Addressing the U.S. Financial/Housing Crisis:

Pareto, Schelling and Social Mobility

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Two important principles governing upward social mobility are Pareto's 80/20 rule[1-3] and Schelling's segregation threshold.[4-5] Pareto shows that wealth follows a power law, where a few have the most. Schelling shows that neighborhood preference (beyond a certain threshold) leads to spatial segregation. The link between these two principles, however, remains undeveloped—particularly in relation to the current U.S. financial crisis. To explore this link, we created an agent-based, Pareto universe of rich, middle and poor agents.[17] The rules for this universe follow Schelling, with a slight modification: while rich agents seek their own, middle and poor agents do not; instead (pursuing upward mobility), middle agents seek rich agents and poor agents seek middle agents. Congruent with the current U.S. financial crisis, our model finds that, in a log-normal wealth distribution with a power-tail, moderate upward social mobility produces spatial segregation, instability and, in particular, unhappiness on the part of middle-class and poor agents. We call this insight the *upward social mobility rule* (MR). Unexpectedly, the MR also provides a corrective: it appears that, at threshold, upward social mobility leads to integrated, stable neighborhoods with very high rates of happiness. The MR therefore suggests that the U.S. financial/housing crisis might be effectively addressed for the greater good of all if upward social mobility is controlled and regulated, even on the part of poor households.

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We Forget that We live in a Pareto Universe: Pareto is well-known amongst scientists today for his work on income distributions.[1-3] He found that many income distributions obey a power law, where "the probability density function *p*(*x*) of the personal income *x* is given by $p(x) = Ax^{-(1+\alpha)}$."[2] Subsequent research has significantly modified this rule—primarily by analyzing the differences between high and moderate income distributions.[1-3] The general consensus is that most income distributions are log-normal for middle incomes, with a power (long) tail for high incomes.[2] Regardless of these modifications, Pareto's general insight (abbreviated as the 80/20 rule) stands: the few have the most and the most have the least. Social mobility, no matter how aggressive or unreflective it is, does not change this basic fact: we live in a Pareto universe. Still, over the last decade many Americans—from the rich to the poor—have used housing and debt (credit cards, second mortgages, etc) to overcome their position along the U.S. Pareto distribution.[7-9] This relatively uncontrolled, unregulated, upward social mobility (encouraged by the U.S. lending and banking system) has not produced the desired effect. Instead, it seems to have skewed the U.S. Pareto distribution to the right, creating greater economic disparities between the rich, middle and poor.[10-11] An important question now, from Wall Street down, is what type of social mobility can "correct" this distribution?

Past a Certain Threshold, Mobility leads to Segregation: Schelling's contribution to the housing and segregation literature is the insight that, past a certain threshold (*x*), individual housing preferences (*p*) lead to segregated neighborhoods $(p > x)$.[4-5] Crucial to this insight is the fact that Schelling's preference threshold is mild: it only requires that people somewhat prefer to live in particular neighborhoods for significant segregation to emerge.[4]

Schelling's insight applies to the current U.S. financial crisis. In the U.S., one of the byproducts of the last decade of housing expansion is the increased spatial segregation of wealth.[5,7,12] Suburban sprawl (or out-migration) is the technical term for this process: upwardly mobile households have sought to live in higher status neighborhoods (primarily 2nd tier suburbs) leaving those of less affluent status behind.[13] One result is a *Pareto Geography*: the rich live in 2nd tier suburbs, in which the middle-class seek to live; meanwhile 1st tier suburbs become residence for lower, middle-class and working-class families, while the cities become segregated poverty traps, mainly comprised of poor households.[12-13] The negative effects of suburban sprawl have been exacerbated by the recent financial collapse. Unable to afford their homes or their debt, many upwardly mobile families (particularly amongst the middle and working class) have fallen backwards, skewing the Pareto distribution to the right. The result: rather than creating or maintaining integrated and relatively stable neighborhoods, the collapsed housing market has spatially segregated the neighborhoods of the rich, middle and poor.[6-15]

The unintended consequence of his segregation is institutional disparity, or what researchers call neighborhood effects.[12,14-15] Segregated, affluent neighborhoods beget excellent schools, high-quality health care, new jobs, economic growth, low crime, good health, and so forth. Segregated, poor neighborhoods beget poverty traps and so on.[12,14-15]

