Visualizing Intergenerational Wealth Mobility and Racial Inequality

Fabian T. Pfeffer and Alexandra Killewald

Online version (recommended) available at viz.theinequalitylab.com

Abstract

The black-white gap in household wealth is large and well-documented. Here, we visualize how this racial wealth gap persists across generations. Animating the flow of individuals between the relative wealth position of parents and their adult children, we show that the disadvantage of black families is a consequence both of wealth inequality in prior generations and race differences in the transmission of wealth positions across generations: black children both have less wealthy parents on average and are far more likely to be downwardly mobile in household wealth. By displaying intergenerational movements between parental and offspring wealth quintiles, we underline how intergenerational fluctuation coexists with the maintenance of a severely racialized wealth structure.

Main Article

The U.S. wealth structure is extremely unequal and marked by very large racial gaps, with the average black household holding less than one tenth the net worth – defined as the total sum of assets minus debts – of the average white household (Oliver and Shapiro 2006). To what extent racial gaps in household net worth persist depends on how many children reproduce the wealth position of their parents, how many move up, and how many fall down. Here, we visualize and extend our recent finding of racial differences in intergenerational wealth mobility (Pfeffer and Killewald 2018) using a dynamic display of changes in relative wealth positions between parents and their children. Due to data limitations, we are only able to compare mobility rates for non-Hispanic blacks and non-Hispanic whites.

Building on long-standing evidence of greater rates of intergenerational downward mobility for blacks than whites, Chetty et al. (2018) used full population tax and Census data to confirm that black children are more likely than white children to fall below their parents' relative income position. Their estimates were subsequently visualized by the *New York Times* (Badger et al. 2018). The same type of visualization is presented in Animation 1 for black-white differences in rates of intergenerational mobility in family wealth. It relies on data from the Panel Study of Income Dynamics (PSID) assembled in Pfeffer and Killewald (2018).

Animation 1. Racial Differences in Wealth Mobility Rates

We display the estimated probability of attaining each quintile (dividing the wealth distribution into five equally-sized groups) of the net worth distribution for black and white children who grow up in the same wealth quintile of the parental wealth distribution. For instance, among those growing up in the middle 20 percent of the parental wealth distribution, black children are much more likely to be downwardly mobile, with 39 percent of them falling to the bottom 20 percent of the wealth distribution compared to 16 percent of white children. Transition probabilities for each parental wealth quintile can be selected interactively and reaffirm the disadvantage of black children in attaining wealth irrespective of the wealth position of their parents.

Animation 2: Wealth Mobility and Maintenance of the Racial Wealth Structure

Animation 1 focuses on racial differences in mobility rates but obscures the fact that black and white children are also unequally distributed across parental wealth origins: white children are far more likely to have wealthy parents. Therefore, Animation 2 rescales the number of dots representing black and white children to match their distribution across parental wealth quintiles. The concentration of black families toward the bottom of the wealth distribution is immediately visible. And although there is considerable intergenerational fluctuation in wealth positions, the wealth distribution in the offspring generation reveals similarly striking racial wealth gaps. While the representation of blacks in the middle 20 percent of the wealth distribution increases (from 8 to 15 percent) and their overrepresentation in the bottom 20 percent of the wealth distribution decreases (from 44 to 30 percent), the overall visual impression underlines the considerable stability of racial gaps in family wealth, despite the fact that 70% of white children and 62% of black children attain a wealth quintile different from their parents'. Animation 2 thus illustrates that ample intergenerational fluctuation in wealth positions coexists with the maintenance of substantial racial inequality in wealth.

Overall, we conclude that today's black-white gaps in wealth arise from both the historical disadvantage reflected in the unequal starting position of black and white children (the focus of Animation 2) *and* contemporary processes (the focus of Animation 1), including continued institutionalized discrimination (see also Oliver and Shapiro 2006; Killewald and Bryant 2018).

Technical Note

These animations were produced using javascript. Data and code to reproduce them as well as other versions that display the stability to alternative analytic decisions are available at http://github.com/fpfeffer/wealthmobility. We have chosen an animated and interactive display of what, at core, is a simple cross-tabulation in an effort to maximize the intuitiveness and accessibility to a wide audience beyond that accustomed to reading mobility tables. In the Supplemental Material, we present interactive Sankey diagrams as an alternative static approach and discuss the distinct features of our approach.

