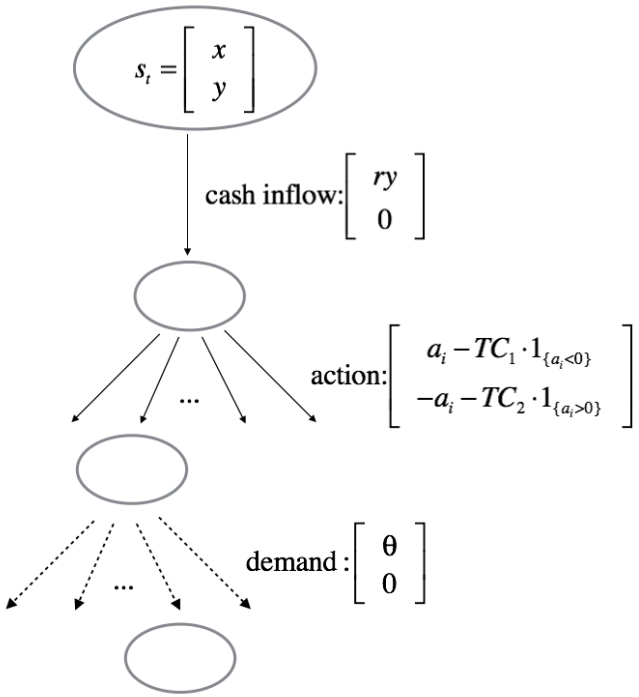

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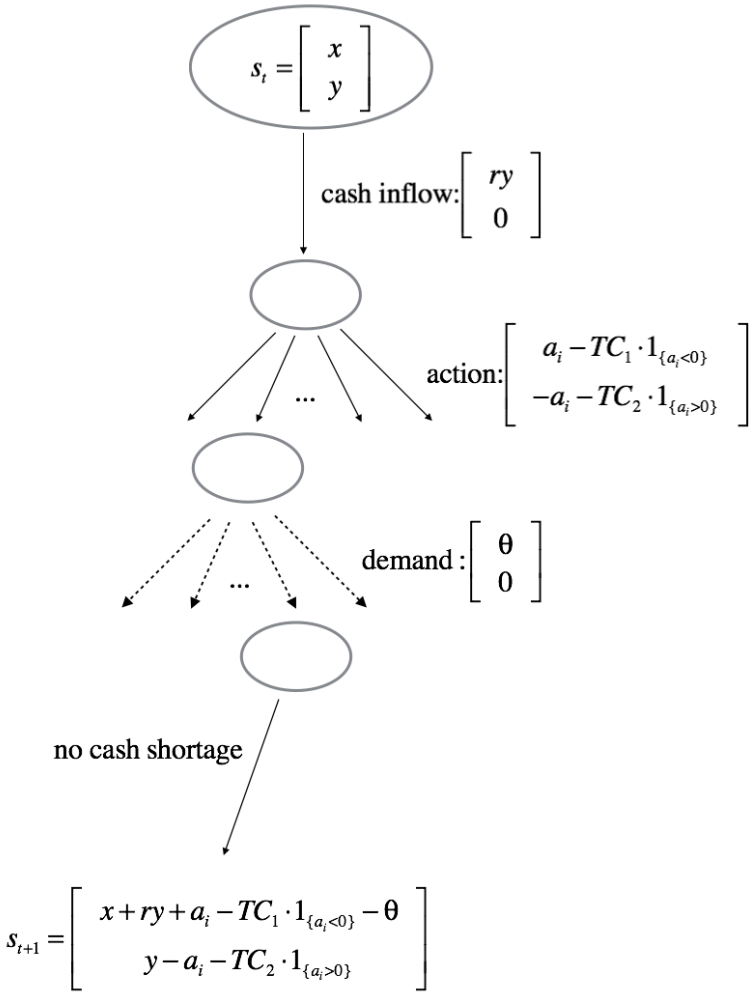