Linking Pareto and Schelling: Schelling's insight is known in complexity science as a bottom-up approach to model building: a few basic rules, put into action by a network of agents, leads to unanticipated patterns at the macro (systems) level.[16] Pareto's model is likewise bottom-up. The 80/20 rule appears unintentional: even in a simulated world where wealth at (t_x) is equally distributed, moderate differences in individual behaviors across time (t_{x+y}) lead to a Pareto distribution. What has yet to be developed, however, are the links between these two bottom-up approaches, particularly in relation to the current U.S. financial crisis. We conceptualize one such link as a type of *upward social mobility rule (MR)*, with particular interest in its implications for the current U.S. financial crisis.

The *MR* links Pareto and Schelling together by examining how upward social mobility creates spatial segregation in a log-normal, power-tail wealth distribution. To demonstrate the *MR*, we define, operationalize, and apply it to an agent-based model.

Agent-Based Model: Our agent-based model (created in *NetLogo*)[17] is a 51X51 lattice structure, upon which a randomly distributed set of upwardly-mobile rich, middle-class, and poor agents roam (See note a, Figure 1). Three rules govern the behavior of these agents: preference, preference-degree, and capacity.

Preference is a modification of Schelling's segregation rules. Unlike the original Schelling model, wherein agents seek their own kind, preference concerns upwardly mobile agents seeking agents of a higher status. In our model, rich agents seek rich agents; middle-class agents seek rich agents; and poor agents seek middle-class agents.

Preference-degree determines the number of higher *status* agents around which others prefer to live. In a 2-D lattice structure, "neighbors" is defined as the total number of spaces available around an individual agent, which range from 0 to 8.

Capacity (which ranges from 0 to 10) determines the number of random spaces an agent can move per iteration. Using our model, we state the *MR* as follows:

Upward Social Mobility Rule: In a Pareto universe, once preference (*p*) for upward social mobility passes a certain threshold (*x*), the spatial segregation of wealth (*S*) emerges. We can state this rule more generally: when $p \leq x$, segregation approaches zero; however, once $p > x$, segregation approaches near completion (1). Furthermore, as *p* moves past threshold, segregation increases—although the relationship between *S* and *p* is nonlinear, levelling off across time (*t*) at about *p* = 3.

$$S \rightarrow \begin{cases} 0 \text{ if } p \leq x \\ 1 \text{ if } p > x \end{cases} \tag{1}$$

In this first formula, the *MR* defines upward social mobility as an agent's *preference* and *capacity* to improve its economic status within a Pareto wealth distribution. Together, capacity and preference create a *likelihood of happiness* distribution (*L*). At any given moment, an agent's likelihood for happiness—that is, the agent's capacity to secure upward social mobility—is expressed as follows:

$$L(H) = \left(\frac{s}{t-h}\right)\left(\frac{c}{c'}\right) \tag{2}$$

Where *H* = happiness; *s* = neighborhood spaces available around the higher status agents being sought; *t* = total population of agents seeking a particular set of spaces; *h* = similar seeking agents that have already secured a position of happiness; *c* = an agent's actual capacity to move randomly at any given point in time; and c' = the agent's ideal capacity. Furthermore, in this second formula, *s* is determined, in part, by preference

(p), which defines the type and number of empty spaces agents are seeking. For example, if rich agents seek spaces with p = 2 neighbors, only those empty spaces are sought by rich agents; s for each of the three agent types is also dependent upon the number of spaces already taken by other agents.

In our model, we simplify the *likelihood of happiness* into a basic *prevalence rate of unhappiness*—which we obtain by plotting the prevalence rate of unhappy rich, middle and poor agents at each moment in time, along with an overall unhappiness rating.

Results Confirm the MR: As shown in Chart 1 (See note a), to test the MR, we ran 27 different preference-degree combinations, starting with *r1,m1,p1* (rich seek one rich agent; middle seek one rich agent and poor seek one middle agent) and ending with *r3,m3,p3* (rich seek three rich, middle seek 3 rich; poor seek 3 middle). We tested each combination 100 times for a total of 2,700 runs (See notes b, c, & d, Figure 1 for more details).

