DATA 604 FINAL

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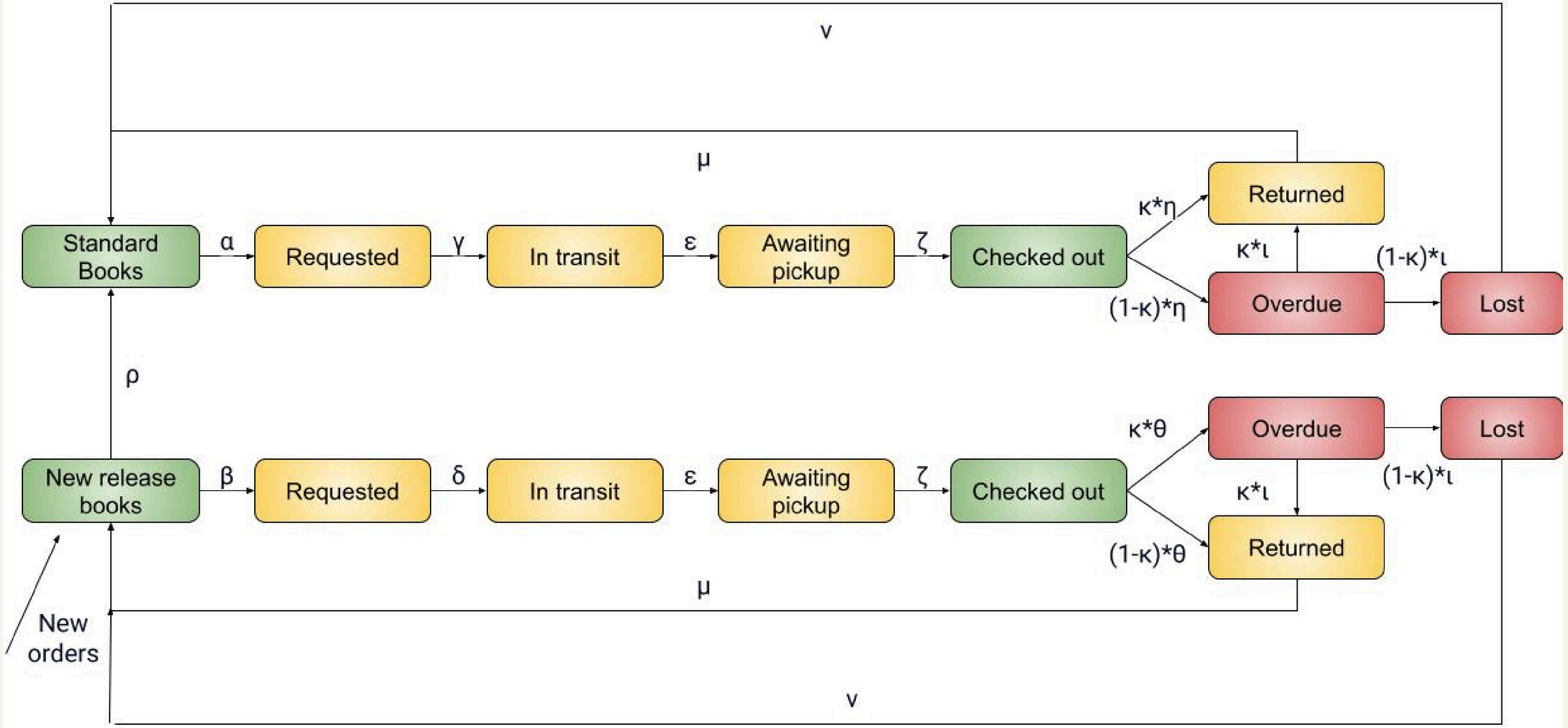
CUNY SPS MSDS | 2024

MODELING A LIBRARY

1. Two categories of books: standard books and new arrivals. New arrivals are limited to a check out time of only two weeks, as opposed to the standard three weeks. New arrivals are moved into the standard category after six months.

2. This library system has multiple branches, and patrons can request books currently located at any branch.

3. The library is seeking to maximize the percentage of the total books that are either available (on the shelf) or currently in the hands of a reader (checked out,) excluding books that are overdue or lost.