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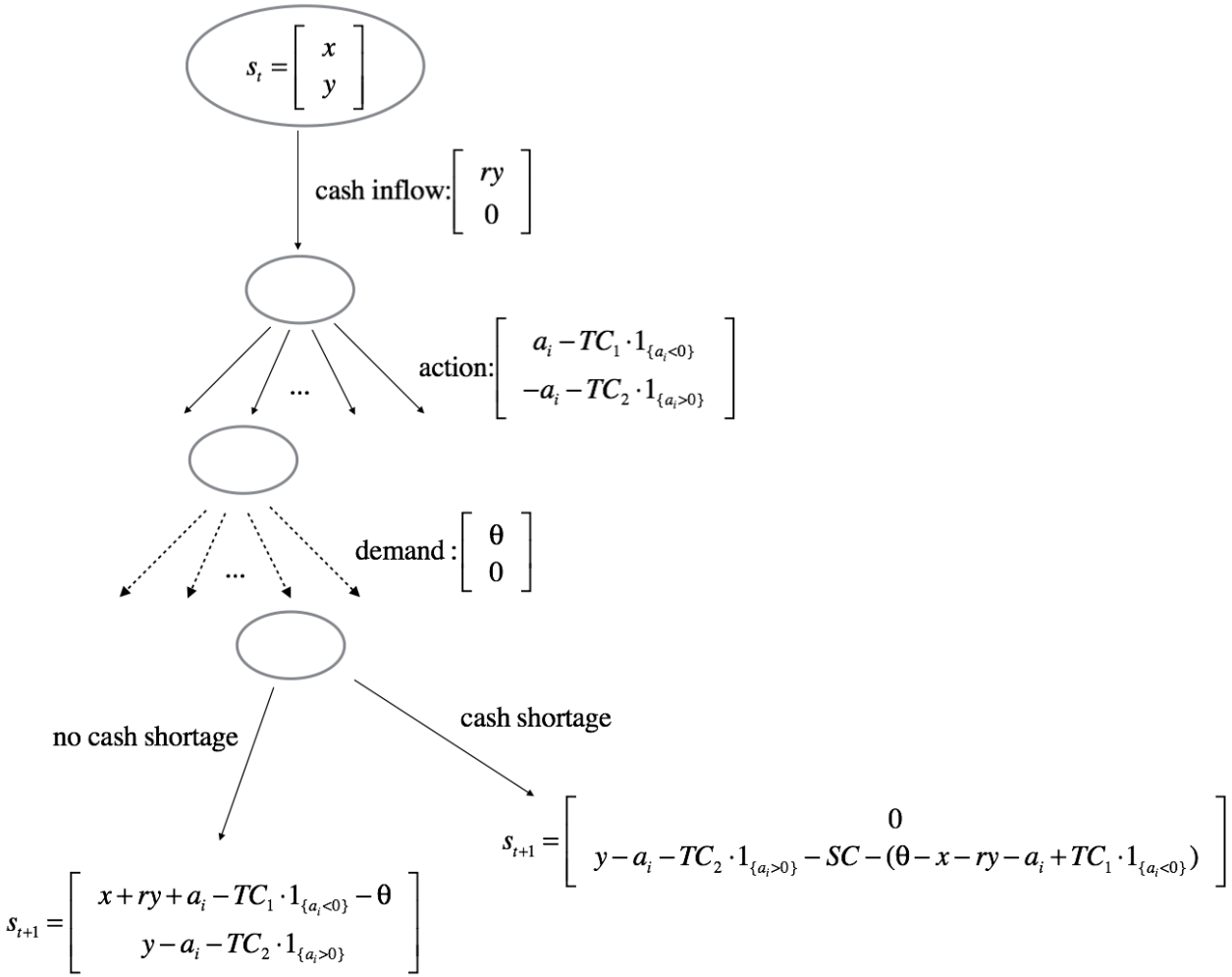
