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Middle Class Flight from Post-Katrina New Orleans: A Theoretical Analysis of Inequality and Schooling

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This paper stylizes the most salient characteristics of New Orleans' people and the Katrina evacuation and constructs a formal, theoretical model of their decision to return. We use the model to examine the post-Katrina population composition of the city, the evolution in its income distribution and in the welfare of its citizens, and changes in the level of education privately and publicly provided. Our results are, overall, positive for the new New Orleans. While smaller, the new New Orleans is more skill-intensive and education levels improve; these changes are broadly consistent with observed effects of Katrina on New Orleans. Moreover, while the possibility remains that Katrina-like events cause "middle-class flight," inequality is reduced under standard distributional assumptions, such as log-concavity. Nonetheless, the fact that many among the unskilled are unable to return remains problematic from an ethical point of view. Our analysis of a disaster's long term impact on a city through its effects on demographic composition, income and human capital distribution, and fiscal structure elucidates major determinants of urban resilience after a natural disaster.

Keywords: local public goods, inequality, disasters, income distribution, education, resilience
JEL codes: H3, H4, I2, I3

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1 Introduction

1.1 New Orleans and Katrina

We begin with an informal narrative of the immediate impact of Katrina on the city and of the long term changes it caused. We then move on to a formal treatment of urban disaster and resilience.

The complete evacuation of a major city like the one that took place in New Orleans after hurricane Katrina is unprecedented in American history. Businesses, schools, and public services shut down. Almost everybody left the city. Not only was the scope of the evacuation exceptional, its duration was too. The first people to return were men. New Orleans was a rough and dangerous place when they began straggling back in late September 2005. Entire city blocks had burned to the ground. Thugs roamed the streets. Trees and power lines were down. Stop signs and signs with street and store names had blown away. There were no working traffic lights, no open stores, no functioning gas stations. The banks were all closed and, without

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power lines and phones, ATM machines and credit cards were useless. In the city's soft alluvial soil, broken water mains readily formed potholes big enough to rip an axle off your car. There was no electricity, no cooking gas, no cell phone service. And, if you were lucky enough to have water, it was for flushing; you did not dare drink it or bathe in it.

As the metropolitan community made up of New Orleans and the less publicized St. Bernard Parish and Slidell attempted to reconstitute itself, it became clear that the pieces no longer fit together quite the way they used to. Mayor Ray Nagin urged New Orleanians to return. Parents asked, "Return to what?" There was no place to live and no place to enroll the kids. One of the first things the city did after the hurricane was to fire all teachers. People improvised. There was the Sugarcane Academy, founded when a small group of evacuees sought refuge together in the Cajun city of Lafayette. Someone recognized two out-of-work public school teachers on the street. They got together in a sugarcane field and held classes for two months, then moved the entire operation back to New Orleans to empty classrooms on the Loyola University campus and the public school continued to operate there. There were the 5 private schools that re-opened make-shift classes in October, by combining students to fill the roster. The 7 best public schools broke off from the official system and re-opened to a diminished student body—many teachers gone—in mid-January. But the vast majority of schools did not open at all during the 2005-2006 school year.¹

At least as important as the physical transformation brought about by the hurricane, looters, insurance cancellations, and human folly were the changes wrought by the collective hiatus. September 2005, the first month of federal government inaction, was very difficult. Families roamed the country by car, bus, and air. They did so in an information vacuum, not knowing if they had lost their house, their job, a loved one. They survived on the generosity of credit card companies that waived late fees and credit limits, rental car companies that didn't ask where their New Orleans cars had gone, cell phone companies that stopped charging roaming fees and forgave excess minutes. They survived on the generosity of family, friends, and complete strangers.

They also survived on the generosity of destination communities that were usually very welcoming. State and local governments, together with private organizations and individual benevolence, provided clothing, shelter, and food. Schools bent over backwards to accept "Katrina refugees" and PTAs donated backpacks and school supplies. After that first month of inaction, the administration made up with adjustment benefits that were cumbersome to obtain, but generous.

New Orleanians had experienced evacuations before. What was unprecedented about this one was that

¹In the fall of 2005 there were 119 public elementary schools in operation in Orleans Parish. Then Katrina hit. In February of 2006 only 17 were open. Of these 17 open schools, only two ordinary schools operated by the local Orleans Parish School Board remained. The other 15 had been taken over by the States Recovery School District or were new charter schools that split off from the main public system (Louisiana Department of Education, 2006).

everyone in the city stayed away long enough to obtain a very good picture of what it would be like to live elsewhere.² They found a place to live and became fully engaged in local routines like shopping, going to church or temple, and enrolling the kids in school. It often meant getting a new car, a new driver's license in another state, and a new job. A year later, more than half of the population had not returned.

Before the fall of 2005 the city of New Orleans was known for a nationally unrivaled cultural legacy of music, architecture, culinary arts, and theater. But the area was also known for having a very unequal distribution of income and one of the worst public school systems in the country. In 1999, 25.6% of New Orleans households were below the poverty line.³ Public schools were miserably bad. Out of 77 Orleans Parish public primary schools controlled by the School Board that were tested by the state in 2004, 43 were classified as having unacceptable academic performance and an additional 4 were closed altogether. Orleans Parish public schools ranked 66th out of 66 parishes in the 2003-2004 school district performance scores measured by the Louisiana Department of Education.⁴

Furthermore, though a majority of the population, public school families were politically disenfranchised. Only 27.9% of registered voters exercised their right in local plebiscites that would affect school financing and administration issues.⁵ One-third of New Orleans students attended private schools before Katrina, 3 times more than the national average. African Americans made up 65% of New Orleanians, but 94% of public school students. Citywide, 40% of children lived below the poverty line, but the proportion in public schools was 77%.⁶

At the 10th anniversary of hurricane Katrina, the city has changed. Only 40 of city's 72 neighborhoods have recovered at least 90% of their pre-storm population (Plyer and Mack, 2015). A quarter of the people who filed federal tax returns from New Orleans in 2005 were filing them from somewhere else in the country (Deryugina et al., 2014). This 25% will probably never return.⁷

Demographic structure and human capital and income distribution also changed. For instance, though both Black and White populations declined, the Black population fell by 44.5% between 2000 and 2013,

²96% of Orleans Parish residents evacuated and 82% stayed away for more than 2 weeks (Geaghan, 2011). The U.S. Census Bureau (2008) estimated that 64% of the July 1, 2005 residents of Orleans Parish remained away on January 1 of 2006, more than 4 months after the storm.

³Authors' calculation based on IPUMS data.

⁴Louisiana Department of Education, "Accountability Reports," <http://www.doe.state.la.us/lde/pair/2069.asp> and <http://www.doe.state.la.us/lde/pair/2228.asp>.

⁵<http://www.sec.state.la.us/elections/MISC/091804-turnout.pdf>. Ballot included elections for a majority of the local School Board seats. The turnout percentage is based on votes for Criminal Sheriff, the election with the largest number of votes cast. School Board votes were actually lower.

⁶The Boston Consulting Group, "The State of Public Education in New Orleans, June 2007," as reported in the publication "A Brief Overview of Public Education in New Orleans, 1995-2009" by the New Schools for New Orleans: http://newschoolsforneworleans.org/downloads/nsno_%20EducFactSheet.7.09.pdf.

⁷Our calculations from IPUMS (2015) data show that Orleans Parish population was still more than 25% lower in 2013 than it had been in the year 2000: it declined from 481,142 in the year 2000 and still stood at only 352,097 in 2013. U.S. Census Bureau (2015) data shows the population of Orleans Parish declined from 484,674 in the year 2000 to 343,829 in 2010. Estimates for 2014 place it at 384,320, still 21% below where it stood nearly 15 years earlier.

whereas the White population was only 9.8% lower.⁸ The areas of lowest income in 2005 have the lowest return rates. Public housing communities were demolished. The 2015 residences receiving mail in the Desire, Florida, and Iberville public housing developments stands at 71%, 0.9%, and 0.1% of their 2005 levels, respectively, and the Lower 9th Ward was at 36.7% (The Data Center, 2015b, Table 1).