Acknowledgments

We thank Abhraneel Sarma for his excellent research assistance, Adam Pearce for making available some of the javascript code behind the visualizations reported in Badger et al. (2018), and *Socius* reviewers for their valuable feedback. Our work on intergenerational wealth correlations has been supported by a grant from the Russell Sage Foundation and the W. K.

Kellogg Foundation. The collection of PSID data used here was partly supported by the National Institutes of Health (R01 HD069609) and the National Science Foundation (1157698). Any opinions expressed are those of the authors alone and should not be construed as representing the opinions of the funding agencies.

References

Badger, Emily, Claire Cain Miller, Adam Pearce, and Kevin Quealy. 2018. "Extensive Data Shows Punishing Reach of Racism for black Boys." *The New York Times*, March 19. https://www.nytimes.com/interactive/2018/03/19/upshot/race-class-white-and-black-men.html

Chetty, Raj, Nathaniel Hendren, Maggie Jones, and Sonya Porter. 2018. Race and Economic Opportunity in the United States: An Intergenerational Perspective. *NBER Working paper 24441*. Cambridge, MA: National Bureau of Economic Research.

Killewald, Alexandra and Brielle Bryan. 2018. "Falling Behind: The Role of Inter- and Intragenerational Processes in Widening Racial and Ethnic Wealth Gaps through Early and Middle Adulthood." *Social Forces* 97(2):705–40.

Oliver, Melvin L. and Thomas M. Shapiro. 2006. *Black Wealth, White Wealth. A New Perspective on Racial Inequality*. Second Edition. New York: Routledge.

Pfeffer, Fabian T. and Alexandra Killewald. 2018. "Generations of Advantage. Multigenerational Correlations in Family Wealth." *Social Forces* 96(4):1411–42.

Supplemental Material

Data, Sample, Variables

We use data from the Panel Study of Income Dynamics (PSID) as prepared for and described in Pfeffer and Killewald (2018). A replication package containing the data and code used in that study is available through the PSID Public Data Extract Repository via OpenICPSR at http://doi.org/10.3886/E101094V1 and a full replication package for the animations reported here is available at http://github.com/fpfeffer/wealthmobility.

The net worth measure in the PSID is based on a set of survey questions on the ownership and value of separate assets components, including financial assets (e.g. savings, stocks, etc.), home ownership (home value minus mortgages), other real assets (e.g. business and farm wealth, real estate, etc.), and different forms of debt. Parental wealth is measured as average household net worth in survey years 1984 and 1989, which contain the first full asset survey modules. Offspring's wealth is measured as average household net worth in survey years 2013 and 2015, the latest available PSID waves. We restrict the analytic sample to offspring aged 45-64 (N=1,936) to reduce life-cycle bias in estimates of intergenerational wealth mobility (as revealed in Pfeffer and Killewald 2018). The average parental age in this sample is 52.1 years (in 1984) and the average offspring age is 53.7 years (in 2013). Net worth quintiles are drawn based on the analytic sample just described and using the distribution of wealth for parents and children (weighted using longitudinal individual weights). The racial classification relies on the first mention of the offspring's race and distinguishes Non-Hispanic whites from Non-Hispanic blacks.[1] The sample size is too low to support separate analyses of other racial or ethnic groups.

Additional Information on Animation 1

Higher rates of intergenerational downward social mobility for black children compared to white children have been established for at least fifty years (Blau and Duncan 1967ff: 208ff) and found across a wide range of indicators of socio-economic well-being (Featherman and Hauser 1978; Hertz 2005; Bloome 2014; Mazumder 2014). This visualization confirms that these racial differences in intergenerational mobility also apply to family wealth (see also Conley and Glauber 2008; Pfeffer and Killewald 2018).

Unlike the visualization in Badger et al. (2018), which relied on full population administrative data (Chetty et al. 2018), our visualization draws on a much smaller sample from survey data. Thus, rather than displaying observed transition rates, we estimate transition probabilities more parsimoniously in a statistical model.[2] Animation 1 displays predicted probabilities from an ordered logistic regression model. We can express offspring's relative wealth position as a latent variable, $\tilde{y}$, that is a function of their parents' wealth position, $\boldsymbol{x}$, measured in quintiles, plus an error term, ε. That is,

---

[1] Drawing on up to four mentions of race and counting as white only those who do not report any classification other than white across all mentions leads to the reassignment of only 29 cases from the white to non-white category.

