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Examining the Educational Spillover Effects of Severe Natural Disasters: The Case of Hurricane Maria

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This study examines the effects of internal migration driven by severe natural disasters on students in host communities, and the mechanisms behind these effects, using the large influx of migrant students into Florida public schools in the aftermath of Hurricane Maria. I find significant adverse effects of the influx in the first year on existing student test scores, disciplinary problems, and student mobility that vanish entirely in the second year. These adverse effects are particularly pronounced among higher-performing students who were proficient on prior year tests: A 5-percentage point increase in migrant share decreases test scores of these students by 0.09 standard deviations in math (0.07σ in ELA), increases disciplinary incidents by 50 percent, and student mobility by 44 percent in the first year. I also find evidence that compensatory resource allocation within schools is an important factor driving the adverse effects. In particular, the results provide evidence that schools reallocate resources – teachers in particular – in a compensatory fashion when faced with a large influx of high-need students, increasing the likelihood that higher-performing students are assigned to less effective teachers.

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The Case of Hurricane Maria**

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Abstract: This study examines the effects of internal migration driven by severe natural disasters on host communities, and the mechanisms behind these effects, using the large influx of migrant students into Florida public schools in the aftermath of Hurricane Maria. I find significant adverse effects of the influx in the first year on existing student test scores, disciplinary problems, and student mobility that vanish entirely in the second year. I also find evidence that compensatory resource allocation within schools is an important factor driving the adverse effects of large, unexpected migrant flows on some incumbent students in the short-run. (*JEL* I20, I24, J15)

Keywords: peer effects; migration; climate change; severe natural disasters; Hurricane Maria

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1. Introduction

Migration and its effects remain to be a contentious topic of debate in developed countries. While these debates typically relate to cross-border migration, there is growing concern about increasing rates of internal migration driven by climate change.[1] This study examines the spillover effects of internal migration due to severe natural disasters – one of the leading consequences of climate change - in the United States. Over the past four decades, the number of "super-severe" weather and climate disasters that cause more than a billion dollars in damage has increased dramatically in the United States, from 3 in 1980 to 16 in 2017 (NOAA, 2018).[2] Furthermore, many climate scientists predict that the quantity and severity of such disasters will increase as global greenhouse gas emissions increase. There is evidence in the literature suggesting that such severe disasters lead to significant increases in out-migration rates (Boustan et al. 2017). According to the Internal Displacement Monitoring Centre (IDMC), 6 million people were internally displaced due to severe weather and climate disasters in the United States between 2008 and 2017.[3]

I address this question using the large influx of Puerto Rican migrants into Florida public schools following Hurricane Maria, which made landfall on Puerto Rico on September 20, 2017,

[1] For example, a recent World Bank report concludes that climate change could force more than 143 million people to move within their countries by 2050 in just three regions of the world: Sub-Saharan Africa, South Asia and Latin America (Kumari Rigaud et al. 2018).
[2] These weather and climate disasters include droughts, freezes, tropical cyclones, wildfires, winter storms, severe storms, and flooding.
[3] As of this writing, the most recent example of internal migration driven by a severe natural disaster in the United States was the migration in the aftermath of the Camp Fire in California where an estimated 20,000 people relocated to Chico, California from the nearby town of Paradise in Fall 2018 (https://www.npr.org/2019/01/14/685137701/in-the-aftermath-of-the-camp-fire-a-slow-simmering-crisis-in-nearby-chico?, accessed 1/15/19).

resulting in thousands of deaths[4] and destroying the island's infrastructure. As of December 2018, the estimated cost of the hurricane was $90 billion, placing Hurricane Maria as one of the costliest hurricanes in U.S. history (NOAA, 2018). In the 12 months after the hurricane, an estimated 160,000 Puerto Ricans (roughly 5 percent of the island's population in 2017) relocated to the United States. Florida received the largest share of these migrants[5] with nearly 12,000 students from Puerto Rico enrolling in Florida public schools between October 2017 and May 2018.[6] The primary objective of this study is to explore the effects - and the mechanisms behind the effects - of this large influx of students on the educational outcomes of existing students including test scores, attendance, disciplinary problems, and student mobility across schools and out of the school district in a large, anonymous district in Florida, which experienced one of the largest influxes of Puerto Rican migrants nationwide with roughly 4,000 Puerto Rican migrants entering during this time frame (Hinojosa, Román, & Meléndez, 2018).