1. As shown in Figure 1, our results suggest that, in a Pareto universe, the spatial segregation of wealth is a function of some type of *social mobility rule*—which can be mapped, across time, as a series of unhappiness distributions.

2. More specifically, it appears that the first combination (*C1*) has the best happiness ratings. In fact, the second best combination (*C2*) is significantly worse (mean diff = 14.43; t-test= -44.99; two-tailed, p =.000), with the unhappiness of middle and poor agents doubling from *C1* to *C2*.

3. The degree of unhappiness in our Pareto universe is best explained in systems terms—that is, the 27 different combinations of micro-level behaviors in Table 1 lead to

unintended and, in some instances, unexpected macro-level patterns. Two systems issues are of particular importance.

The first has to do with the behavior of rich agents. In Table 1, the upward mobility of rich agents at $p \geq 2$ negatively impacts the happiness of middle and poor agents. Rich agents close-out middle agents because of their increased mild preference (p = 2), which causes a rippling effect wherein the lack of spaces for middle agents causes instability, which makes it harder for poor agents to secure a stable place to live.

The second has to do with the behavior of middle and poor agents. The rippling effect of the rich is less dramatic when the upward mobility of middle and poor agents is kept at $p = 1$. In other words (and unexpectedly so), middle and poor agents have a much better chance at happiness when they enact a mild level of upward mobility, especially when rich agents begin seeking higher rates of mobility.

4. It appears that *C1* is the most spatially integrated of all 27 models. To demonstrate, Figure 1 shows two random runs: *R1* uses *C1* (r1,m1,p1) and *R2* uses *C15* (r2,m2,p2). In *R1*, 90% of all rich, middle and poor agents are clustered together in integrated neighborhoods, with only 10% of agents roaming. In *R2*, only 39% of all agents are in integrated neighborhoods, with 61% of agents roaming. *R1* is also highly settled. In contrast, *R2* (even after 10,000 iterations) is unstable and chaotic, with an overall unhappiness rating of 56%. Finally, unlike *R1*, the settled neighborhoods of *R2* are comprised mostly of rich agents and are not very integrated.

5. Spatial segregation in our Pareto universe is also best explained in systems terms. Again, two systems issues are of particular importance.

First, higher rates of mobility amongst rich, middle and poor agents lead to higher rates of spatial segregation—both within and between agent types. More specifically, once preference-degree becomes moderate, reaching p=3, almost everyone in a Pareto universe (from the rich to the poor) has high rates of unhappiness.

Second, if preference-degree is kept at threshold $(x = .15)$, integrated, stable neighborhoods emerge and unhappiness is low. For example, because *R1* (see note e, Figure 1) remains at threshold, spatial segregation amongst the three agent types is almost absent. (Note: here preference is expressed as $\left(\frac{p}{n}\right)$, where *p* = preference-degree and *n* = total neighborhood spaces available, which in our model (*n*=8).

6. In an already segregated model, setting social mobility at (p = 1) functions as a corrective: it improves integration and happiness. In R2, for example, after 1000 iterations, we reset mobility at (r1,m1,p1). Another 1000 iterations later, unhappiness dropped from 61% to 23% and segregation significantly decreased.

Threshold mobility and the U.S. Financial/Housing Crisis: Congruent with the current U.S. financial crisis, our model suggests that, in a log-normal wealth distribution with a power-tail, moderate upward social mobility produces significant system-wide spatial segregation, instability and, in particular, unhappiness on the part of the middle-class and poor.

Unexpectedly, however, our model also suggests that, one way to address the current U.S. financial crisis is to slow down mobility to a mild, threshold level. The important byproduct of this more systemically aware mobility is integrated, stable neighborhoods that have very high rates of happiness. In other words, Pareto's law seems more effectively addressed for the greater good of all if upward social mobility is controlled and regulated, even on the part of poor households. This is particularly true in terms of housing.