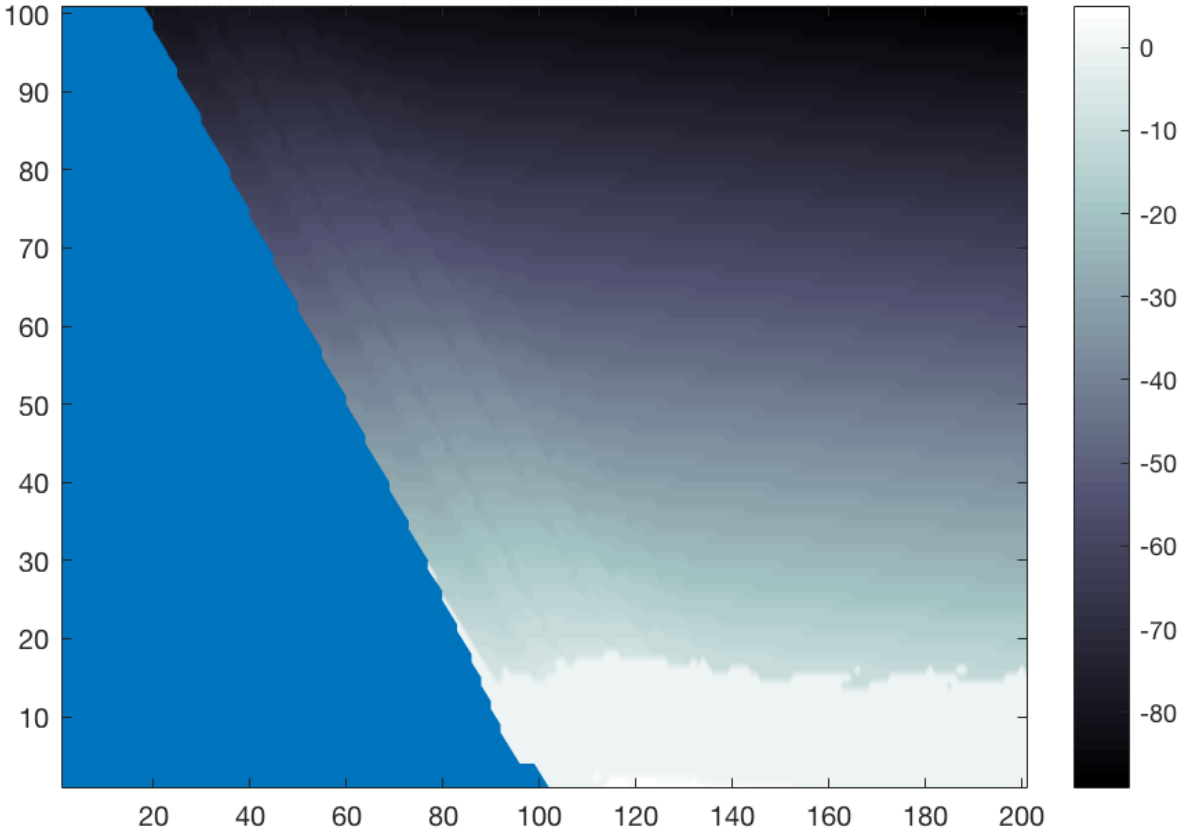
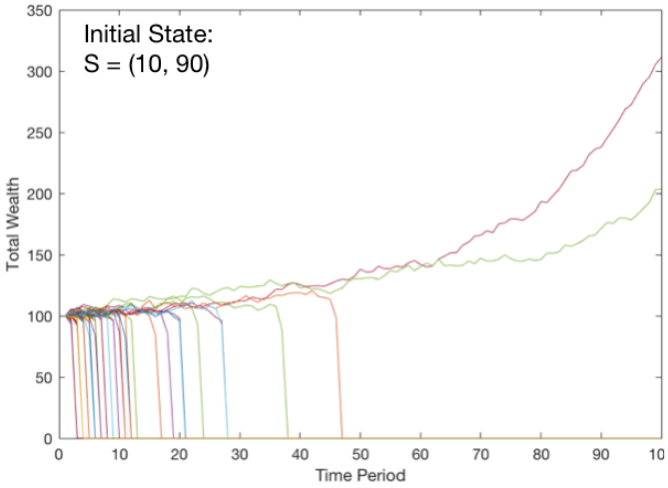
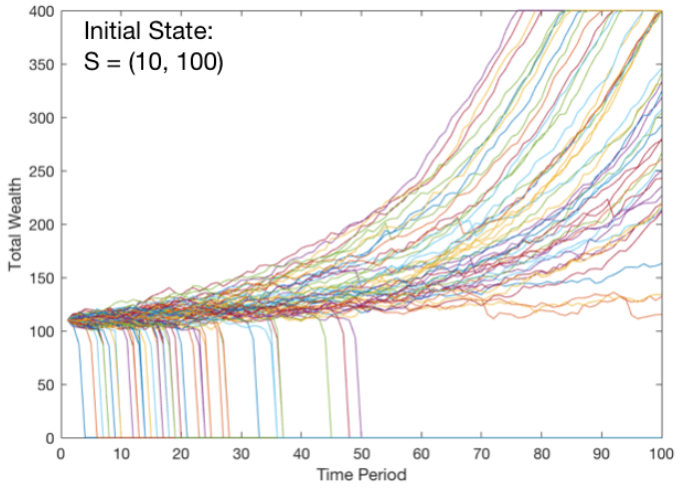