The average educational attainment of adults increased: the share with at least a high school degree rose from 75% in 2000 to 85% in 2013, close to the national average of 87%. At the same time, the share with a college degree rose from 26% to 36%, a full six points higher than the national average (The Data Center, 2015a). This obviously did not happen because the entire population became more educated. We believe many of the city's changes happened because of selective return.⁹

Deryugina et al. (2014) use synthetic control methods to analyze a 1999 to 2010 panel of individual IRS tax return data. They show that, after an initial dip, adjusted gross income of New Orleanians was significantly higher than it would have been without the storm. Wages followed a similar pattern, dipping 15% below the control group in 2006, equaling control wages in 2007, and then rising to surpass them by 10%. The unemployment rate jumped above control levels in 2005, and 2006, but dipped significantly below the control group in 2007 and after.¹⁰

The educational system was even more dramatically transformed. And, while the impacts on learning are still being evaluated, there is no doubt that an unprecedented amount of attention has been paid to improving New Orleans schools. The Cowen Institute Report (2005) wrote: *“A hybrid model where charter schools outnumber district-operated schools two to one has resulted in a newfound emphasis on innovation and school autonomy. While significant challenges remain, the new model of delivering education to the city’s youth has begun to yield results. Today, the once academically, morally and financially bankrupt system is nationally recognized as a potential model for urban school system reform.”* Jabbar (2015a) writes that: *“The New Orleans school-choice market, consisting overwhelmingly of open-enrollment charter schools, is arguably the most competitive district ever created in the United States.”* Now, 84% of New Orleans students attend charter schools (Jabbar, 2015b). New Orleans has also become something of a world leader in other areas, including storm water innovation (GNO, 2013 and Shrinath and Plyer, 2015), health care delivery (Sebelius, 2015), and eco-friendly transportation (Huffington Post, 2015).

Such drastic change in only 10 years would have been unimaginable without the Katrina stimulus: wages and educational expenditures are higher, the population is smaller, but more skilled, average educational attainment is higher than it used to be, and public services have improved. The post-Katrina equilibrium

⁸See also Groen and Polivka (2010).

⁹McIntosh (2008) reports that New Orleans evacuees living in Houston up to August of 2006 were on average less educated than their hosts; 58% had at most a high school education, compared to 47% of non-evacuee Houston residents. Also, De Silva et al. (2010) find a persistent downward effects of New Orleans migrants on Houston’s unskilled wage rate.

¹⁰Deryugina et al. (2014) also provides a review of the empirical literature regarding the effects of Katrina.

of our model captures many of these effects.

1.2 Key elements of the model

There are three key elements in our model. The first is that some agents are born with a locational attachment to their city. This helps to capture the pre-K reality of New Orleans,¹¹ where wages and the quality of public services were much worse than in other parts of the country and yet the population was stable, a fact otherwise inconsistent with full mobility of identical agents across jurisdictions. Thus, we consider two types of agents that differ in their endowments. Agents are born either with an endowment e_1 of good 1 or with a one unit endowment of good 2. Both are fully mobile across cities. For simplicity we call these goods “skilled” and “unskilled” labor. We assume that all unskilled agents are identical; however, skilled agents differ in their attachment to the city. We capture the attachment as a productivity enhancement to e_1 in New Orleans that is lost by moving. We measure the productivity enhancement with the function $a(\cdot) \geq 1$. Hence, skilled agent j is endowed with an operational local “skill” level $e_1(j) = e_1 \cdot a(j)$ when she lives in New Orleans, but her endowment reverts to $e_1(j) = e_1$ if she leaves.¹²

The second key element of our model is a fixed cost of moving for each type that captures all of the pecuniary and psychic costs associated with moving away from New Orleans. Information plays an important role here. It is reasonable to posit that, in normal circumstances, it is costly for people who live in one city to obtain precise information on the opportunities for work, schools, and general living conditions in another city. So, to the extent that people choose not to incur those costs, the benefits of moving remain uncertain, resulting in migrational equilibria that are consistent with non-negligible differences in quality of life across disparate local economies. However, a long evacuation after a major disaster forces these information costs on the evacuees, and they then learn about labor markets, schools, and quality of life in other places. This means that, when the disaster has passed, marginal agents return only if the quality of life in the city of origin is higher than it used to be. We model the effect of Hurricane Katrina as reducing the moving cost out of New Orleans or, equivalently for our purposes, as a perceived improvement in the utility of living outside New Orleans brought about by the reduction in uncertainty following the forced evacuation experience.¹³

The third and final key component of our model is a congestable public good (see Scotchmer, 2002),

¹¹We adopt the new local vernacular and refer to “pre-K” and “post-K” equilibria.

¹²We can think of many examples. For instance a cab driver, a physician in private practice, a mobster or a lawyer can all carry their professions with them—driving, medical practice, extortion—but they will all be less productive in a new community. Surely, locational attachments are present in many communities. Nonetheless, New Orleanians are well-known to be exceptionally attached to their city. Groen and Polivka (2008) explore whether early labor market outcomes for evacuees differed depending on whether they returned to New Orleans or not. They find that individual characteristics including education and the extend of damage to their original neighborhoods mattered most. In our model the physical destruction of a neighborhood could be interpreted as a reduction in the attachment parameter, if it reduces market productivity.

¹³A different approach is to model the effect of disasters as a destruction in capital and current output, see, e.g., Albaladejo (1993).

“public education,” which is publicly provided and affects the utility of returning to the city. The different responses of skilled and unskilled agents to Katrina determine the changes in the level of provision of public education. Therefore, our analysis of the effects of a disaster on public good provision complements that of Anbarci *et al.* (2005), who deal with the effects of a public good, “disaster mitigation,” on the destructive potential of a disaster.¹⁴

1.3 Our results

We find that skills return in greater proportion than unskilled labor, thus lowering the returns to skill and increasing the wage for unskilled labor. The post-K New Orleans is smaller and more skill-intensive; moreover, among skilled agents, the larger the New Orleans specific productivity, the larger the likelihood of return. This three-fold effect on population makes predicting the evolution of income inequality a tricky exercise. In particular, if unskilled agents earn less than the poorest skilled agent—a realistic assumption—then there arises the possibility of “middle class flight” from the city. We identify a sufficient condition on the function $e_1(\cdot)$ such that this is not the case and, in the post-K equilibrium, income distribution becomes more equal. Furthermore, we link this condition to the shape of the initial distribution of income. In particular, we show that commonly used statistical functions satisfy our condition, including the class of log-concave densities. Per-capita expenditure on public education increases, because skilled agents see this as a convenient way to induce more unskilled agents to return and mitigate the increase in their wage. In terms of utility, skilled labor is unambiguously worse off because the unskilled wage rate must rise. But even though their wages rise and the quality of public education goes up, unskilled workers end up being no more than exactly compensated for their cost of returning to the city. Therefore, the main technical contribution of our theoretical exercise is to show that a simple, standard framework accounts for the apparent stylized facts.

Overall, our main message is one of *tempered optimism*. Yes, there are improvements in terms of education and wages. However, the main reason for these improved outcomes is that, even interpreting Katrina as a classless shock, many among the unskilled do not return to the city. In our model this lack of incentive to return is structural and it has an indirect, positive equilibrium effect on education levels and unskilled wages. However, the non-return of many among the poor/unskilled to return is problematic from an ethical point of view.

The rest of the paper proceeds as follows. Section 2 describes the model and calculates equilibrium. Section 3 contains our results about the effects of Katrina on population, wages, income distribution, and level of public good provision. We perform this analysis both in the short-run, where the political process is

¹⁴Edwards (2015) reviews other papers on the political economy of disaster mitigation.

not allowed to adjust so that the level of public good is constant, and in the long-run where it can adjust. Section 4 concludes. Technical proofs are in the Appendix.