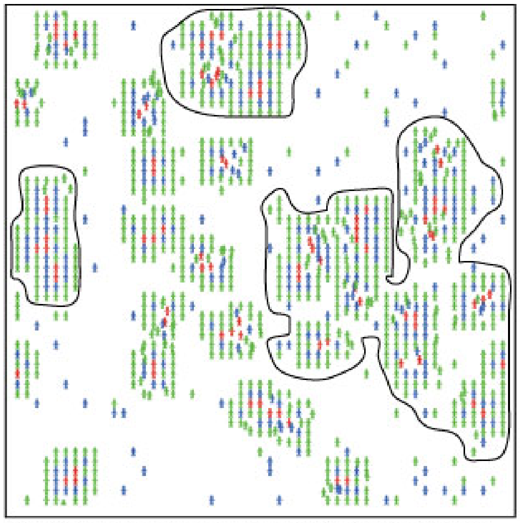
Over the last decade, many Americans and their lenders have used a variety of high-risk housing strategies (sub-prime lending, etc) to obtain higher levels of upward social mobility. The result has been the increased spatial segregation of wealth: the neighborhood distances from the rich to the poor have geographically increased as upwardly mobile families lost their homes, primarily through failed attempts to gain more than they could financially support. Within the confines of our model, the failure of this strategy seems evident. Past a certain threshold, upward social mobility threatens (rather than stabilizes) the system, creating unstable, chaotic mobility patterns amongst the poor and middle-class—which results in increased, rather than decreased, wealth segregation.

In such a chaotic system, the effects of neighborhood, in particular poverty traps, also make sense—albeit with an important (and unexpected) twist. As shown in R2, once mobility passes a certain threshold, poor agents (despite their individual efforts) remain stuck. They cannot improve their position no matter how aggressive their social mobility. In other words, poverty traps are not strictly a function of neighborhood effects. Instead, poverty traps and neighborhood effects are the product of something larger: the system, or more specifically, the mobility patterns of the rich, middle-class and poor.

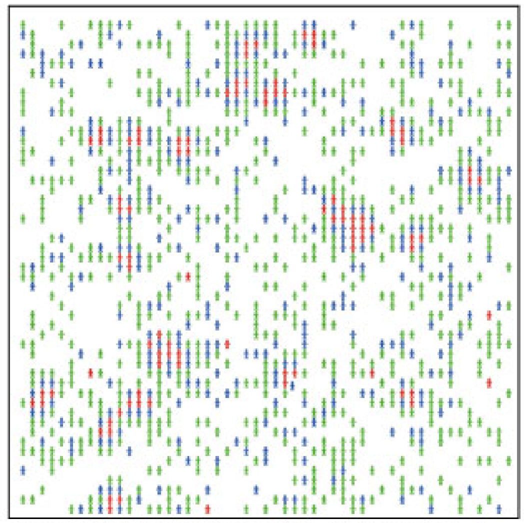
This last finding is perhaps our most important. Individual micro-level social mobility is not self-regulating. Contra Adam Smith, our model suggest that there is no invisible hand guiding the role upward social mobility plays in the spatial distribution of wealth. As the recent U.S. financial/housing crisis shows, and our model seems to concur, in a Pareto Universe, without some type of threshold-based recognition, upward social mobility (even at relatively mild levels) does not promote the good of the community; instead, it supports Schelling-like segregation.