[2] This illustrates the well-known trade-off between data and assumptions. One of the advantages of full population data is that they often allow the display of observed relationships without further parametric assumptions, eliminating the need for additional explanation.

$$\tilde{y} = \boldsymbol{x}\beta + \varepsilon \qquad (1)$$

The probability that a child's attained wealth quantile, *y*, is quantile q can then be expressed as

$$\Pr(y = q|\boldsymbol{x}) = F(\tau_q - \boldsymbol{x}\beta) - F(\tau_{q-1} - \boldsymbol{x}\beta) \qquad (2),$$

where F is the logistic cumulative distribution function and the τ_q parameters describe the cut-points of the latent measurement model. We estimate the ordered logistic regression interacting race and wealth origins to accommodate racial differences in transition rates, β. The regressions are estimated using PSID's longitudinal individual weights, which partly adjust for attrition (Berglund et al. 2017a; more on weighting below).

One of the parametric assumptions of the ordered logistic models is the *proportional odds assumption*, which constrains all βs to be equal across outcome categories q. Using global significance tests (see Long and Freese 2014: 329), across all but one test we cannot reject the null hypothesis of this assumption.[3]

Animation S.1: Transition probabilities produced under different modeling approaches

To assess robustness of the reported patterns to alternative modeling approaches with either more or less stringent constraints, we provide Animation S.1, which displays the results created under alternative statistical models. First, a slightly less parsimonious model estimates the ordered logistic regression model separately for whites and blacks, which not only accommodates different transition rates, β, but also allows the cut-points of the measurement model, τ_q, to vary by race, effectively allowing the distribution of the underlying latent variable to differ by race. In these models, we find clear statistical support for the proportional odds assumption.[4] Second, we include results from a multinomial logistic regression, which – with interaction terms for race and parental wealth – imposes no further constraints on the data (saturated model): In contrast to the ordered logistic regression model, it allows the coefficients for each independent variable to vary by outcome category and thereby corresponds to the observed probabilities.[5] Third, we provide results from a stereotype ordinal regression model. In

---

[3] Only the Wald test – but not other statistical tests (likelihood ratio test, score test, Wolfe-Gould test, and Brant test; see Buis 2013) – fails to reject the proportional odds assumption ($p < 0.1$). Fit statistics that take into account model parsimony (e.g., BIC) indicate that the ordered logistic model is preferred over the more flexible generalized ordered logistic model, which relaxes the proportional odds assumption (see Long and Freese 2014: p.371ff).

[4] For both whites and blacks, different tests (see footnote 3) fail to reject the null hypothesis that coefficients are equal across outcome categories and the ordered logistic model is also indicated as preferred over the generalized ordered logistic model based on BIC. Because the very low number of black children in the top two quintiles results in situations of perfect prediction, the statistical tests of the proportional odds assumption for black children have to be restricted to the bottom three quintiles. Naturally, the near absence of black children from the top 40% of the parental wealth distribution is not merely a methodological or modeling challenge, but follows from a fundamental empirical fact, namely, the severely racialized structure of wealth holdings in the United States, which is the focus of Animation 2.

[5] These probabilities also reveal the issue of empty cells in the underlying cross-tabulation for black children who grow up in the top two quintiles of the wealth distribution. We believe that the lack of any black children from these quintiles who also end up in the top wealth quintile themselves is a feature of the small sample. The model-based probabilities produced under the other statistical models represent our best estimates of the share of cases we would observe if we observed the full population.

terms of parsimony, this model occupies a middle ground between the ordered and multinomial model: Instead of fixing the coefficients to be equal across outcome categories (as in the ordered logistic model) or allowing them to vary freely (as in the multinomial logistic model), it imposes a linear proportionality constraint on the associations of the independent variables with each outcome category (Anderson 1984).

Additional Information on Animation 2

This animation relies on the weighted cross-tabulation of parental and offspring wealth quintiles, separately for whites and blacks. To correctly represent the racial distribution across quintiles, we rescale the number of observations by multiplying all observations in these cross-tabulations with the average longitudinal individual weight of blacks and whites in the offspring generation (in 2013). These weights adjust both for the initial PSID oversample of black households and sample attrition (for a detailed description of the PSID weighting scheme see Berglund et al. 2017a; 2017b).