ν
μ
Standard Books
α
Requested
γ
In transit
ε
Awaiting pickup
ζ
Checked out
κ*η
Returned
κ*ι
(1-κ)*ι
(1-κ)*η
Overdue
Lost
ρ
New release books
β
Requested
δ
In transit
ε
Awaiting pickup
ζ
Checked out
κ*θ
Overdue
Lost
(1-κ)*ι
κ*ι
(1-κ)*θ
Returned
μ
New orders
ν

[409]
```
# define number of days until new requests come in
standard_request_time = 2
new_request_time = 1

alpha = 1 / standard_request_time
beta = 1 / new_request_time

# define number of days patrons wait in line after request
wait_time_standard = 3
wait_time_new = 21

gamma = 1 / wait_time_standard
delta = 1 / wait_time_new

# define number of days in transit
time_in_transit = 4

epsilon = 1 / time_in_transit

# define number of days a books waits to be picked up
days_awaiting_pickup = 3

zeta = 1 / days_awaiting_pickup

# define check out times
standard_check_out_time = 21
new_check_out_time = 14

eta = 1 / standard_check_out_time
theta = 1 / new_check_out_time
```

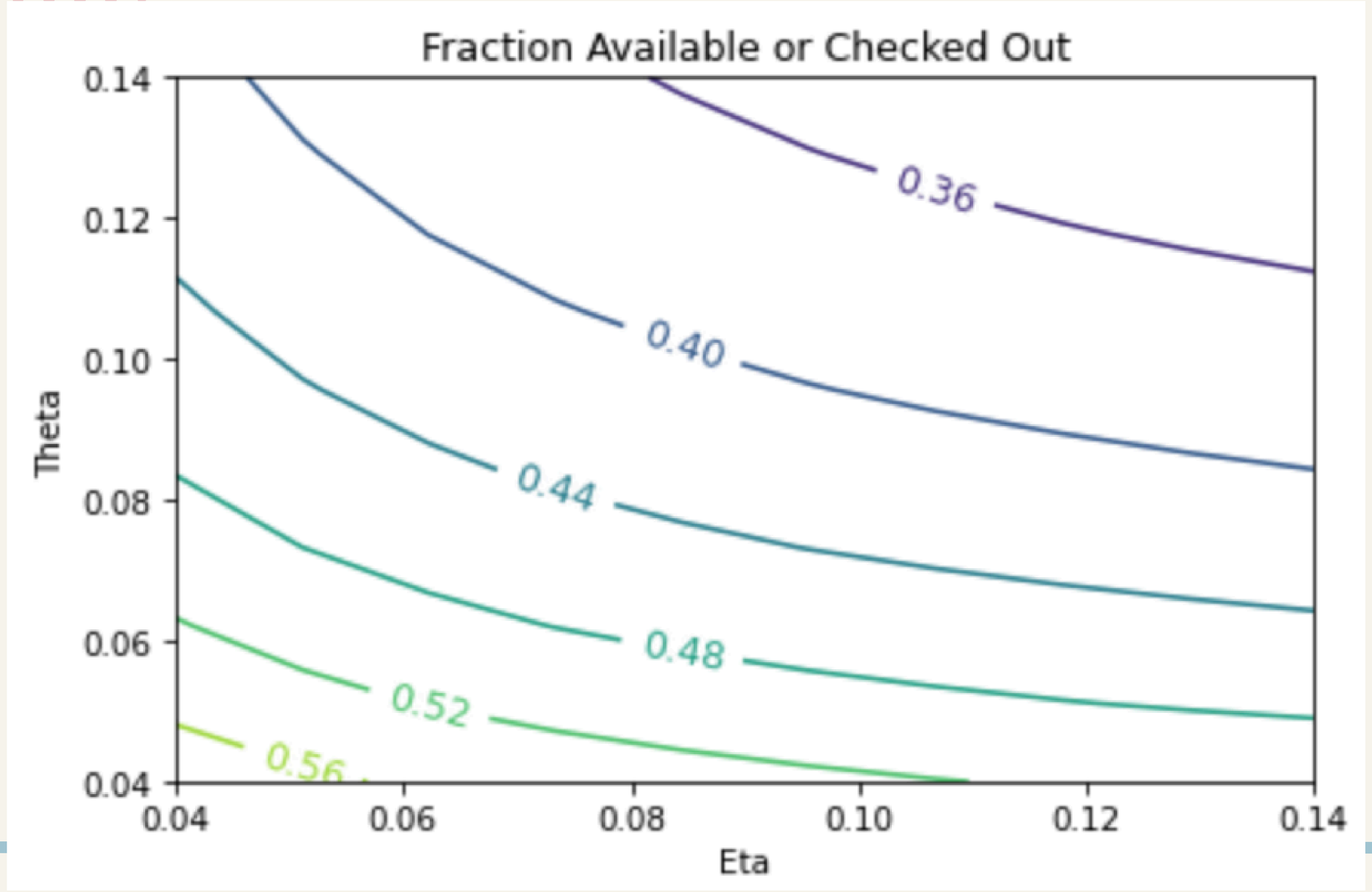
```
# define fraction of patrons that return book (both on time and eventually)
kappa = 0.9

# define number of days until book is considered lost
time_until_lost = 30

iota = 1 / time_until_lost

# define number of days to re-shelve returned book
time_until_shelved = 1

mu = 1 / time_until_shelved

# define number of days to replace lost book
time_until_replaced = 10

nu = 1 / time_until_replaced

# define number of days until a new book is re-categorized as standard
time_until_standard = 156

rho = 1 / time_until_standard

# define number of new books per day
new_orders = 20
```