REFERENCES

1. Boccara, N. *Modeling Complex Systems* (Springer, New York, 2004).
2. Souma, W. Universal structure of the personal income distribution. *Fractals-Complex Geometry Patterns and Scaling in Nature and Society* **9**, 463-470 (2001).
3. Coelho, R., Richmond, P., Barry, J. & Hutzler, S. Double power laws in income and wealth distributions. *Physica A* **387**, 3847-3851 (2008).
4. Bruch, E. E. & Mare, R. D. Neighborhood choice and neighborhood change. *AJS* **112**, 667-709 (2006).
5. Clark, W. A. V. Residential preferences and neighborhood racial segregation: A test of the Schelling segregation model. *Demography* **28**, 1-19 (1991).
6. Schiller, R. J. *Irrational Exuberance, 2nd edition*. Princeton Univ Press, Princeton 2005).
7. Fujita, M., Krugman, P. & Venables, A.J. *The Spatial Economy: Cities, Regions and International Trade*. (MIT Press, Boston, 2001).
8. Surowiecki, J. Going for broke. *New Yorker, The Financial page*, 7 April 2008.
9. Soros, G. *The New Paradigm for Financial Markets: The Credit Crisis of 2008 and What It Means* (Public Affairs, New York, 2008.
10. Neckerman, K. M. & Torche F. Inequality: causes and consequences. *Ann Rev of Soc* **33**, 335-357.
11. Krugman, P. The great wealth transfer. *Rolling Stone*, 30 Nov 2006 (accessed at: www.rollingstone. com/politics/ story/12699486/paul_krugman_on_the_great_wealth_ transfer/print.
12. Bowles, S., Durlauf, S. N. & Hoff K. *Poverty Traps* (Princeton University Press, Princeton, 2006).
13. Transit Cooperative Research Program. *Costs of Sprawl 2000-TCRP Report 74*. (National Academy Press, Washington D.C., 2002). (accessed at: onlinepubs.trb.org/Onlinepubs/ tcrp/tcrp_rpt_74-a.pdf).
14. Robert, S. Socioeconomic position and health: the independent contribution of community socioeconomic context. *Ann Rev of Soc* **25**, 489-516.
15. Health inequalities and place: A theoretical conception of neighborhood. *Soc Science & Med* **65**, 1839-1852.
16. Epstein, J. *Generative Social Science: Studies in Agent-Based Computational Modeling* (Princeton University Press, Princeton, 2007).
17. Wilensky, U. NetLogo. (accessed at: ccl.northwestern.edu/netlogo) (Center for Connected Learning and Computer-Based Modeling. Northwestern University, Evanston, IL, 1999).



Run #1. Preference-degree: rich (red)= 1; middle (blue)= 1; poor (green)= 1. Unhappiness at 1,000 iterations: rich = 0.0%; middle = 22.5; poor = 5.07; overall = 9.64%



Run #2. Preference-degree: rich (red)= 2; middle (blue)= 2; poor (green)= 2. Unhappiness at 1,000 iterations: rich = 7.78%; middle = 66.56; poor = 65.49; overall = 61.16%

Figure 1 | Model at-threshold (p=1) and over-threshold (p=2).

a, Our first model was created in Visual Basic, which we then recreated in NetLogo to test its validity and to facilitate its usage by other researchers. Both models generated the same results. To download, modify or read about our two models go to www.personal.kent.edu/~bcastel3 and click on Pareto/Schelling model. **b,** We used the Behavior Space tool in NetLogo to run 2,700 tests of our model. See table 1 for output. **c,** We used the Wealth Distribution model in the Netlogo library to generate our Pareto wealth distribution numbers: rich = 90 agents; middle = 320 agents; poor = 710 agents. **d,** Capacity was set at rich = 9; middle = 6; and poor = 3. These estimate were based on our analysis of the existing literature—see references. **e,** The circles in Run #1 are examples of integrated communities. **f,** Run #2 demonstrates that, following Schelling, past a mild threshold (p > 1), the number and size of integrated neighborhoods drop dramatically; chaotic behavior is significant; and poverty traps (chaotic clusters of poor agents emerge.