Animation S.2: Mobility across quartiles for different samples
Animation S.3: Mobility across terciles for different samples

Other research on intergenerational mobility, in particular by economists following Solon (1992), has excluded the oversample ("SEO sample") and instead reverted to unweighted analyses of only the population-representative part of the original PSID sample (the "SRC sample"). The resulting lower sample size increases concerns about low cell counts (N=1,223), particularly for blacks (N=94). The issue of low cell counts can be ameliorated by choosing broader wealth quantile categories. Animations S.2 and S.3 display the intergenerational wealth structure using quartiles and terciles, respectively, though we caution that the broader the categories, the more they hide inequality in the wealth position of black and white children within those categories. However, based on these coarser wealth categories, Animations S.2 and S.3 can also be used to display results restricted to only the population-representative SRC sample.[6]

Alternative Display and Comparative Advantage of the Animation

There are many other ways to visualize mobility tables, each with different comparative advantages in highlighting certain aspects of the mobility process. Examples include overlaying the cross-tabulation with a heat map that represents variation in mobility rates with different colors, or altering the size of the cells of a mobility table to include information on generational difference in the extent of inequality (see Lawrence 2018). The approach pursued here and in Badger et al. (2018) focuses on the comparison of transitions between different population

[6] The use of only the SRC sample portion of the PSID prohibits the use of any weights (as the weights were constructed based on both the SEO and SRC sample). For this reason, this sensitivity analysis does *not* use weights at any stage of the process (i.e., neither in the construction of the quantiles nor in calculating the cross-tabulations).

groups (Animation 1) and the interplay between structural reproduction and individual-level dynamics (Animation 2). Of course, even within that focus, other approaches are available.

Figure S.1: Sankey diagram as static version of Animation 1
Figure S.2: Sankey diagram as static version of Animation 2

A commonly used alternative to our visualization is Sankey diagrams, which are displayed for comparative purposes in Figures 1 and 2 (as alternatives to Animations 1 and 2, respectively). While these static versions display the same quantitative information, we believe that the animations make the information more intuitively accessible and reduce the general reader's cognitive work in the following ways (for meta-analytic evidence on the educational benefits of animations compared to static displays see Höffler and Leutner 2007). First, the displayed movement of individuals who *fall* down or *rise* up is a fitting visual representation of the *dynamics* of downward and upward mobility; the Sankey diagrams are static and do not convey this movement as directly. Second, the directionality of the flow (from origins to destinations) in the animation assures that non-specialists read the information in the intended direction (since we are displaying outflow, not inflow percentages), but the direction of flow is less obvious in the Sankey diagrams. Third, the focus of this contribution is on the between-race comparison, which is directly supported by overlaying information on both racial groups in the same display. To achieve a similar goal, the Sankey diagrams display racial groups next to each other within each quintile (rather than separate Sankey diagrams for each racial group), but the direct between-race comparison is still much more immediate in our animations. Fourth, both experts and non-experts are better at reading and interpreting natural frequencies – e.g., 10 in 100 – than percentages – e.g., 10% – (see Hoffrage et al. 2000; 2015) and our visualization evokes that interpretation. Fifth, and perhaps most importantly, Animation 2 provides a visual illustration of the fundamental sociological insight that structural reproduction can coincide with ample fluctuation at the individual level. The co-existence of stability (reproduction of the racial wealth structure) and movement (individual-level dynamics) cannot be displayed as effectively in a static way.

Finally, we point to two aspects of what we consider purposeful pedagogical design: The underlying transition estimates are clearly too numerous to display at once (5 origin quintiles * 5 destination quintiles * 2 races = 50 transitions). We therefore decided to direct readers' attention in two ways: First, we have made Animation 1 interactive, purposefully forcing the reader to look at only one origin quintile at once (Figure 1 seeks to do the same by highlighting quintiles upon hovering over connected paths). This is important because the visual impression should focus on the cross-race comparison within quintiles. Second, to help focus readers' attention in Animation 2, we decided to initialize the visualization. That is, rather than displaying the full flow at once (as in Animation 1), the animation reveals important information step-by-step (for other examples of the effectiveness of "chunking" strategies see e.g. Rieber 1991) and, we hope, correctly timed to correspond to readers' cognitive processing, which we imagine to unfold as follows:

- Start – Second 8: Observation of overrepresentation of black children at the bottom of the distribution;
- Second 8-13: Observation of ample intergenerational fluctuation;
- Second 13-22: Observation that the overrepresentation of black children at the bottom of the distribution has not changed dramatically
- Second 22-End: Closer investigation (based on the now revealed estimates of the racial

composition in the destination distribution) reveals some equalization; but the overall visual impression remains

<u>*References*</u>

Anderson, J. A. 1984. "Regression and Ordered Categorical Variables." *Journal of the Royal Statistical Society Series B* 46(1):1–30.

Badger, Emily, Claire Cain Miller, Adam Pearce, and Kevin Quealy. 2018. "Extensive Data Shows Punishing Reach of Racism for black Boys." *The New York Times*, March 19.

Berglund, Patricia A., Wen Chang, Steven G. Heeringa, Katherine McGonagle, Charles Brown, and David Johnson. 2017a. Construction and Evaluation of the Longitudinal Sample Weights 2015. *PSID Technical Report*.

Berglund, Patricia A., Wen Chang, Steven G. Heeringa, and Katherine McGonagle. 2017b. PSID Cross-Sectional Individual Weights, 1997-2015. *PSID Technical Report*.

Blau, Peter M. and Otis Dudley Duncan. 1967. *The American Occupational Structure*. New York: The Free Press.

Bloome, Deirdre 2014. "Racial Inequality Trends and the Intergenerational Persistence of Income and Family Structure." *American Sociological Review* 79(6):1196–1225.

Buis, Maarten L. 2013. "oparallel: module providing post-estimation command for testing the parallel regression assumption" *User-written software*: http://fmwww.bc.edu/RePEc/bocode/o/

Chetty, Raj, Nathaniel Hendren, Maggie Jones, and Sonya Porter. 2018. Race and Economic Opportunity in the United States: An Intergenerational Perspective. *NBER Working paper 24441*. Cambridge, MA: National Bureau of Economic Research.

Conley, Dalton and Rebecca Glauber. 2008. *Wealth Mobility and Volatility in Black and White*. Washington, D.C.: Center for American Progress.

Featherman, David L. and Robert M. Hauser. 1978. *Opportunity and Change*. New York: Academic Press.

Hertz, Tom. 2005. "Rags, Riches, and Race. The Intergenerational Economic Mobility of Black and White Families in the United States." Pp. 165–91 in *Unequal Chances: Family Background and Economic Success*, edited by S. Bowles, H. Gintis, and M. Osborne Groves. New York: Russell Sage Foundation

Hoffrage, Ulrich, Stefan Krauss, Laura Martignon, and Gerd Gigerenzer. 2015. "Natural Frequencies Improve Bayesian Reasoning in Simple and Complex Inference Tasks." *Frontiers in Psychology* 6.

Hoffrage, Ulrich, Samuel Lindsey, Ralph Hertwig, and Gerd Gigerenzer. 2000. "Communicating Statistical Information." *Science* 290(5500):2261–62.

Höffler, Tim N. and Detlev Leutner. 2007. "Instructional Animation versus Static Pictures: A Meta-Analysis." *Learning and Instruction* 722–738.

Lawrence, Matthew. 2018. "Visualizing Income Inequality and Mobility Together." *Socius* 4:1–3.

Long, Scott J. and Jeremy Freese. 2014. *Regression Models for Categorical Dependent Variables Using Stata*. College Station, TX: Stata Press.

Mazumder, Bhashkar. 2014. "Black–White Differences in Intergenerational Economic Mobility in the United States." *Economic Perspectives* 38(1).

Panel Study of Income Dynamics, public use dataset. 2018. Produced and distributed by the Survey Research Center, Institute for Social Research, University of Michigan, Ann Arbor, MI

Pfeffer, Fabian T. and Alexandra Killewald. 2018. "Generations of Advantage. Multigenerational Correlations in Family Wealth." *Social Forces* 96(4):1411–42.

Solon, Gary. 1992. "Intergenerational Income Mobility in the United States." *American Economic Review* 82(3):393–408.