2 The Model

2.1 Description of the Economy

We consider a two-good, exchange economy with a continuum of agents of two types, distinguished by the nature of their endowment. Type 1 agents, referred to as “skilled”, are endowed with good 1, they are indexed by $j \in R^+$, and each has an “attachment premium” to the city, $a(j) \geq 1$. The function $a(\cdot)$ is continuous and, without loss of generality, strictly decreasing. Further, we assume $|a'| < \infty$. If any skilled agent leaves the city, then the attachment premium is lost and the endowment becomes $e_1 > 0$, identical across skilled agents. In contrast, within the city of New Orleans the attachment premium applies, so that the endowment of skilled agent j takes on the value $e_1(j) = e_1 \cdot a(j)$. Type 2 agents, referred to as “unskilled”, are all identical. They are endowed with one unit of good 2, no matter where they live.

The common utility function of all agents is

$$u(c_1, c_2, g) = \log c_1 + \log c_2 + \log g, \tag{1}$$

Utility

where c_1 is the consumption of good 1, c_2 is the consumption of good 2, and g is the consumption of education. Consumption of goods 1 and 2 is determined in a competitive equilibrium. Good 1 is the numeraire and the price of good 2 is P . Education is produced using good 1, with a one-to-one technology.

There are private and public school options available to all agents.¹⁵ Schooling can be acquired privately in any amount desired in exchange for good 1, or it can be obtained for free in a public school, at the pre-specified level g_m . For simplicity, we assume agents that take the public option cannot privately add to this level.¹⁶

This is a first approximation that captures the effects of many real-life factors, such as time constraints, that would add a level of complexity unnecessary for our analysis. Public education is financed by a budget-balancing tax on the endowment of skilled agents. For simplicity, we consider a flat tax rate t . The choice of policy therefore reduces to the one-dimensional variable g_m .¹⁷

¹⁵The choice between public and private education has been extensively modeled in the literature, see Gradstein and Justman (1996), for instance.

¹⁶A model that considers the implications of relaxing this constraint is Bearse *et al.* (2005).

¹⁷Our modeling choice for taxation is meant to capture institutional features such as the homestead exemption, which aim to make local taxation more progressive. Indeed, the largest source of financing for the City of New Orleans is the real estate tax, which is subject to a homestead exemption of \$75,000 of assessed value. In 2004 there were 149,745 property tax payers. Of these, 73,978 filed for a homestead exemption, of which 36,246 (49%) were entirely covered by the homestead exemption

Any agent can leave the city to earn a reservation utility by paying a one-time moving cost. We incorporate this cost in the reservation utilities, which we denote with $\log R_s$ for skilled agents and $\log R_u$ for unskilled agents. In our choice of monikers for agents and of taxation structure we have made the implicit assumption that skilled agents are “richer” than unskilled ones. This is formally accomplished in equilibrium, as the next Section shows, with the assumption that R_s is larger than R_u .

2.2 Equilibrium

We define an equilibrium as a collection C of:

- Consumption and education choice functions for each agent in the city
- Location decisions
- Tax rate t
- Policy variable g_m
- Price P

that jointly satisfy these conditions:

1. Each agent maximizes utility subject to her budget constraint, taking as given t , g_m , and P . The resulting optimal consumption and education choices are such that markets clear, given location decisions.
2. Each agent, fully anticipating the optimal decision in Condition 1, chooses the utility-maximizing location.
3. The tax rate t balances the budget, given g_m , the education decisions in Condition 1, and the location decisions in Condition 2.
4. The level g_m is such that there exists no other collection that satisfies Conditions 1-3, with $\tilde{g}_m \neq g_m$, in which the utility of any agent that locates in the city (in the current collection C) is increased. In the determination of g_m we assume that each agent fully anticipates all implications on prices, taxes, and city population.¹⁸

and so paid no real estate taxes. (Louisiana Tax Commission, 2003, 2005, 2007, 2008, 2014.)

¹⁸We can sidestep more complex descriptions of the political structure because, given the logarithmic utility in (1), all agents end up preferring the same level of g_m , as clarified in the discussion following Proposition 1, *infra*. A more general treatment can be found in Conley and Konishi (2002).

We now characterize equilibrium and show its existence and uniqueness. For clarity, the characterization is broken up in a series of Lemma. We start with the analysis of individual consumption and schooling decisions.

Skilled agents that acquire education privately choose c_1 , c_2 , and g to maximize the utility in (1) subject to the budget constraint

$$c_1 + Pc_2 + g \leq e_1(j)(1-t).$$

Any skilled agent that opts for public provision has the same utility function expressed in (1), but the budget constraint becomes

$$c_1 + Pc_2 \leq e_1(j)(1-t).$$

In addition, this agent faces the public provision constraint

$$g = g_m. \tag{2} \quad \text{GM}$$

Unskilled agents solve similar problems. The only change in their utility-maximization problem is the right-hand side of the budget constraint. Since unskilled agents are endowed with one unit of good 2 and do not pay taxes, their real income is simply P .

1:edcsk

Lemma 1 (Education and consumption choices of skilled agents). *The consumption and education decisions of skilled agent j that acquires education privately are*

$$c_1 = \frac{1}{3}e_1(j)(1-t), \quad c_2 = \frac{1}{3P}e_1(j)(1-t), \quad g = \frac{1}{3}e_1(j)(1-t). \tag{3} \quad \text{SKIDEM}$$

The consumption and education decisions of skilled agent j that opts for public education are

$$c_1 = \frac{e_1(j)(1-t)}{2}, \quad c_2 = \frac{1}{P} \frac{e_1(j)(1-t)}{2}, \quad g = g_m. \tag{4} \quad \text{SKIPUB}$$

The indirect utility of skilled agent j who acquires education privately is

$$\log \frac{1}{P} \left(\frac{e_1(j)(1-t)}{3} \right)^3, \tag{5} \quad \text{Indutiskipri}$$

while if she opts for public provision her utility is

$$\log \frac{1}{P} \left(\frac{e_1(j)(1-t)}{2} \right)^2 g_m. \tag{6} \quad \text{Indutiskipub}$$

Therefore, a skilled agent j opts for the public system if and only if $e_1(j) < e_1^*$, where

$$e_1^* \cdot (1 - t) = \frac{27}{4} g_m. \quad (7)$$

SKIPUBPCH

Beyond characterizing the optimal consumption and education decisions, Lemma 1, with proof in the Appendix, shows that only relatively rich agents attend private school. The intuitive explanation of this result exploits the trade-off between having flexibility in choosing the level of education vs. bearing the full cost of education. The richer an agent, the more important flexibility becomes relative to bearing the cost of education. Therefore, private education becomes more attractive with income.

Thus, another interesting remark follows from Lemma 1: the per-capita amount of education acquired privately is strictly larger than the per-capita public expenditure g_m . Moreover, a discrete gap exists between the two. Indeed, using (3), (4), and e_1^* , one can verify that the smallest amount of private education acquired by any skilled agent is more than double the amount provided by public schools. Intuitively, no private choice of education “close” to g_m can be optimal. This happens because the benefits of education increase continuously, while the cost of self-financing has a discrete jump, of size not smaller than g_m , at the switch from public school to private. In other words, the distribution of school quality is discontinuous at g_m because it makes no sense to bear the full cost of schooling to ensure only a marginally superior education. Note that our model is successful in replicating stylized facts about education in New Orleans, albeit crudely. If we equate resources spent with education quality, the quality of private education is markedly superior to the quality of public education.

Unskilled agents are simpler to analyze, because they all make the same choice, which we describe in the following Lemma. (The proof is similar to that of Lemma 1 and therefore omitted.)