I find significant adverse effects of hurricane migrants on the educational outcomes of existing students in the first year. Specifically, the results indicate that a 5-percentage point increase in the share of hurricane migrants reduces test scores by roughly 6 percent of the standard deviation (0.06σ) in math and 0.04σ in English language arts (ELA), which correspond to relative learning losses equivalent to 1 to 2 months of instruction, increases the likelihood of being involved in a disciplinary incident by 15-20 percent (of the dependent variable mean) in middle and high school, and increases the likelihood of existing students leaving their schools

[4] A recent study by Kishore et al. (2018) estimates nearly 3,000 deaths related to Hurricane Maria in Puerto Rico from September 20 through December 31, 2017.
[5] See Hinojosa, Román, & Meléndez (2018).
[6] https://www.flgov.com/2018/05/18/gov-scott-education-commissioner-pam-stewart-to-visit-puerto-rico-offer-continued-assistance-to-displaced-students/, accessed on 11/26/2018.

before the start of 2018-19 school year (especially among White and African American students) by roughly 7 percent.

The results also indicate that these adverse effects are mainly concentrated among higher-performing students, especially in disadvantaged school settings. For example, a 5-percentage point increase in migrant share decreases test scores of existing students who were deemed as proficient in both ELA and math (based on their prior year test scores) by 0.09σ in math and 0.07σ in ELA, increases incident rates by 50 percent, and student mobility by 44 percent for these students. In high-poverty or low-performing schools, a similar increase in migrant share decreases math scores by 0.13σ to 0.14σ, ELA scores by 0.08σ, increases absence rates by 10 percent, and disciplinary incidents by roughly 60 percent among high-performing students. In contrast, I find statistically and economically insignificant effects of a similar-sized increase in migrant share on low-performing students who were not proficient in both ELA and math, with declines of 0.003σ in ELA and math test scores, an increase of 1 percent in incidents, and an increase of 9 percent in student mobility.

To assess the magnitude of these effects, it is helpful to compare them to other estimates in the family and education literature. Using Florida data, Figlio et al. (2014) show that a 10 percent increase in birth weight increases test scores by 0.05σ; Breining et al. (2020) show birth order effects of 0.08σ on reading scores; Figlio, Holden, and Özek (2018) find that extending school day by an hour to provide literacy instruction increases reading scores by 0.05σ in elementary schools; Rouse et al. (2013) show that receiving a failing school grade (“F”) under Florida’s school accountability system increases student test scores by 0.06σ to 0.14σ in math and by 0.06σ to 0.10σ in reading. More related to the research question addressed in this study, Imberman, Kugler, & Sacerdote (2012) find that an increase of 5-percentage points in

Katrina/Rita migrant share decreased math scores by 0.045σ among existing elementary school students in Houston. Therefore, the first-year effects presented in this study (especially the effects on higher-performing students) are not only statistically significant, but also economically meaningful and comparable to (and in many cases larger than) the effect sizes found in other contexts.

Using detailed data on student course enrollment that are linked to individual teachers, I examine some of the mechanisms that could explain these findings. I show that an increase in migrant share leads to a much larger increase in the number of migrants entering the classrooms of lower-performing students compared to higher-performing students especially in disadvantaged school settings. Further, the results provide evidence of schools reallocating resources (teachers in particular) to accommodate the needs of entering migrants. In particular, a 5-percentage point increase in migrant share reduces the likelihood that a high-performing student (proficient in both ELA and math) is assigned to a "highly effective" teacher (the highest teacher rating in the district out of 4 possible categories) by roughly 60 percent and almost doubles this likelihood for students who were not proficient in both subjects. In contrast, a similar increase in migrant share increases the likelihood that a high-performing student is assigned to an "unsatisfactory" teacher (the lowest teacher rating in the district) or a teacher who is new to the district by 44 percent, and reduces the same likelihood by 19 percent for low-performing students. Given that students assigned to "highly effective" teachers score roughly 0.23σ better in math (0.08σ better in ELA) and are significantly less likely to be involved in disciplinary incidents than students in the same school with similar prior achievement and background characteristics who are assigned to "unsatisfactory" or new teachers, these findings provide evidence that compensatory resource reallocation within schools is an important factor driving the observed adverse effects of migrants on some students in the short-run.