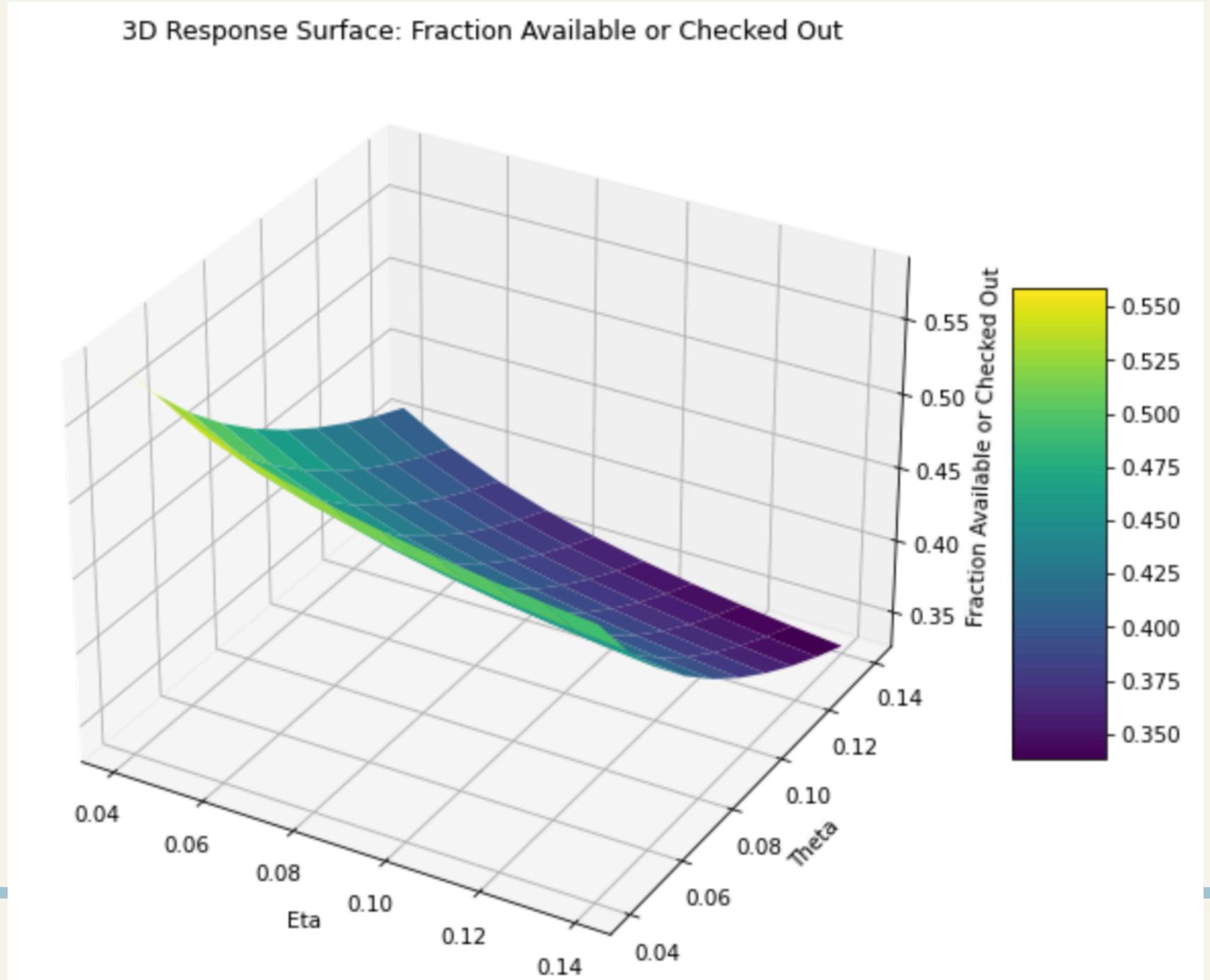
EQUATIONS IN UPDATE FUNCTION

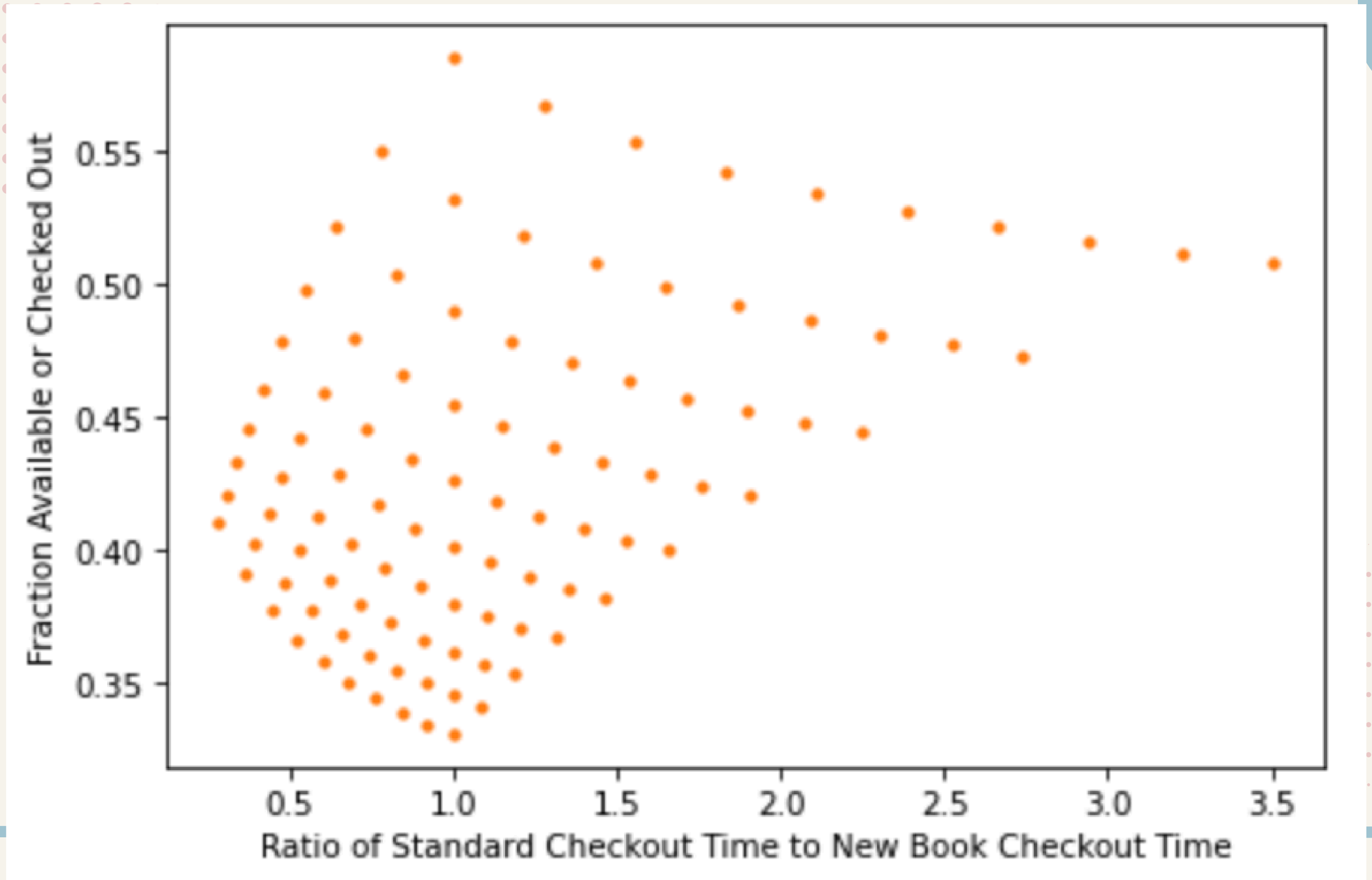
```
s_requested = system.alpha * sbk
n_requested = system.beta * nbk
s_transit = system.gamma * srq
n_transit = system.delta * nrq
s_ready = system.epsilon * strn
n_ready = system.epsilon * ntrn
s_checked_out = system.zeta * srd
n_checked_out = system.zeta * nrd
s_returned_on_time = system.kappa * system.eta * sch
n_returned_on_time = system.kappa * system.theta * nch
s_overdue = (1-system.kappa) * system.eta * sch
n_overdue = (1-system.kappa) * system.theta * nch
s_returned_late = system.kappa * system.iota * sovr
n_returned_late = system.kappa * system.iota * novr
s_lost = (1-system.kappa) * system.iota * sovr
n_lost = (1-system.kappa) * system.iota * novr
s_shelved = system.mu * srt
n_shelved = system.mu * nrt
s_replaced = system.nu * slo
n_replaced = system.nu * nlo
s_shelved_new = system.rho * nbk
```