Lemma 2 (Education and consumption choices of unskilled agents). *The education and consumption choices of an unskilled agent that opts for public provision are*

$$c_1 = \frac{P}{2}, \quad c_2 = \frac{1}{2}, \quad g = g_m, \quad (8)$$

UNSDM

resulting in indirect utility equal to

$$\log \frac{1}{4} P g_m. \quad (9)$$

Indutiunspubj

The education and consumption choices of an unskilled agent that acquires education privately are

$$c_1 = \frac{1}{3} P, \quad c_2 = \frac{1}{3}, \quad g = \frac{1}{3} P, \quad (10)$$

demunspripro

resulting in indirect utility equal to

$$\log \frac{P^2}{27}. \quad (11)$$

Indutienspri

Therefore, all unskilled agents opt for public provision if and only if

$$g_m > \frac{4}{27}P. \quad (12)$$

UNSPUBSCH

Having established the individual-level choices, we now turn to the determination of the economy-wide variables for prices, tax rates, and population, given a level of public expenditure on schooling g_m . The equilibrium price and tax rate are determined by the requirements of market clearing and a balanced government budget. These requirements depend on three conditions about population size and composition, endowments, and the consumption of education. First, we need the endogenous measures of skilled and unskilled agents in the city, denoted by N_s and N_u respectively. These measures come from the constraint that all N_u unskilled agents and the marginal skilled agent $j = N_s$ must be indifferent between living in the city, or receiving their reservation utilities elsewhere. Second, city population and composition determine total endowments, which determine prices in equilibrium. The total endowment of good 1 in the economy is E_1 , defined as

$$E_1 = \int_0^{N_s} e(j) dj.$$

The total endowment of good 2 in the city, E_2 , is equal to N_u , since every unskilled agent brings one unit to the city. In the third and final condition, we account for the choice of schooling, because it determines demand and therefore equilibrium prices and tax rates.

To complete the characterization of equilibrium, the level of public expenditure g_m is chosen to satisfy Condition 4 in the definition of equilibrium. Proposition 1 below shows a condition that guarantees existence and uniqueness of an equilibrium in which all skilled agents opt for private provision and all unskilled agents attend public school. Intuitively, this happens when the reservation utility for skilled agents is sufficiently large relative to that of unskilled agents, so that only relatively rich skilled agents live in the city. This implies a very unequal income distribution, matching another fact about the New Orleans economy. Proposition 1 furthermore derives the equilibrium level of public school education g_m .

Proposition 1 (Existence and uniqueness of equilibrium). *A unique equilibrium exists if*

$$\frac{R_s}{R_u} \geq \left(\frac{3^4}{40}\right)^2 \approx 4.1. \quad (13)$$

C1P1

In such an equilibrium, the measure of skilled agents N_s^{EQ} is the unique value of N_s^{EQ} which solves

$$e_1(N_s^{EQ}) = \frac{6R_u + g_m^2}{R_u} \sqrt[3]{\frac{R_s}{g_m} \cdot \frac{R_u}{2}}. \quad (14) \quad \text{NSKIEQ}$$

The equilibrium measure of unskilled agents is

$$N_u^{EQ} = \frac{g_m}{6R_u + g_m^2} E_1 = \frac{g_m}{6R_u + g_m^2} \int_0^{N_s^{EQ}} e(j) dj, \quad (15) \quad \text{NUNSEQ}$$

the equilibrium price is

$$P^{EQ} = 4 \frac{R_u}{g_m}, \quad (16) \quad \text{PEQ}$$

the equilibrium tax

$$t^{EQ} = \frac{g_m^2}{6R_u + g_m^2}, \quad (17) \quad \text{TEQ}$$

and the level of public good provided solves

$$g_m^2 = \frac{6}{5} R_u. \quad (18) \quad \text{C2P1}$$

Proof. We proceed by construction. For the moment, fix the level of public provision g_m and assume that all skilled agents acquire education privately and that all unskilled agents opt for public provision. At the end of the proof, g_m will be endogenously determined and the assumptions will be verified. We begin with the determination of prices and tax rates. Using the expression for skilled and unskilled demands, that is, conditions (3) and (8), the market clearing condition is

$$\frac{2 \cdot E_1 \cdot (1-t)}{3} + P \cdot \frac{N_u}{2} = E_1 (1-t),$$

for any given population size and composition. Taxes are determined by the budget balance constraint:

$$t = \frac{N_u g_m}{E_1}.$$

Together, the two previously displayed equations yield P , the price at which good 2 is trading for good 1:

$$P = \frac{2}{3} \frac{E_1 - N_u g_m}{E_2}. \quad (19) \quad \text{Priceexopop}$$

As expected, equation (19) shows that P is increasing in E_1 and decreasing in E_2 . Note as well that the burden of providing education falls partly on unskilled agents, through its effect on P .

Now, we turn to population. Using the reservation utilities in Lemma 1 and 2, the conditions that

determine N_s and N_u are

$$\frac{1}{4}Pg_m = R_u, \quad (20) \quad \text{OEUNS}$$

for the unskilled agents, and

$$\frac{1}{P} \left(\frac{e_1(N_s)(1-t)}{3} \right)^3 = R_s, \quad (21) \quad \text{OESKI}$$

for the marginal skilled agents. Conditions (20) and (21) ensure all unskilled agents and the marginal skilled are indifferent between living in the city and receiving their reservation utility elsewhere. Therefore, using (19), (20), and noting that $E_2 = N_u$, the equilibrium measure of unskilled agents is

$$N_u^{EQ} = \frac{g_m}{6R_u + g_m^2} E_1,$$

which verifies (15), with associated equilibrium price

$$P^{EQ} = 4 \frac{R_u}{g_m},$$

which verifies (16), and equilibrium tax

$$t^{EQ} = \frac{g_m^2}{6R_u + g_m^2},$$

which verifies (17). From (15), N_u^{EQ} is a one-to-one (linear) function of E_1 , which in turn is a one-to-one (strictly increasing) function of N_s . Therefore, if the equilibrium population of skilled agents, N_s^{EQ} , is uniquely determined, only one candidate equilibrium corresponds to each g_m . Using (15), (16), and (21) we obtain the following relation:

$$(e_1(N_s)(1-t^{EQ}))^3 = 27 \cdot 4 \cdot \frac{R_s \cdot R_u}{g_m}. \quad (22) \quad \text{COMPLEMMA1}$$

Substituting (17) into (22) and recalling that $e(\cdot)$ is monotone, the equation that uniquely determines N_s^{EQ} is:

$$e_1(N_s^{EQ}) = \frac{6R_u + g_m^2}{R_u} \sqrt[3]{\frac{R_s}{g_m} \cdot \frac{R_u}{2}},$$

which verifies (14). Therefore, as long as the level of g_m is such that skilled agents acquire education privately and unskilled agents opt for public provision, all equilibrium variables beyond g_m are uniquely determined by Conditions 1–3 in the equilibrium definition.

We now turn to the endogenous determination of g_m . The critical requirement in Condition 4 of the equilibrium definition is that agents fully anticipate the effects of different levels of g_m on the economy. This implies that utility for unskilled agents is the same for all levels of g_m , because when g_m rises P falls: immigration or emigration will force any unskilled agent's utility to be exactly the outside reservation

utility. Therefore, we focus on the preferences of skilled types over g_m . A skilled type's utility is given in (5). Substituting equilibrium values in (16) and (17), we obtain that the derivative of the indirect utility in (5) with respect to g_m is

$$\frac{6R_u - 5g_m^2}{g_m(6R_u + g_m^2)},$$

therefore, by strict quasi-concavity, $g_m^2 = 6R_u/5$ is the unique maximizer of (5). Thus, $g_m = \sqrt{6R_u/5}$ is the public school quality level that the skilled population provides for their unskilled fellow citizens. Note that public school quality depends directly on R_u , the opportunities of unskilled labor outside New Orleans net of moving costs.