I also examine the extent to which these adverse effects persist in the second year. This is an important question because approximately half of the Hurricane Maria migrants left the school district at the end of the first year. Overall, I find precisely estimated zero effects of migrant share on the test scores, disciplinary problems, and attendance of existing students in the second year; however, there is evidence suggesting that the first year effects decline, yet persist in the second year in high-poverty or low-performing schools.

2. Prior Literature and Contributions

There is an extensive literature looking at the effects of cross-border migrants (immigrants or refugees) on existing students yielding mixed results. For example, using the large influx of Russian Jews into Israel after the collapse of the Soviet Union, Gould, Lavy, & Paserman (2009) study the effects of immigrants and find a large adverse effect on the high school dropout rates and high school matriculation test passing rates among native Israeli students. Similarly, Jensen and Würtz-Rasmussen (2011) find negative effects of immigrant concentration on both native and immigrant secondary school students in Denmark. On the other hand, Hunt (2017) finds that an increase in the immigrant share in the population increases the likelihood of high school graduation among native-born black students in the United States. Similarly, Brunello and Rocco (2013) and Geay, McNally, & Telhaj (2012) find small or no negative spillover effects of immigrants on natives, and Ohinata and Van Ours (2013) and Schneeweis (2015) find large negative effects of immigrant concentration on the educational outcomes of immigrant students, yet no significant effect on natives. Finally, Figlio & Özek (2019) examine the effects of Haitian refugees who entered Florida public schools in the aftermath of the Haitian earthquake of 2010, and find precisely estimated zero effects on existing students, regardless of their socioeconomic status, race/ethnicity, and nativity.

There are several important reasons why the effects of internal disaster migrants could be different from the effects of cross-border migrants. First, internal disaster migrants, similar to refugees, are forced to leave their homes due to an imminent threat to their lives. In contrast, immigrants typically make conscious choices to leave their countries of origin seeking “a better life” elsewhere (Figlio & Özek, 2019). Internal migrants also face fewer barriers of entry into the host community compared to cross-border migrants. As such, these migrants could be less likely to be positively selected from, and more likely to be representative of, their communities of origin.[7]

Further, severe natural disasters induce much larger influxes of internal migrants compared to cross-border migrants due to differences in barriers to entry, which could lead to more severe adverse effects on host communities. For example, the migrant influx in the aftermath of Hurricane Maria into Florida public schools had been significantly larger than the Haitian refugee influx following the Haitian earthquake of 2010: Roughly 4,000 Haitian students entered Florida public schools in the four months after the earthquake compared to 11,000 Puerto Rican students in the four months after the hurricane (Rayer, 2018). On the other hand, internal migration could be less detrimental than cross-border migration as the migrants are expected to be more similar to the host community culturally/linguistically and, unlike cross-border migrants, are eligible for social assistance programs. Finally, there is evidence in the literature suggesting that disaster migrants are more likely to be transitory and more likely to leave the host

[7] For example, there is evidence in the literature suggesting that refugees generally are more impoverished with lower earnings than economic migrants, and have lower levels of education and language skills when they arrive (Connor, 2010; Potocky-Tripodi, 2004). To the best of my knowledge, there is no study to date that examines selection in internal migration driven by severe natural disasters.

communities in the long-run (Figlio & Özek, 2019): As such, these students could have different long-term effects on incumbent students compared to economic migrants.[8]

