Sensitivity Analysis of "Patience" in the Aftermath of a Disaster

IND E 535 Project Report

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Abstract The goal of this project is to perform a sensitivity analysis on the "patience" of those that suffer a natural disaster. The *DESaster* framework allows the use of patience levels when searching for money or trying to find a home after a disaster. For example, one's patience for finding a new home could run out after 365 days; at this point they would stop looking. In this analysis, these patience values are varied across a wide range of time, with the goal of observing how this variation affects the decisions made after a disaster and the ultimate effect that patience has on disaster aftermath.

Contents

1 Introduction

1.1 Background

In the aftermath of a disaster, individuals often need to search for money to repair damages to their home or search for a new home altogether. This process, like most any search process, requires patience on the part of the searcher. The *DESaster* framework includes multiple parameters for the patience required in these situations.

Within *DESaster*, the patience parameters are used to determine how long it will take for an individual to give up their search. There are two types of patience used:

- Money patience is used when individuals search for money to repair damage to their homes. Money can be obtained through multiple sources, such as FEMA assistance and loans from the Small Business Association.
- Home patience is used when individuals search for a new home to replace their current home.

1.2 Scope

This project will focus on money patience for homeowners and how its value affects the duration of time individuals spend searching for money. Home patience will not be examined in this analysis.

1.3 Objective

The goal of this analysis is to determine how sensitive a *DESaster* model is to changes in the money patience parameter. If relatively small changes in money patience result in drastic changes in the duration of time individuals search for money before giving up, it will be very important to use realistic money patience values when designing models using the *DESaster* framework. If the model is fairly robust to changes in money patience, it will be less important to use hyper-realistic values.

2 Methods

2.1 Modeling Approach

The model used in this analysis was based around the *DESaster Application Template.ipynb* [2] file that can be found in the *DESaster* repo on Github [1]. This template includes custom master processes for the following entities:

- **Landlord**
- **OwnerHousehold**
- **RenterHousehold**

This template provides a fairly simple model that can be used to examine the sensitivity of the

money patience parameter.

2.2 Simulation Setup

2.2.1 Generate Fake Data

The *generate_fake_desaster_data.ipynb* file [3] was used to generate fake input data for the model. All damage states were changed to "complete" in order to maximize the number of individuals searching for money.

name	income	savings	credit	insurance	address	occupancy	area	bedrooms	bathrooms	value	monthly_cost	year_built	listed	damage_state	latitude	longitude	tenure
Carol Reynolds	95000	10687	743	0	7035 Reynolds Fords Suite 249	Single Family Dwelling	1819	2	1	272933	1318	1975	TRUE	Complete	40.83648323	-73.87682193	Owner Occupied
Thomas Jackson	105000	13125	915	0	2830 Kenneth Centers	Single Family Dwelling	1781	2	1	267153	1290	1989	FALSE	Complete	40.84344833	-73.87818966	Owner Occupied
Terri Bailey	100000	11874	783	0	78047 Contreras Views Suite 665	Single Family Dwelling	1416	2	1	212536	1026	1997	FALSE	Complete	40.84655135	-73.86742614	Owner Occupied
Frederick Leblanc	10000	62	793	0	30226 Myers Trafficway	Single Family Dwelling	500	0	1	27402	132	1972	FALSE	Complete	40.83824938	-73.86906233	Owner Occupied
Caroline Reid	35000	1312	753	0	05922 Steven Meadows Suite 350	Mobile Home	601	0	1	90207	435	2007	TRUE	Complete	40.83896597	-73.86668589	Owner Occupied
Jennifer Conley	45000	2250	939	0	083 Erin Street Apt. 441	Single Family Dwelling	793	1	1	119032	575	1993	FALSE	Complete	40.83842069	-73.87604309	Owner Occupied
Elizabeth Arnold	45000	2250	669	0	476 Rivas Plain	Single Family Dwelling	733	1	1	110060	531	1974	FALSE	Complete	40.8429355	-73.86542329	Owner Occupied
Ryan Hernandez	40000	1749	749	0	1211 Christopher Groves	Single Family Dwelling	780	1	1	117135	565	1973	FALSE	Complete	40.84823613	-73.87212545	Owner Occupied
Mark Williams	35000	1312	872	0	2870 Paul Landing Apt. 203	Single Family Dwelling	601	0	1	90293	436	2003	FALSE	Complete	40.84466881	-73.87689581	Owner Occupied
Jeffrey Goodwin	165000	33000	769	0.8	28014 Hall Meadows	Single Family Dwelling	3107	4	3	466132	2252	2003	FALSE	Complete	40.8424426	-73.87369959	Owner Occupied
Elizabeth Rodriguez	25000	625	817	0	21741 Joe Key	Single Family Dwelling	500	0	1	60605	292	2016	TRUE	Complete	40.83901369	-73.86702415	Owner Occupied
Todd Turner	155000	29062	777	0.8	36843 Kaitlyn Hills Apt. 653	Single Family Dwelling	3051	4	3	457688	2211	1970	FALSE	Complete	40.83151084	-73.87049638	Owner Occupied
Jordan Nichols	125000	18750	801	0.8	785 Curtis Tunnel Suite 518	Single Family Dwelling	2142	3	2	321424	1552	1989	TRUE	Complete	40.84317716	-73.87604542	Owner Occupied
Riley Lopez	145000	25375	843	0.8	29822 Sandra Via	Single Family Dwelling	2369	3	2	355417	1717	1972	FALSE	Complete	40.83625358	-73.87701615	Owner Occupied
Kyle Anderson	30000	937	872	0	8442 Vickie Islands Suite 311	Single Family Dwelling	577	0	1	86668	418	1984	FALSE	Complete	40.83885619	-73.8767637	Owner Occupied
Colin Young	15000	187	673	0	88290 Deleon Pine Apt. 143	Single Family Dwelling	500	0	1	31812	153	2016	FALSE	Complete	40.83457737	-73.87428526	Owner Occupied
Mason Oconnell	65000	4874	676	0	40426 Lee Extensions	Single Family Dwelling	908	1	1	136345	658	1995	TRUE	Complete	40.84748135	-73.87095656	Owner Occupied