To complete the proof, we now verify consistency of school choices. For unskilled agents to opt for public provision, using (12) we need

$$g_m^2 \geq \frac{16}{27}R_u,$$

which is satisfied by (18). So that all skilled agents choose private provision, we need $e_1(N_s^{EQ}) > e_1^*$, or, using (7) and (22),

$$27 \cdot 4 \cdot \frac{R_s \cdot R_u}{g_m} \geq \left(\frac{27}{4}g_m\right)^3.$$

By (18), this last inequality reduces to condition (13) in the statement of Proposition 1. \square

Several interesting remarks follow from Proposition 1. First, as the proof of Proposition 1 makes clear, the assumption of a logarithmic utility function considerably simplifies the description of the economy because skilled agents unanimously prefer the same level of public schooling to be provided to the unskilled. With a more general utility function, an adjustment to Condition 4 in the definition of equilibrium would be necessary, for example specifying more in detail the characteristics of the political and voting processes. One important fact would be unchanged though: unskilled agents' utility would be the same for any value of g_m . This is a consequence of mobility and homogeneity of unskilled agents: immigration or emigration will force their utility to be exactly their outside reservation utility net of moving costs.¹⁹ Thus, even in more realistic models, as long as voting is costly and at least partially motivated by economic interest, we can expect skilled agents to have a larger incentive to vote than unskilled agents.

Second, note that, through the determination of g_m , skilled agents selfishly affect the total pool of unskilled labor by trading off the cost of financing public schools against lower prices that result from having a larger pool of unskilled workers in the city.²⁰ In other words, increasing public school quality is a way of decreasing the price of the good that unskilled agents supply. This grim interpretation is made worse by an

¹⁹Berliant and Edwards (2004) show that reaching equilibrium in this way is unlikely to be efficient.

²⁰This tradeoff is described in equations (16) and (17).

additional fact: given the equilibrium price in (16), unskilled agents would choose a level of education higher than the equilibrium g_m if there were no public schools.²¹ This implies that unskilled agents suffer from a reduction in flexibility. Moreover, note that the equilibrium level of public provision in (18) is increasing in the reservation utility R_u . Indeed, as (16) shows, an increase in R_u translates into an increase in the price of the unskilled good P , and therefore it raises the unskilled agents' income and demands.²²

Third, note that at the equilibrium level of public education provision, that is, when $g_m^2 = 6R_u/5$, the population of skilled agents is maximized, but overall city size is not. This can be seen by differentiating for g_m the condition that determines the population of skilled agents in equilibrium. Using (14) we obtain that

$$\text{sign} \left(\frac{de_1(N_s^{EQ})}{dg_m} \right) = \text{sign} \left(g_m^2 - \frac{6}{5}R_u \right).$$

Since $e_1(\cdot)$ is decreasing, the smaller is $e_1(N_s^{EQ})$, the larger N_s^{EQ} becomes. Therefore, since at $g_m^2 = 6R_u/5$ the function $e_1(\cdot)$ attains a global minimum, $g_m^2 = 6R_u/5$ also maximizes N_s^{EQ} . But for total population, we have

$$\left. \frac{d(N_s^{EQ} + N_u^{EQ})}{dg_m} \right|_{g_m^2 = \frac{6}{5}R_u} = \frac{6R_u - 2g_m^2}{(6R_u + g_m^2)^2} E_1 = \frac{E_1}{12} > 0,$$

using (15). Therefore, a higher g_m would increase city size.

Finally, the equilibrium displays a marked income inequality, much as described in the motivating observations in the introduction. Simple algebra, along with (13), shows that $P^{EQ} < e_1(N_s^{EQ})$. In other words, the value of the endowment of any unskilled agents is smaller than the value of the poorest skilled agent's endowment.

We conclude this section with the calculation of the Lorenz curve $l(x)$ in equilibrium. Since $P < e(N_s)$, the first agents to be added in order of increasing income are the unskilled, who are all identical. Therefore, for $x \in \left[0, \frac{N_u^{EQ}}{N_u^{EQ} + N_s^{EQ}}\right]$, $l(x)$ is a straight line with $l(0) = 0$ and $l\left(\frac{N_u^{EQ}}{N_u^{EQ} + N_s^{EQ}}\right) = \frac{PE_2}{PE_2 + E_1}$. For $x \in \left(\frac{N_u^{EQ}}{N_u^{EQ} + N_s^{EQ}}, 1\right]$, the expression for the Lorenz curve of market income is

$$l(x) = \frac{PE_2}{PE_2 + E_1} \left(1 + \int_{\left(\frac{N_u^{EQ}}{N_u^{EQ} + N_s^{EQ}}\right)(1-x)}^{N_s^{EQ}} \frac{E_1}{PE_2} \frac{e(j)}{E_1} dj \right). \quad (23) \quad \boxed{\text{LC}}$$

²¹This fact follows from the comparison of (10) and (18).

²²Foreshadowing our results in the next Section, this discussion helps in explaining why, in response to increases in R_u , improving public schools' quality is a very effective way of inducing more unskilled agents to live in the city. Indeed, along with a direct increase in consumption of education, the utility cost of the reduction in flexibility in education choice is lessened, because g_m becomes closer to the optimal, unconstrained level unskilled agents would choose for themselves, if they had to pay for it. Note that if public education provides externalities by teaching citizenship, respect for property and hygiene, then the motivation for preferring it to a higher wage for unskilled labor is strengthened.

3 After Katrina

The hurricane has brought many changes: the housing stock has been depleted, the infrastructure of the city has been severely damaged, the spirit of citizens itself has been tested. All these circumstances, along with others, have an effect on the city's economy. We focus on a non-controversial aspect: all citizens have been displaced. In our model, this results in larger R_s and R_u . Indeed, for a citizen of New Orleans that was considering moving out of the city before the hurricane, the relevant comparison involved the outside standard of living *minus* the moving cost. After the hurricane, the moving cost has already been incurred, albeit involuntarily. The decision to *return* to the city now involves a moving cost. A similar increase in reservation utilities may derive from other considerations, such as more familiarity with job markets, school systems, and support networks of cities other than New Orleans. Moreover, an identical mathematical effect obtains from considerations that reduce the utility of living in the city such as the cost of housing repairs or higher flood- and wind-damage insurance rates. For the rest of the analysis, we assume that the new reservation utilities satisfy (13), so that the characterization and uniqueness results of Proposition 1 remain valid.

Our results in this section follow from the comparative statics properties of equilibrium, which we summarize in Proposition 2.

Proposition 2 (Comparative statics). *Changes to equilibrium are characterized by the following perturbation equations*

$$\frac{\Delta N_u^{EQ}}{N_u^{EQ}} - \frac{e_1(N_s^{EQ}) N_s^{EQ}}{E_1} \cdot \frac{\Delta N_s^{EQ}}{N_s^{EQ}} + \frac{5}{6} \cdot \frac{\Delta R_u}{R_u} - \frac{2}{3} \cdot \frac{\Delta g_m}{g_m} = 0, \quad (24) \quad \text{Pereq1}$$

$$\frac{e'_1(N_s^{EQ}) \cdot N_s^{EQ}}{e_1(N_s^{EQ})} \cdot \frac{\Delta N_s^{EQ}}{N_s^{EQ}} - \frac{1}{6} \cdot \frac{\Delta R_u}{R_u} - \frac{1}{3} \cdot \frac{\Delta R_s}{R_s} = 0, \quad (25) \quad \text{Pereq2}$$

and

$$\Delta g_m = \frac{3}{5g_m} \Delta R_u. \quad (26) \quad \text{Pereq3}$$

Proof. Follows by applying the implicit function theorem to the equilibrium equations in Proposition 1. For example, (24) obtains by first log-linearizing (15) into

$$\log N_u^{EQ} = \log \frac{g_m}{6R_u + g_m^2} + \log E_1,$$

then totally differentiating to derive

$$\frac{\Delta N_u^{EQ}}{N_u^{EQ}} - \frac{e_1(N_s^{EQ}) N_s^{EQ}}{E_1(N_s^{EQ})} \frac{\Delta N_s^{EQ}}{N_s^{EQ}} = -\frac{6}{(6R_u + g_m^2)} \Delta R_u + \frac{g_m^2 - 6R_u}{(6R_u + g_m^2)} \frac{\Delta g_m}{g_m},$$

and finally substituting $g_m^2 = 6R_u/5$ from (18). Condition (25) is similarly obtained, and (26) follows from (18). \square

In Proposition 2, we express (24) as a function of Δg_m in order to analyze the short-term transition period where the level of public schooling may not yet have adjusted. With a longer time horizon, Δg_m is given in (26), and can be substituted into (24). Two corollaries follow immediately, and appropriately match evident empirical facts about the “new” New Orleans.