In contrast to the extensive literature about the effects of cross-border migrants on host communities, relatively little is known about the effects of internal migration due to severe natural disasters. One study that is worth highlighting is Imberman, Kugler, & Sacerdote (2012), which investigates the effects of Hurricane Katrina (and Irma) evacuees on incumbent students in Louisiana and Houston. They find a moderate negative effect of the influx only on math scores in Houston elementary schools, with students in schools that received higher-achieving evacuees faring better than students in schools that received evacuees that were low-performing before the hurricane. This study complements Imberman, Kugler, & Sacerdote (2012) in two ways. First, I examine the effects of a migrant influx that is similar in size, yet very distinct in terms of the educational needs (English skills in particular) of the migrants, compared to Katrina evacuees. Indeed, I find significantly larger spillover effects in the aftermath of Hurricane Maria.

Second, to the best of my knowledge, this study is the first to shed light on the mechanisms behind these migrant effects, particularly about the effects of a large, unexpected influx of migrants with high educational needs on the resources available for existing students. I find evidence suggesting that unexpected migrant influxes do not only alter the peer input in education production function (EPF) for existing students, but they also lead to schools reallocating instructional resources across classrooms (thereby affecting the teacher input in EPF), which makes it difficult to attribute the observed effects of migrants on existing students to changes in peer quality alone.

3. Data and Descriptive Statistics

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[8] For example, roughly 40 percent of Haitian earthquake migrants left Florida public schools within 18 months after the earthquake (Figlio & Özek, 2019).

In this study, I use student-level administrative data from a large, anonymous school district in Florida that provide detailed information about all students in grades K-12 between 2014-15 and 2018-19 school years. These school records contain Florida Standards Assessment (FSA) scores in ELA and math of all students in tested grades (between grades three and ten for ELA, and grades 3 through 8 for math)[9] along with a wealth of student characteristics including student demographics (e.g., race/ethnicity, gender), whether the student receives subsidized meals, measures of English proficiency (limited English proficiency indicator and language spoken at home), detailed information about disciplinary incidents, attendance, and special education status. The administrative records also provide information about student courses that are linked to individual teachers. More importantly for the purposes of this study, the data contain the country and state of birth, and the entry and withdrawal dates of all students to/from the schools they attended in a given school year, which allow me to identify Puerto Rican migrants who entered the district for the first time after the hurricane.

Figure 1 presents the number of Puerto Rican migrant students who entered the district in the aftermath of Hurricane Maria (between September 20, 2017 and the end of 2017-18 school year).[10] As a comparison, the figure also presents the number of students born in Puerto Rico who entered the district for the first time during the same time frame in the prior two school years. Clearly, the district experienced a significant migrant student influx after the hurricane. In particular, 3,089 Puerto Rican migrants entered the district in the three months following the hurricane. This is in stark contrast to the number of entering Puerto Rican students in the prior two years when a total of 687 student entered the district. The hurricane migrant influx

[9] Throughout the remainder of the paper, I use FSA scores in ELA and math standardized to zero mean and unit variance at the grade-year level in the test score analysis.
[10] I also check the accuracy of this measure of Puerto Rican hurricane migrants using the "hurricane migrant" flag created by the district in school records, and reach almost identical numbers.

decelerated, yet continued, after the winter break, reaching a grand total of 3,991 Puerto Rican students until the end of 2017-18 school year.[11]

To put this number in context, the Puerto Rican influx in the anonymous district was slightly smaller than the volume of Hurricane Katrina evacuees who entered Houston Independent School District (HISD) in 2005-06 school year. 4,986 students entered HISD in the aftermath of Hurricane Katrina, which corresponds to 2.9 percent of the existing student body in the HISD at the beginning of 2005-06 school year (Imberman, Kugler, & Sacerdote, 2012) whereas the Puerto Rican migrants constitute 2.1 percent of the total enrollment in the district at the beginning of 2017-18 school year. Yet, the Puerto Rican influx was much larger than the volume of Haitian refugees in Spring 2010 when 3,743 Haitian students entered Florida public schools, which represents 0.14 percent of the total enrollment in the entire state in Fall 2009 (Figlio & Özek, 2019).