Figure 1. Fake input data used for the model

2.2.2 Modify owner_process()

In the original template, the money patience value was defined within the **owner_process** master process; in order to easily change the money patience value in each simulation, this process was modified to accept money patience as an input value. This modification can be seen in Code Snippet 1.

Code Snippet 1 Modified owner process that accepts money patience as an input

```
def owner_process(env, inspection_program, insurance_program,
 ↪ fema_program, loan_program,
                  assessment_program, permit_program,
                   ↪ demolish_program, rebuild_program,
                   search_stock, entity,
                  owner_money_patience, owner_home_patience):

#     money_patience = 200000  # days until give up the search
 ↪ for rebuild money
    money_patience = owner_money_patience
#     home_patience = 15000  # days until give up the search
 ↪ for a new home
    home_patience = owner_home_patience
```

2.2.3 Set Patience Parameters to Loop Over

A section of the code was devoted to setting the money patience parameters that are to be looped over, seen in Code Snippet 2.

Code Snippet 2 Code for setting patience parameters

```
landlord_money_patience = 100000

# owner_money_patience = 100
owner_money_patience_min = 1 # minimum patience value
owner_money_patience_max = 50 # maximum patience value
owner_money_patience_step = 1 # patience step size

owner_home_patience = 40

renter_money_patience = 365
renter_home_patience = 550
```

Three values are required for the patience parameter: minimum, maximum, and step size. The code runs a simulation with the minimum patience value, then increases the value by the step

size and repeats the simulation. This process continues until the maximum patience value is reached.

2.2.4 Loop Over Patience Parameters

A separate simulation was run for each money patience value; this was achieved through the use of a *for* loop, as seen in Code Snippet 3. Note that a large section of code was removed from the for loop for the sake of brevity; the important part is running the **owner_process** process for each owner and for each patience value.

Code Snippet 3 Using *for* loop to run simulation for each patience value

```
for owner_money_patience in np.arange(start =
 ↪ owner_money_patience_min,
                                       stop =
                                        ↪ owner_money_patience_max
                                        ↪ + 1,
                                       step =
                                        ↪ owner_money_patience_step):
    env = simpy.Environment()

    ################
    # [code removed from snippet for brevity]
    ################

    for i in range(len(owners)):
        env.process(owner_process(env, inspection, insurance,
         ↪ fema_ia, sba_home_loan,
                                  assessment, permitting,
                                   ↪ demolition, repair,
                                  owned_stock, owners[i],
                             owner_money_patience,
                              ↪ owner_home_patience))

    for i in range(len(renters)):
        env.process(renter_process(env, inspection, insurance,
         ↪ sba_biz_loan, assessment, permitting,
                                  demolition, repair,
                                   ↪ rented_stock,
                                   ↪ renters[i],
                              renter_money_patience,
                               ↪ renter_home_patience,
                              landlord_money_patience))

    env.run()
```