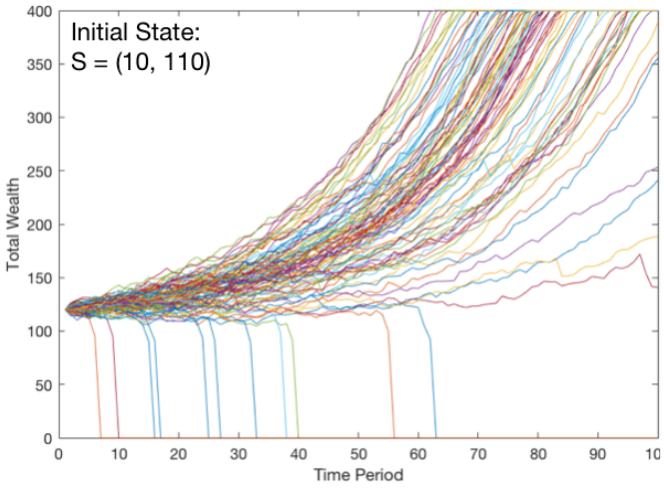
An optimal solution of the two-asset CM model

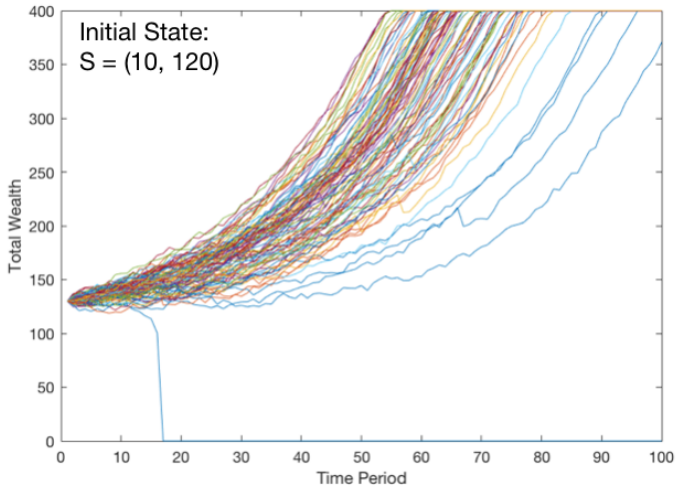


Simulation of the strategy









Probability of going bankrupt

- At stage 0 (the last period of time planning horizon), any state $S_{x,y}$ with $y \neq 0$ has value (probability of going bankrupt) equal to 0 and any state $S_{x,y}$ with $y = 0$ has value (probability of going bankrupt) equal to1.
- for any stage $k : k \geq 1$

$$V^k_{[x,y]} = \sum P\left\{ S_{(0,0)} : W(S_{x,y}) = S_{(0,0)} \middle| \, a = A^*(S_{x,y}) \right\} + \sum P\left\{ S_{x',y'} : W(S_{x,y}) = S_{x',y'} \middle| \, a = A^*(S_{x,y}) \right\} V^{k-1}_{[x',y']}$$

where $V^k_{[x,y]}$ is the probability that the company will eventually going bankrupt if it is in state $S_{x,y}$ at stage k

Cash management with loan options

- State: $S_{x,y,z}$ where x and y represent the current cash and asset level and z represent the remaining times of loan repayment.
- Loan Repayment LP: let L be the loan size, lr be the loan rate and once the manager take the loan, he has to make an equally amount of repayment in following N time periods. Then for each time period, he has to pay

$$LP = L \cdot \frac{lr \cdot (1 + lr)^N}{(1 + lr)^N - 1}$$

- We assume that companies with debt unpaid cannot take more loans.
- At time t, if the manager take the loan, then the cash inflow increases by L amount and its loan state s changes from 0 to N. In the following N time periods, the company's cash demand will increase by LP amount and z value decreases by 1.