The three panels in Figure 2 examine the distribution of Puerto Rican migrants across schools in the anonymous district. In particular, the cumulative distribution function (CDF) of the number of entering hurricane migrants by school is given in Panel A; the CDF of the share of entering hurricane migrants in the entire student body by school is given in Panel B; and the CDF of the share of entering hurricane migrants among English learners by school is given in Panel C. Panel A suggests that 33 schools – or roughly 14 percent of all schools in the district – did not receive any migrants in 2017-18 school year. Of the schools that received at least one hurricane migrant, 40 percent received fewer than 10 migrant students, 70 percent received fewer

[11] In this study, I focus on Hurricane Maria migrants from Puerto Rico, yet it is important to note that there were also students from U.S. Virgin Islands who entered the anonymous district after the hurricane. That said, Puerto Rican migrants constitute the overwhelming majority of the Hurricane Maria migrants in the district – only 300 students from U.S. Virgin Islands entered the district after the hurricane compared to nearly 4,000 students from Puerto Rico. It is also important to note that the main results presented below are robust to the inclusion of hurricane migrants from U.S. Virgin Islands.

than 25 migrant students, and 94 percent received fewer than 50 students. Looking at the share of migrants in each school in Panel B, in 64 percent of schools, migrants constitute less than 2 percent of the existing student body whereas the migrant share exceeds 5 percent of the student body in 10 percent of all schools. The results in Panel C also reveal that the entering hurricane migrants, 85 percent of who were identified as English learners, constitute a significant portion of the existing English learner population. In nearly 25 percent of all schools, entering migrants represent more than 10 percent of the existing English learners.

Table 1 compares the characteristics and outcomes of Puerto Rican hurricane migrants in the first and second year (column (I)) with Puerto Rican migrants in previous two years (column (II)) and existing students who were enrolled in the district at the beginning of 2017-18 school year (column (III)). Compared to Puerto Rican migrants in prior years, hurricane migrants were more likely to receive subsidized meals (95 percent versus 82) [12], less likely to be identified as special education students (16 percent versus 20), more likely to report Spanish as the primary language spoken at home (94 percent versus 89), and more likely to be classified as an English learner (84 percent versus 79) when they first entered the district. Hurricane migrants had similar test scores in the first year as the Puerto Rican migrants in prior two years, yet they had significantly lower absence rates (8 percent versus 10), and were less likely to be involved in a disciplinary incident (5 percent versus 7). Importantly, 62 percent of hurricane migrants left their schools and roughly half of the migrants left the school district before the start of the following

[12] It is important to note that it is harder to use "receiving subsidized meals" as a measure of student socioeconomic status in our data because of the United States Department of Agriculture's (USDA) recently implemented community eligibility provisions (CEP), which allow high poverty schools to provide free meals to all enrolled students without collecting household applications. As such, it is hard to compare the socioeconomic status of Puerto Rican migrants (as proxied by free or reduced priced lunch eligibility) with that of Katrina evacuees or Haitian earthquake refugees. 44 percent of Puerto Rican hurricane migrants who were identified as free or reduced price lunch eligible in our sample received free meals via schoolwide designations. For more information on CEPs, see Domina et al. (2017).

school year. Both of these numbers are considerably larger than the first-year attrition rates of the Puerto Rican migrants in the prior two years (45 percent and 29 percent respectively). The differences in test scores, absences, and disciplinary incidents between the two groups widened in favor of the hurricane migrants in the second year after they entered the school district: Hurricane migrants outscored other Puerto Rican migrants by 0.13σ and 0.14σ in math and ELA respectively, had fewer absences, and were almost half as likely to be involved in a disciplinary incident.[13]

Compared to existing students in the district, Puerto Rican hurricane migrants were more disadvantaged both socioeconomically and academically. Hurricane migrants were significantly more likely to receive subsidized meals, nearly six times more likely to be classified as English learners, and 50 percent more likely to be identified as special education students. Existing students also outperformed these migrants considerably on standardized tests in the first year (by 1.25 standard deviations in ELA and by one standard deviation in math), and had lower absence rates, yet were almost two times more likely to be involved in a disciplinary incident.[14] These gaps shrunk considerably, yet persisted, in the second year.