Corollary 1 (Population). *The after-Katrina population of both kinds of agents is smaller.*

Corollary 2 (Prices). *The after-Katrina price of good 2 is higher.*

Proof. The proof of both corollaries follows immediately from (16), (24), and (25). Indeed, since $\frac{1}{6} \frac{\Delta R_u}{R_u} + \frac{1}{3} \frac{\Delta R_s}{R_s} > 0$ and $e'_1 < 0$, then $\frac{\Delta N_s^{EQ}}{N_s} < 0$ from (25). In the short-term, $\frac{\Delta g_m}{g_m} = 0$, which then implies $\frac{\Delta N_u^{EQ}}{N_u} < 0$ from the first equation. In the long-term, g_m changes according to $g_m^2 = \frac{6}{5} R_u$, so we have $\frac{2}{3} \frac{\Delta g_m}{g_m} = \frac{1}{3} \frac{\Delta R_u}{R_u}$, which substituted into (24) reduces the absolute value of $\frac{\Delta N_u^{EQ}}{N_u}$, but it is insufficient to change its sign. In the short-run, since $P^{EQ} = 4R_u/g_m$, then P^{EQ} clearly increases. In the long-run, substituting $g_m = \sqrt{\frac{6}{5} R_u}$ into the value for $P^{EQ} = 4R_u/g_m$ and then differentiating for R_u , we still obtain that P^{EQ} increases. \square

It is worth noting that while population falls and price rises both in the short and in the long-term, the magnitude of changes is smaller if g_m is allowed to adjust. Moreover, while the algebra involved is simple, the change in the terms of trade in Corollary 2 just described plays an important role in the welfare comparison of agents that live in the city before and after the hurricane. One may think that, since outside opportunities are better, agents that optimally decide to return must be better-off than before the storm, excluding the one-shot costs associated with the hurricane. This natural intuition is true, but only for marginal agents. In other words, the price of the good supplied by unskilled agents must increase, to induce at least some of them to return. This is not the case for skilled agents, because they are heterogeneous. Richer agents absorb the negative (for them) consequence of Katrina, i.e., the larger P demonstrated in Corollary 2. Returning richer agents’ utility is lower than it was before the storm, but still higher than $\log R_s$. This is because they strictly prefer living in New Orleans, but for the lone marginal agent. In analytical terms, (21) is binding only for the marginal skilled agent, but is slack for $j < N_s^{EQ}$. Proposition 3 summarizes the welfare effects on different types of agents.

Proposition 3. *Any returning unskilled agent is exactly compensated for the increase in reservation utility due to the hurricane. On the contrary, all returning skilled agents are made worse-off.*

Proof. From (20), unskilled agents are exactly compensated. As for skilled agent j , her utility is given in (5). Substituting the equilibrium values in (16) and (17), simple algebra shows that j 's utility is decreasing in R_u . The result for skilled agents and the one for unskilled ones are true for g_m fixed and for g_m variable. \square

We now explore after-Katrina income inequality. A first step is to determine changes in the equilibrium population ratio of skilled to unskilled agents. Naturally, the larger the percentage change in the reservation utility of one type of agent, the larger the the percentage change in the population of that type of agent. For the rest of our analysis, to avoid favoring a particular direction of the changes, we maintain the assumption that reservation utilities for living outside the city change by the same percentage for skilled and unskilled agents. However, Corollary 2 shows that, even with identical percentage changes in reservation utilities, the terms of trade must change in favor of unskilled agents. Therefore, one may think that unskilled agents must have become relatively scarcer. This natural intuition must be amended because skilled agents are heterogeneous: an increase in P implies that E_1 must rise with respect to E_2 , not necessarily that the number of agents moves in favor of the skilled. If all skilled agents had the same endowment, the change in E_1 would result in a larger proportional change in type-1 agents. Inequality among skilled agents, however, implies that the poorer skilled agents are the ones that leave the city. An especially marked inequality among skilled agents might then require a very large change in skilled population to obtain the required percentage change in E_1 . This reasoning shows that, while our results establish that there is “middle class flight” from New Orleans, it can become so substantial that it more than offsets the equalizing effect of higher wages for unskilled workers.

It turns out that the relation between average and marginal endowment of skilled agents plays a crucial role in determining the proportion of agent types in the after-Katrina city. Define the average endowment of good 1 from $j = 0$ to $j = N$ as

$$e_{1avg}(N_s) \equiv \frac{\int_0^{N_s} e_1(j) dj}{N_s},$$

and define the ratio of average and marginal endowment as

$$S(N_s) \equiv \frac{e_{1avg}(N_s)}{e_1(N_s)}.$$

As the upcoming Propositions 5 and 6 demonstrate, the condition ‘ $S(N_s)$ increasing’ is of great importance for our results. Therefore, it is interesting to explore its relation with more standard ways of modeling income distributions. Denote with h the hazard rate of the income distribution for skilled agents:

$$h(y) \equiv \frac{f(y)}{1 - F(y)},$$

where $F(y)$ is the cdf of the income distribution of skilled agents and $f(y)$ is the respective density. Our next result shows that $S(N_s)$ is increasing if h is increasing. A sufficient condition is that f is log-concave.

p:logc

Proposition 4 (Log-concavity). *If the density of skilled agents' income is log-concave, then h is increasing (Bagnoli and Bergstrom, 2005). If h is increasing, then $S(N_s)$ is increasing.*

The following proposition establishes a sufficient condition for unskilled agents to become relatively more scarce in the after-Katrina city. The proofs of this and following results are technical, and they can be found in the Appendix.

p:relprop

Proposition 5 (Relative composition of population). *If $\frac{\Delta R_u}{R_u} = \frac{\Delta R_s}{R_s} > 0$ and $S(N_s)$ is increasing, then*

$$\left| \frac{\Delta N_s^{EQ}}{N_s^{EQ}} \right| < \left| \frac{\Delta N_u^{EQ}}{N_u^{EQ}} \right|.$$

It turns out that the same sufficient condition in Proposition 5 causes inequality to be reduced after Katrina. (The comparison of Lorenz curves is illustrated in Figure 1.)

p:ineq

Proposition 6 (Inequality is reduced). *If $\frac{\Delta R_u}{R_u} = \frac{\Delta R_s}{R_s} > 0$ and $S(N_s)$ is increasing, then*

$$l_{AK}(x) > l_{BK}(x), \forall x \in (0, 1),$$

where we denote the Lorenz curve before Katrina as l_{BK} and the one after the storm as l_{AK} .

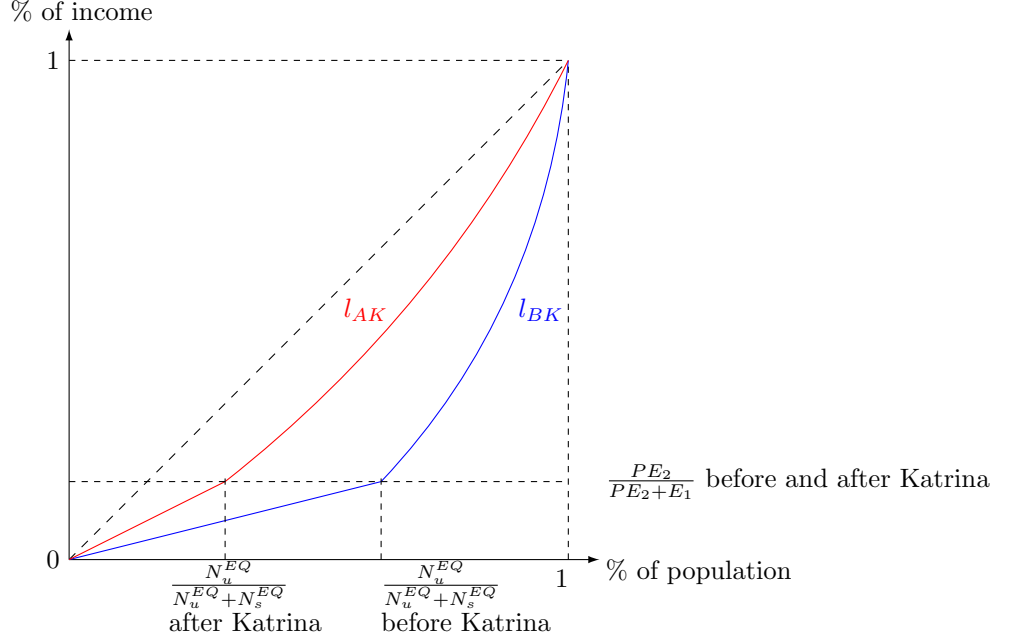


Figure 1: Lorenz curves before and after Katrina.