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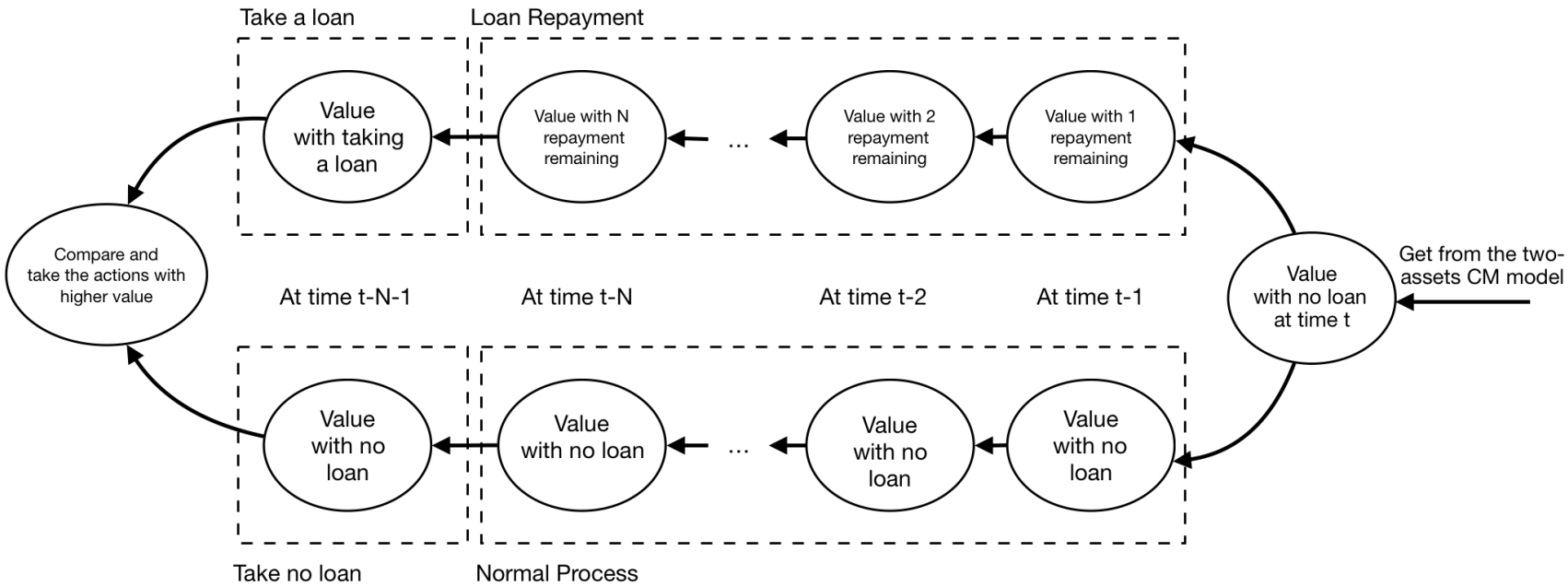
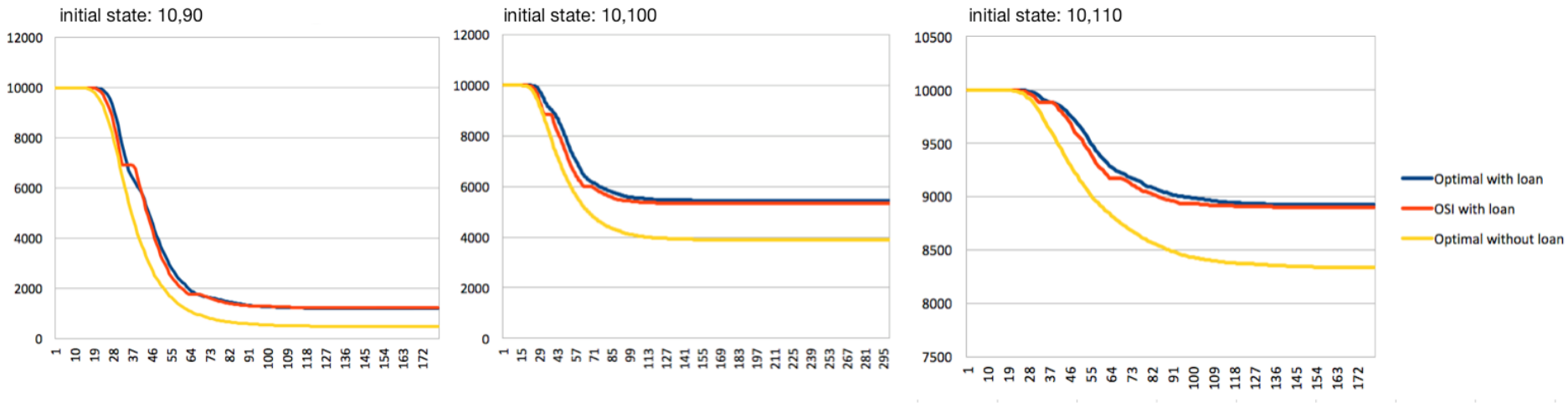
- Heuristic Method: One-step policy improvement.