A number of studies have shown that recent immigrants are more likely to settle in neighborhoods with larger shares of immigrants, typically from their countries of origin (e.g., Card, 2001; Figlio & Özek, 2019). While Puerto Rican migrants are not technically immigrants, this is also what was observed in the aftermath of Hurricane Maria in the anonymous district.[15]

[13] This divergence in outcomes could partially be explained by differential attrition at the end of the first year. Hurricane migrants who left the district at the end of the first year had significantly lower ELA scores (0.11σ) (yet similar math scores) compared to the hurricane migrants who stayed. The former group also had higher absence rates. In contrast, differential attrition was less pronounced among Puerto Rican migrants in prior years – migrants who left the district before the beginning of the second year had similar test scores compared to those who stayed.

[14] The difference in disciplinary incident rates could be explained by the common finding in the literature suggesting that immigrant students are less likely to have disciplinary problems than natives (e.g., Figlio & Özek, in press).

[15] Based on anecdotal evidence (e.g., media reports), many hurricane migrants stayed with their relatives who were already in the district at the time of the hurricane and some have arranged temporary housing in hotels or rental

Table 2 presents the estimated coefficient on the school migrant share in regressions where the outcome of interest is the existing student attribute provided in the table.[16] The estimates suggest that schools with higher hurricane migrant shares also had students with significantly lower prior year achievement in both ELA and math, had higher shares of students born in Puerto Rico, Hispanic students, English learners, and students receiving subsidized meals. As such, simple comparisons between the educational outcomes of existing students in schools that received Puerto Rican hurricane migrants and those that did not would likely yield biased estimates of the causal effects of the migrant influx.

4. Empirical Strategy

To deal with this selection issue, following Figlio & Özek (2019), I rely on within-school, across-grade variation in migrant concentration to study the effects of the student influx on host students. Using students who were enrolled in a public school in the district at the time of the hurricane I estimate:

$$Y_{itsg} = \alpha + \beta M_{sg} + \delta_s + \theta_g + \varepsilon_{it} \tag{1}$$

where Y_{itsg} is the year t educational outcome (test scores standardized to zero mean and unit variance at the year-grade level[17], an indicator for being involved in a disciplinary incident, % absent days multiplied by 100, and an indicator for leaving the school in Fall 2017 before the

units. As a result of the migrant influx, the number of students in the district living in unstable housing circumstances (e.g., living in an emergency or transitional shelter; living in shared housing due to loss of housing or economic hardship; living in cars, parks, campgrounds, public spaces, abandoned buildings, substandard housing, bus or train stations; or living in a hotel or motel) increased by 58 percent in 2017-18 school year.

[16] School migrant share is defined as the number of Puerto Rican hurricane migrants who entered the school between September 20, 2017 and the end of 2017-18 school year divided by the number of existing students in the school at the beginning of 2017-18, multiplied by 100.

[17] I normalize test scores at the year-by-grade level using all tested students (including the migrants), which could lead to an increase in the test scores of students in grades that received more migrants as these migrants had significantly lower test score. That said, in all specifications I control for grade fixed-effects which account for such discrepancies across grades.

start of 2018-19[18]) of student i who attended school s and grade g at the beginning of 2017-18 school year, M_{sg} is the percentage of Puerto Rican hurricane migrants in grade g and school s in 2017-18 school year, and δ_s and θ_g are school and grade fixed-effects of the school and the grade that student i attended in Fall 2017 respectively. In some specifications, I also include a vector of student characteristics (X_{it}) to check the robustness of the findings and cluster standard errors at the school-by-grade level.