fig:complc

Finally, we explicitly consider the effects of Katrina on the levels of schooling, both publicly provided and privately chosen, and taxes. Proposition 7 summarizes our results.

p:edutax

Proposition 7 (Education and taxes). *Comparing the after Katrina levels with the situation before the storm*

1. *Per-pupil public school education level is higher.*
2. *Per-pupil private school education is higher.*
3. *Tax rates are unchanged*

Proof. Part 1 follows immediately from (26) in Proposition 3. The intuition for the result that the per-pupil public school education level is higher is the following. Unskilled agents are all marginal; therefore, in order for them to be willing to incur the cost of returning to New Orleans, at least one of two things must happen: they must receive a higher compensation for their endowment, i.e., P must rise, or they must receive better public services, i.e., g_m must rise. Actually, both happen in equilibrium. Corollary 2 shows that unskilled agents' income and demands increase as P rises. Thus, the gap between the desired level of education and the one actually provided becomes larger, implying that the utility cost of the reduction in flexibility incurred by attending public school increases. Therefore, from the point of view of skilled agents, increasing g_m is an especially effective way of inducing more unskilled agents to live in the city and moderate the increase in P : along with a direct increase in consumption of education, an increase in g_m lessens the utility cost of the reduction in flexibility. The result in Part 2 that per-pupil private school education is higher depends on the fact that only relatively rich skilled agents return to the city and that the level of education chosen by skilled agent j is unaffected by Katrina. In turn, this depends on the result in Part 3 that tax rates are unchanged by Katrina. To see these last two facts note that, using (3), the optimal choice of the privately acquired g depends only on the equilibrium tax rate t , determined in (17). Since g_m has adjusted after Katrina so that $g_m^2 = 6R_u/5$, t turns out to be constant in equilibrium, so g is unchanged as well. Therefore, because poorer skilled agents do not return, the average level of spending on private education increases. Clearly, the implication in Part 3 that t is constant and therefore that the education level chosen by agent j is unchanged are dependent of the specific modeling assumption. However, the result that average private education spending increases is much more robust. Indeed, any individual-level effect on private education is likely to be swamped by the population-composition effect: skilled agents in New Orleans after Katrina have higher average income because poorer agents do not return. \square

4 Conclusion

We construct a formal, theoretical model of the decision to return to New Orleans in the aftermath of Hurricane Katrina. In particular, we examine the post-Katrina population composition of the city, the evolution of its income distribution and of the welfare of its citizens, and the changes in the level of education privately and publicly provided. The key component of our model is a locational attachment to the city, operationalized as a productivity enhancement to skilled workers that is lost by moving away.

Our overall results are positive for the new New Orleans. While smaller, the new New Orleans is more skill-intensive and education levels improve. Moreover, we provide a sufficient condition on the distribution of skills such that inequality is reduced. Finally, we show that our sufficient condition is closely related to standard representations of distributions, such as those with log-concave densities.

We view the contribution of our paper as two-fold. We interpret and explain some changes that are apparent in New Orleans post-Katrina. In this dimension, we regard the simplicity of our model as an asset, identifying some of the key elements common to disaster impact and the resilience of the recovery. Further, we provide a baseline framework for structuring and interpreting empirical research. We view our model as a starting point for further investigations. In particular, as far as the evaluation of empirical research, any findings that contradict our theoretical results deserve great attention, because such findings would require a careful—and interesting—rethinking of the simple forms of interactions we have chosen for our model. For instance, while the evidence on improvements in education is uncontroversial, there is less consensus about the evolution of income inequality. Shaughnessy *et al.* (2010) document a decrease in inequality right after the storm and up to 2007 that is consistent with our theoretical findings as depicted in Figure 1. However, these findings are not causal. More recent empirical evidence suggests that inequality has risen.²³ Our model can provide guidance here. It points to a number of possible causes. First, it may be that there was middle class flight. This could result from unequal changes in reservation utilities.²⁴ Second, new population groups (e.g., Hispanic workers and young volunteers) have been attracted to the city after the storm and we do not account for them in our model. Third, the income distribution of skilled agents may have been strongly bimodal, or may have otherwise violated the log-concavity condition in Proposition 4.

Moreover, our research can be of help in informing and guiding policy. Skilled agents in our model are perfectly selfish. Nonetheless, they find that it is in their best interest to improve the quality of public education after a Katrina-like disaster, even if they do not consume public education directly. This is a very

²³Bloomberg (2015) reports that, of the 50 American cities ranked by Gini coefficient, New Orleans ranks second highest with a Gini coefficient value of 0.57. This was up 5.4% since 2008. See also Geagham (2011).

²⁴Fussel *et al.* (2010), documents that African-Americans “suffered more severe housing damage which, in turn, led to their delayed return to the city.” This is consistent with middle-class flight if African-Americans comprise a large proportion of the lower end of the skill distribution.

stark example showing that the interactions within the whole community result in more than a zero-sum game. Some policy changes, such as improving public education, end up benefiting all agents. It goes without saying that a number of analogues to the improved public education of our framework can be expected in a richer model.

We conclude by sounding a note of caution. The driving force behind the statistical “improvements” in New Orleans is the selective return of evacuees, not a magical resilience that brings things back better. Our model predicts that New Orleans data should look “better” partly because the poorest and least educated population stay away in larger numbers, and partly because the wealthier returnees improve public services as a way of attracting more of the poor back. Also, our inability to theoretically rule out that disasters may cause an increase in inequality is interesting, if somewhat troubling. This suggests that special attention should be devoted to the topic of “middle-class flight.” It is not difficult to imagine social situations in which members of the middle class function as glue between the lower and upper echelons of society, interacting with either at different times and different places. During periods of recovery, when resilience depends on the unity of an entire community, the potential loss of the middle class is cause of concern.

5 Appendix

Proof of Lemma 1. By concavity, the first order conditions are necessary and sufficient. They yield conditions (3) and (4). Substitution of these optimal choices into the utility function in (1) results in the indirect utility levels (5) and (6). The cutoff level e_1^* equates (5) and (6). The difference between the indirect utility levels obtained through private schooling in (5) and public schooling in (6) is

$$\log \frac{1}{P} \left(\frac{e_1(j)(1-t)}{3} \right)^3 - \log \frac{1}{P} \left(\frac{e_1(j)(1-t)}{2} \right)^2 g_m = \log e_1(j)(1-t) \frac{4}{27g_m}.$$

Since the above is an increasing function of $e_1(j)$, public school is preferred by any agent j such that $e_1(j) < e_1^*$. Similarly, if $e_1(j) > e_1^*$, then private school is preferred. \square

Proof of Proposition 4. The first implication follows immediately from Corollary 2 in Bagnoli and Bergstrom (2005): log-concavity of the density f implies h increasing. Next, we establish the result that h increasing implies $S(N_s)$ increasing with two Lemma.