Simulation results of one-step policy improvement

Assume there is only one loan available on the market:
$L = 40, lr = 0.03, N = 40$



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- Environmental factors.
- Other actions the manager could take while manage the cash, such as taking investment, open a new branch, etc.

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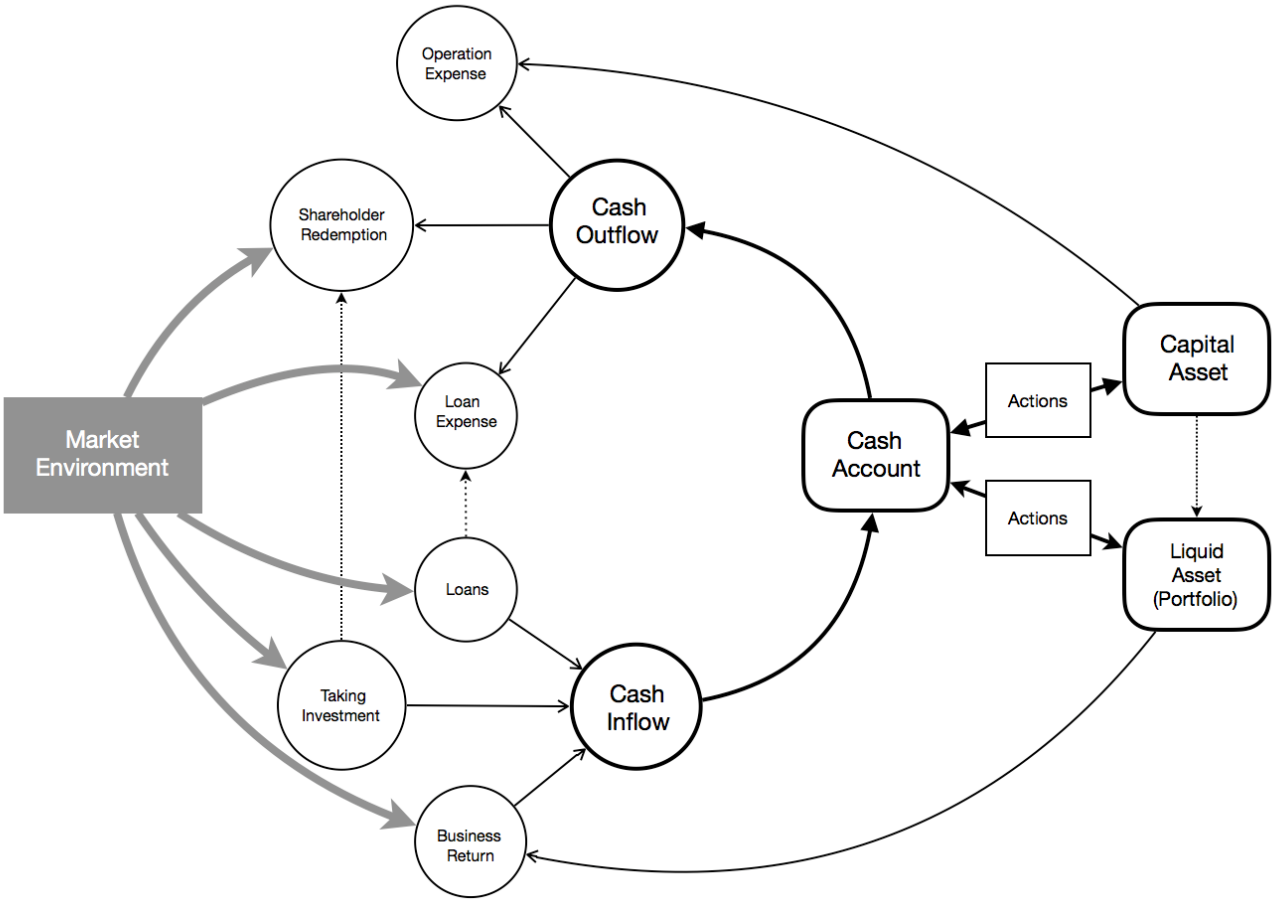

THANK YOU

FOR YOUR ATTENTION

ANY QUESTIONS...?