The critical assumption behind identification here is that M_{sg} is uncorrelated with unobserved characteristics of existing students as well as school-by-grade level attributes (such as teacher effectiveness and experience), controlling for schools attended. While it is not feasible to validate this assumption directly, Table 3 presents indirect evidence and provides the estimated associations between M_{sg} and observed characteristics of existing students and school-by-grade characteristics, with and without school fixed-effects. The estimates presented in column (I) show that, similar to Table 2, migrant share is significantly correlated with existing student attributes. However, once school fixed-effects are introduced, these associations vanish in almost all cases (only 2 out of 18 estimates are statistically different than zero at conventional levels), and in cases where it is statistically significant, the magnitude of the association shrinks considerably.[19] This approach also requires significant cross-grade variation in M_{sg} within schools. Appendix Figure 1 presents the CDF of the cross-grade range in M_{sg} by school and

[18] The "Left school before the start of 2018-2019" variable is an indicator that equals 1 if (a) the student left the district before the start of 2018-19 school year or (b) stayed in the district but moved to another school before the start of 2018-19 school year. As such, it captures both within school-year student mobility (i.e., students who left the school during the 2017-18 school year) and those who left the school during the summer after the 2017-18 school year. The overwhelming majority of the variation in this mobility indicator comes from students leaving their schools after the 2017-18 school year – roughly 80% of the students who left their schools before the start of 2018-19 school year left after the end of 2017-18 school year.

[19] For example, without school fixed-effects, one percentage point change in school-by-grade migrant share is associated with nearly 3 percentage point increase in the share of English learners. This estimate shrinks to 0.185 in magnitude once school fixed-effects are introduced.

shows that the range exceeds 2.5 percentage points in half, and exceeds 5 percentage points in 25 percent of all migrant-receiving schools.

An important concern with this approach is the possibility that school administrators strategically place migrants in grades based on unobservable factors. For this, using the exact birth date of each student, I utilize the variation in the naturally occurring age distribution of entering migrants in each school as an instrument for M_{sg}, and assume that this within-school, across-grade age distribution is orthogonal to existing student and school-by-grade characteristics. In particular, using 2SLS, I estimate:

$$\begin{aligned} M_{sg} &= \phi + \gamma A_{sg} + \delta_s + \theta_g + \nu_{sg} \\ Y_{itsg} &= \rho + \theta \widehat{M}_{sg} + \delta_s + \theta_g + \vartheta_{itsg} \end{aligned} \tag{2}$$

where A_{sg} is the number of migrants who entered school s and were age-appropriate for grade g multiplied by 100 and divided by the number of existing students enrolled in the same school-grade. Columns (III) and (IV) of Table 3 repeats the same analysis in columns (I) and (II) replacing M_{sg} with A_{sg}, and shows that once school fixed-effects are introduced, the instrument is uncorrelated with existing student and school-by-grade characteristics. To further investigate the strategic placement of migrants across grades within schools, I also present a falsification exercise where I estimate (1) using student outcomes in the year prior to the hurricane, assigning M_{sg} to the students in school s and grade g in 2016-17 school year. If the cross-grade, within-school differences in student outcomes are indeed driven by differences in migrant concentration (instead of unobserved school-by-grade level attributes such as teacher effectiveness), one would expect to find no significant correlation between this ‘pseudo’ migrant concentration and the outcomes in 2016-17.

5. First Year Effects

Table 4 presents the effects of hurricane migrant share on existing student outcomes in 2017-18 estimated using OLS (equation (1)) in columns (I) and (II), and using 2SLS in columns (III) and (IV). Each coefficient in this table presents the estimated effect of a 1-percentage point increase in migrant share on student outcomes in the first year. All regressions include the lagged dependent variable to improve the precision of the estimates and columns (II) and (IV) introduce the other student characteristics listed in the second panel of Table 2. The findings reveal significant adverse effects of the migrant influx in the short-term. To assess the magnitude of these effects, consider an increase of 5-percentage points in migrant share at the school-by-grade level (roughly 30 percent of all district schools had at least one grade that received an influx larger than 5 percent of the student body in that grade). The point estimates presented in the first two rows of Table 4 imply that a 5-percentage point increase in migrant share leads to a decline of 0.05σ to 0.065σ in the math scores of existing students. This adverse effect is slightly lower for ELA scores with 0.035σ to 0.045σ decline in existing student scores. Given that students in elementary and middle school typically gain about 0.30σ per year on the current-year standardized tests[20], these effect sizes represent relative learning losses comparable to about 1 to 2 months of instruction. Put differently, a 5-percentage point increase in migrant share moves an existing student in the 50^{th} percentile of the prior year test score distribution in ELA and math to 48^{th} and 47^{th} percentiles respectively.