3 Results

3.1 Results Data Frame

The results were stored in a data frame (from the *pandas* library [4]), as seen in Figure 2.

```
results.head(10)
```

	patience	num	min	avg	max
1	1	40	11.5	24.175	31
2	2	40	12.5	25.175	32
3	3	40	13.5	26.175	33
4	4	40	14.5	27.175	34
5	5	40	15.5	28.175	35
6	6	40	16.5	29.175	36
7	7	40	17.5	30.175	37
8	8	40	18.5	31.175	38
9	9	40	19.5	32.175	39
10	10	40	20.5	33.175	40

Figure 2. Analysis results stored in data frame

For each simulation run, the data frame shows:

- **patience**: the money patience value in that simulation
- **num**: the number of individuals that gave up searching for money
- **min**: the earliest simulation time at which an individual gave up searching
- **avg**: the average simulation time at which the individuals gave up searching
- **max**: the latest simulation time at which an individual gave up searching

3.2 Results Graph

Figure 3 shows the number of people who gave up searching as a function of owner money patience.

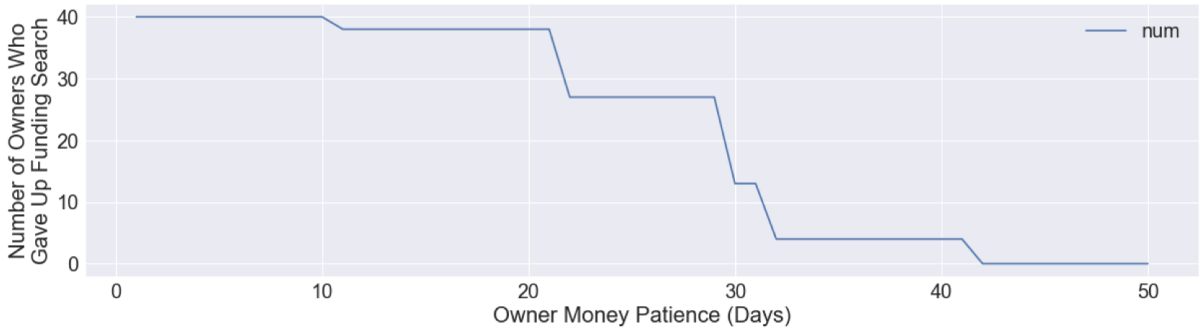

Figure 3. Owner money patience vs. number of owners who gave up searching for money

As owner money patience increases, there is a monotonic decrease in the number of owners who give up their funding search. Large drops in the number of owners who give up can be seen at money patience values of 22 and 30 days.

4 Discussion

As would be expected, this analysis showed that increasing money patience decreases the number of individuals that give up their search for money. Interestingly, the decrease is neither smooth nor uniform; for instance, there is a large drop in the number of individuals who give up their search when money patience is increased from 29 to 30 days.

These large drops in number of individuals that give up for small changes in money patience

represent a potential challenge when setting up a simulation. The results of this analysis show that it is possible for small variations in money patience to have a drastic effect on the simulation as a whole; therefore, it is important to carefully consider what patience parameters are used and how they are determined.

This analysis was performed on only one set of parameters and one implementation of the *DESaster* framework; it also only focused on money patience. In the future, more research should be done on the sensitivity of all the patience parameters, and how their sensitivity changes when other parameters change within the model.

References

1. https://github.com/milessb/DESaster
2. https://github.com/milessb/DESaster/blob/master/scenarios/desaster_application_template.ipynb
3. https://github.com/milessb/DESaster/blob/master/inputs/generate_fake_desaster_data.ipynb
4. https://pandas.pydata.org/

Appendix

Project Code

iPython Notebook: https://georgoff.github.io/DESaster_project/sensitivity_analysis.ipynb

Python File: https://georgoff.github.io/DESaster_project/sensitivity_analysis.py

HTML: https://georgoff.github.io/DESaster_project/sensitivity_analysis.html