1:3 **Lemma 3.** $S(N_s)$ is increasing if the following condition holds:

$$e'(N_s) + N_s e''(N_s) < 0. \tag{27} \quad \text{C4}$$

Proof of Lemma 3. In a right neighborhood of $N_s = 0$, $S(N_s)$ is increasing, because

$$\lim_{N_s \rightarrow 0} S(N_s) = 1,$$

and

$$\forall N_s > 0, S(N_s) > 1,$$

since $\frac{E(N_s)}{N_s}$ is decreasing by $e(N_s)$ decreasing. Therefore, if $S(N_s)$ is strictly decreasing over some range, it must have a local maximum. Note that

$$N_s S'(N_s) = 1 - S(N_s) \left(1 + N_s \frac{e'(N_s)}{e(N_s)} \right);$$

further differentiation yields

$$S'(N_s) + N_s S''(N_s) = -S'(N_s) \left(1 + N_s \frac{e'(N_s)}{e(N_s)} \right) - S(N_s) \frac{d \left(N_s \frac{e'(N_s)}{e(N_s)} \right)}{d N_s}.$$

The necessary condition for a local maximum for $S(N_s)$ then implies $\frac{d \left(N_s \frac{e'(N_s)}{e(N_s)} \right)}{d N_s} \geq 0$, or

$$\frac{(N e''(N_s) + e'(N_s)) e(N_s) - N_s (e'(N_s))^2}{(e(N_s))^2} \geq 0.$$

Since the above displayed inequality is violated when (27) holds, we conclude that, if (27) holds, then $S(N_s)$ must be increasing. \square

The second Lemma relates condition (27) to the hazard rate of the income distribution.

1:4 Lemma 4. *Condition (27) in Lemma 3 holds if and only if $h(y)$ is increasing.*

Proof of Lemma 4. The transformation from the endowment function $e(\cdot)$ to the income function $F(\cdot)$ occurs with the two next displayed equations: for any N such that $e(N) = y \geq e(N_s^{EQ})$, we have

$$F(y) = \frac{N_s^{EQ} - e^{-1}(y)}{N_s^{EQ}},$$

and

$$f(y) = -\frac{1}{N_s^{EQ} e'(e^{-1}(y))}.$$

Moreover, we have

$$f'(y) = \frac{e''(e^{-1}(y))}{N_s^{EQ} (e'(e^{-1}(y)))^3}.$$

Now, note that

$$d \log h(y) = d \log f(y) - d \log(1 - F(y)) = \frac{f'(y)}{f(y)} + \frac{f(y)}{1 - F(y)}.$$

Therefore, $h(\cdot)$ is increasing if and only if

$$-1 < \frac{1 - F(y)}{f(y)} \cdot \frac{f'(y)}{f(y)} = \frac{\frac{e^{-1}(y)}{N_s^{EQ}}}{-\frac{1}{N_s^{EQ} e'(e^{-1}(y))}} \cdot \frac{\frac{e''(e^{-1}(y))}{N_s^{EQ} (e'(e^{-1}(y)))^3}}{-\frac{1}{N_s^{EQ} e'(e^{-1}(y))}} = N \frac{e''(N)}{e'(N)}.$$

But the extremes of the above displayed inequality are nothing but (27), since $e' < 0$. □

The combination of Lemma 3 and 4 establishes the desired result. □

Proof of Proposition 5. If $S(N_s)$ is increasing, then taking derivatives we have

$$\frac{\left(e_1(N_s) N_s - \int_0^{N_s} e_1(j) dj \right) e_1(N_s) - N_s e_1'(N_s) \int_0^{N_s} e_1(j) dj}{N_s^2 (e_1(N_s))^2} > 0,$$

which evaluated at $N_s = N_s^{EQ}$ yields

$$(e_1(N_s^{EQ}) N_s^{EQ} - E_1(N_s^{EQ})) e_1(N_s^{EQ}) - N_s^{EQ} e_1'(N_s^{EQ}) E_1(N_s^{EQ}) > 0,$$

or

$$\left(\frac{e(N_s^{EQ})}{E_1(N_s^{EQ})} - \frac{e'(N_s^{EQ})}{e(N_s^{EQ})} \right) N_s^{EQ} > 1, \tag{28} \quad \text{Cond 4}$$

From (24), (25), and (26), with $\frac{\Delta R_u}{R_u} = \frac{\Delta R_s}{R_s}$ we obtain

$$\frac{\frac{\Delta N_u^{EQ}}{N_u^{EQ}}}{\frac{\Delta N_s^{EQ}}{N_s^{EQ}}} = N_s^{EQ} \left(\frac{e_1(N_s^{EQ})}{E_1(N_s^{EQ})} - \frac{e_1'(N_s^{EQ})}{e_1(N_s^{EQ})} \right),$$

so that, using (28) and recalling that both $\frac{\Delta N_u^{EQ}}{N_u^{EQ}}$ and $\frac{\Delta N_s^{EQ}}{N_s^{EQ}}$ are negative,

$$\left| \frac{\Delta N_s^{EQ}}{N_s^{EQ}} \right| < \left| \frac{\Delta N_u^{EQ}}{N_u^{EQ}} \right|.$$

□

Proof of Proposition 6. Denote the equilibrium populations before the storm as N_u^{BK} and N_s^{BK} , while N_u^{AK} and N_s^{AK} indicate the equilibrium populations after the storm. Similarly, we use $l_{BK}(x)$ and $l_{AK}(x)$ for the before and after Lorenz curves, whose formal definition is in (23) and immediately above it. From (15), (16), and (18), we have that the ratio of skilled to unskilled market income, $\frac{E_1}{PN_u} = \frac{E_1}{PE_2}$, is constant in equilibrium. Therefore, $l_{AK}(x) > l_{BK}(x) \forall x \left[0, \frac{N_u^{AK}}{N_u^{AK} + N_s^{AK}}\right]$, since, by Proposition 4, $\frac{N_u^{AK}}{N_u^{AK} + N_s^{AK}} > \frac{N_u^{BK}}{N_u^{BK} + N_s^{BK}}$. $l_{AK}(x) \geq l_{BK}(x)$ holds. Therefore, if $l_{AK}(x)$ and $l_{BK}(x)$ intersect for $x \in (0, 1)$, then they must do so at a point x^1 where $l'_{BK}(x^1) \geq l'_{AK}(x^1)$. We now show this is impossible when $S(N_s)$ is increasing. The condition $l_{AK}(x^1) = l_{BK}(x^1)$ implies

$$\int_{(N_u^{AK} + N_s^{AK})(1-x^1)}^{N_s^{AK}} \frac{e_1(j)}{e_1(j) dj} dj = \int_{(N_u^{BK} + N_s^{BK})(1-x^1)}^{N_s^{BK}} \frac{e_1(j)}{e_1(j) dj} dj,$$

which in turn implies

$$\frac{\int_0^{(N_u^{AK} + N_s^{AK})(1-x^1)} e_1(j) dj}{\int_0^{N_s^{AK}} e_1(j) dj} = \frac{\int_0^{(N_u^{BK} + N_s^{BK})(1-x^1)} e_1(j) dj}{\int_0^{N_s^{BK}} e_1(j) dj}. \quad (29) \quad \text{EQUALITY}$$

Using $S(N_s)$ increasing and $N_u^{AK} + N_s^{AK} < N_u^{BK} + N_s^{BK}$, we have

$$\begin{aligned} & (1-x^1) (N_u^{BK} + N_s^{BK}) \frac{e((1-x^1)(N_u^{BK} + N_s^{BK}))}{\int_0^{(N_u^{BK} + N_s^{BK})(1-x^1)} e_1(j) dj} \\ & < (1-x^1) (N_u^{AK} + N_s^{AK}) \frac{e((1-x^1)(N_u^{AK} + N_s^{AK}))}{\int_0^{(N_u^{AK} + N_s^{AK})(1-x^1)} e_1(j) dj}, \end{aligned}$$

which, using (29) implies,

$$(N_u^{BK} + N_s^{BK}) \frac{e((1-x^1)(N_u^{BK} + N_s^{BK}))}{\int_0^{N_s^{BK}} e_1(j) dj} < (N_u^{AK} + N_s^{AK}) \frac{e((1-x^1)(N_u^{AK} + N_s^{AK}))}{\int_0^{N_s^{AK}} e_1(j) dj},$$

However, using (23), the above displayed equation directly contradicts $l'_{BK}(x^1) \geq l'_{AK}(x^1)$. \square

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