EQUATIONS IN UPDATE FUNCTION

```
sbk += s_shelved + s_replaced + s_shelved_new- s_requested
nbk += n_shelved + n_replaced - n_requested - s_shelved_new + system.new_orders
srq += s_requested - s_transit
nrq += n_requested - n_transit
strn += s_transit - s_ready
ntrn += n_transit - n_ready
srd += s_ready - s_checked_out
nrd += n_ready - n_checked_out
sch += s_checked_out - s_returned_on_time - s_overdue
nch += n_checked_out - n_returned_on_time - n_overdue
srt += s_returned_on_time + s_returned_late - s_shelved
nrt += n_returned_on_time + n_returned_late - n_shelved
sovr += s_overdue - s_returned_late - s_lost
novr += n_overdue - n_returned_late - n_lost
slo += s_lost - s_replaced
nlo += n_lost - n_replaced
```


Fraction Available or Checked Out
0.14
0.12
0.10
0.08
0.06
0.04
Theta
0.36
0.40
0.44
0.48
0.52
0.56
0.04
0.06
0.08
0.10
0.12
0.14
Eta


3D Response Surface: Fraction Available or Checked Out
Eta
Theta
Fraction Available or Checked Out
0.04
0.06
0.08
0.10
0.12
0.14
0.35
0.40
0.45
0.50
0.55
0.350
0.375
0.400
0.425
0.450
0.475
0.500
0.525
0.550


Fraction Available or Checked Out
0.55
0.50
0.45
0.40
0.35
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Ratio of Standard Checkout Time to New Book Checkout Time

VALIDATION & VERIFICATION

Validation

The process and parameters are modeled on the New York Public Library's system of online requests and check outs.

Verification

in sweeping the parameters eta and theta, the simulation was run 100 times.

FINDINGS

- Allowing patrons to keep their books checked out longer (lower values of eta and theta) will result in a higher percentage of books that are available or checked out.

- Maximizing the amount of time that the new books are checked out for has more of an impact on the overall proportion of books that are available or in use than maximizing the amount of time that the standard books are checked out for.