Preference Degree	Overall Unhappy	Rich Happy	Middle Happy	Poor Happy	SD Overall	SD Rich	SD Middle	SD Poor
1) r1m1p1	12.16	.58	24.10	8.24	2.54	.58	3.31	2.89
2) r2m1p1	26.58	14.08	45.60	19.59	1.96	3.01	3.13	2.03
3) r1m2p1	31.59	.00	67.48	19.42	1.08	.00	1.82	1.52
4) r1m1p2	32.14	.67	21.22	41.06	2.14	.61	3.24	2.17
5) r2m2p1	35.85	15.26	72.62	21.88	1.45	3.36	1.91	1.66
6) r2m3p1	41.35	.38	86.47	26.21	1.17	.69	.87	1.70
7) r1m3p1	43.05	.00	89.41	27.61	1.31	.00	1.27	1.84
8) r1m1p3	46.67	.33	7.23	70.32	1.46	.51	3.56	1.11
9) r3m1p1	46.70	84.36	72.30	30.38	1.97	7.08	2.81	2.09
10) r2m1p2	47.66	14.61	43.46	53.75	2.00	3.55	2.92	1.86
11) r3m2p1	52.96	84.58	92.50	31.12	2.11	7.06	2.51	2.01
12) r3m3p1	53.83	73.86	97.14	31.78	1.90	8.92	1.02	2.09
13) r1m2p2	57.70	.00	60.45	63.78	1.40	.00	1.78	1.72
14) r2m1p3	61.70	14.94	35.55	79.41	1.89	3.13	3.60	1.32
15) r2m2p2	62.25	14.90	69.05	65.19	1.30	3.47	1.64	1.43
16) r2m3p2	68.83	.00	82.08	71.59	.99	.00	.90	1.46
17) r1m3p2	71.21	.00	87.93	72.70	1.09	.00	1.55	1.63
18) r3m1p2	71.46	84.78	71.92	69.57	1.82	5.56	2.62	1.63
19) r1m2p3	73.22	.00	54.84	90.78	.93	.00	1.54	1.15
20) r2m2p3	77.24	12.49	64.13	91.36	.97	3.69	2.01	.93
21) r3m2p2	78.12	83.96	91.61	71.30	1.98	6.68	2.76	1.72
22) r3m3p2	79.07	71.80	96.11	72.31	1.61	9.41	1.33	1.56
23) r2m3p3	82.86	.00	82.20	93.67	.63	.00	1.04	.81
24) r1m3p3	84.42	.00	87.33	93.80	.73	.00	1.55	.83
25) r3m1p3	84.87	86.31	69.91	91.43	2.05	6.98	3.34	1.30
26) r3m2p3	91.78	85.44	90.23	93.28	1.78	7.96	3.55	1.04
27) r3m3p3	92.39	72.18	96.01	93.32	1.53	11.08	1.65	1.00

Table 1 | Unhappiness ratings for different combinations of preference-degree (N=1,000 iterations).

*** percentage; ** SD = standard deviation. a,** column 1 provides the degree preference combination: the number of rich agents (r) preferred by rich; (m) rich agents preferred by the middle; and (p) middle agents preferred by the poor. **b**, the preference combination with the least unhappiness is r=1,m=1,p=1. **c,** we defined the combination in **b** as our preference threshold, which, divided by 8 (the totol possible neighbors) is (*p=.15)*.

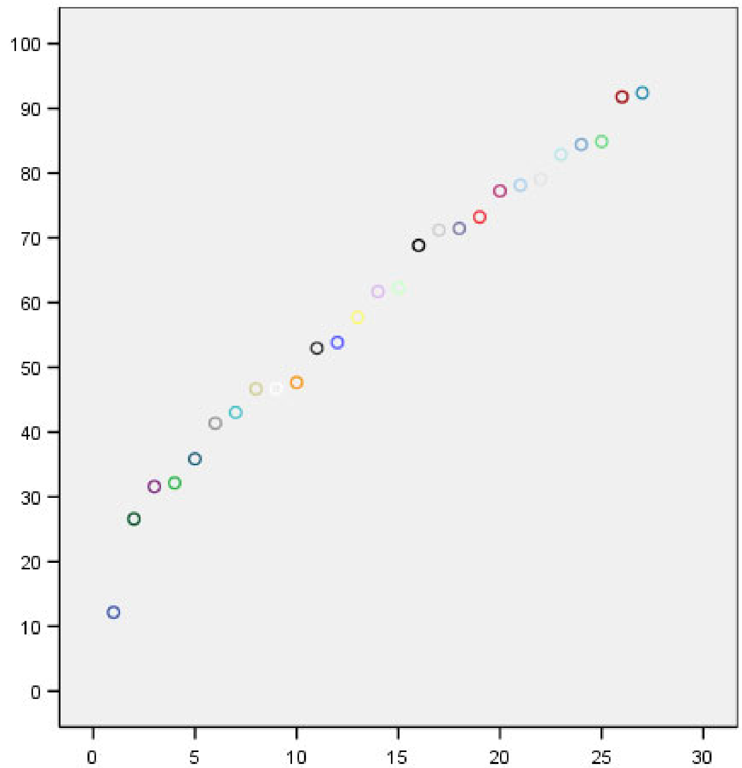


Chart 1 | Plot of overall unhappiness ratings for 27 preference-degree combinations.

a, Going from left to right, each circle represents the 27 different combinations of preference-degree found in Chart 1, first column.