Columns 3 to 6 of Table 4 present the effects on the non-test outcomes of existing students. The results suggest that a 5-percentage point increase in migrant share increases the disciplinary incident rate by about 0.6 to 0.9 percentage points, which correspond to roughly 5 to 7 percent of the mean, yet the estimated effects are only marginally significant in the 2SLS

[20] Based on the author's calculations using ECLS-K. For more information on methodology, please see the Appendix in Nichols and Ozek (2014).

framework. In middle and high school where disciplinary incidents are more common[21], these adverse effects on disciplinary incident rates are more pronounced with an increase of 2.7 percentage points (or 16 percent of the dependent variable mean) in incident rates as a result of a 5-percentage point increase in migrant share.

It is important to note that the increase in disciplinary incident rates could be driven by changes in student behavior or changes in enforcement following the migrant influx. While it is hard to identify which mechanism is at play here given administrative data limitations, Appendix Table 2 presents an exploratory analysis examining the effect of migrant share on different types of referral action (i.e., what action was taken once the student was involved in a disciplinary incident) in middle and high school. The results indicate that while an increase in migrant share significantly increases the incident rate, it does not lead to any increases in the likelihood of receiving an in-school or out-of-school suspensions that are typically reserved for more serious incidents. This finding could imply (a) that the migrant influx increased the incident rate, yet decreased the severity of the incidents and/or (b) that the migrant influx had no effect on the severity of the incidents, yet increased the leniency of school administrators for the same disciplinary infractions.

The results in Table 4 also indicate that a 5-percentage point increase in migrant share increases the likelihood of leaving the school before the start of 2018-19 school year by 1.2 to 1.5 percentage points, which roughly correspond to 6 to 8 percent of the dependent variable mean. This is similar to the evidence in the previous literature suggesting that that native students are likely to leave their schools when facing a major immigrant influx (Schindler-Rangvid, 2010;

[21] Disciplinary incidents are less common at the elementary level in the anonymous district than in middle and high school. In particular, only 5 percent of the elementary school students were involved in a disciplinary incident in 2017-18 school year compared to 19 percent of middle and high school students.

Gerdes, 2010). Panel A in Appendix Figure 2 breaks down the effect of migrant share on student mobility further and examines the timing of student departure from their schools in the first year. In particular, using exact withdrawal dates, each bar on this graph presents the estimated coefficient (along with the 95% confidence interval) on the migrant share variable in regressions where the dependent variable is an indicator that equals 1 if the student left their school (the school they attended at the beginning of 2017-18 school year) by the date given on the x-axis (the last entry on the x-axis represents the end of school year). The results indicate that the mobility results presented in Table 4 are primarily driven by the effect of the migrant influx on student mobility at the end of the school year rather than during the school year.

Panel B in Appendix Figure 2 repeats the same analysis replacing the mobility indicator with a sample attrition indicator that equals 1 if the student left the district by the date given on the x-axis. This is an important exercise for the validity of the estimates presented in Table 4 because if the migrant influx leads to differential attrition from the sample during the 2017-18 school year among existing students (e.g., an increase in migrant influx leads to higher-performing students leaving the sample), the adverse effects observed in the first year could be driven by changes in the composition of existing students rather than changes in their educational outcomes. The results reveal small and statistically insignificant effects of migrant share on existing student attrition from the sample during the school year, but a significant and much larger effect on student attrition from the sample at the end of the year.

Panels (C) and (D) repeat the same analysis for high-performing students (students who were proficient in ELA and math in the previous year), and examine the extent to which an increase in migrant share leads to high-performing students leaving their schools (and the district) before the end of 2017-18 school year. The findings reveal that an increase in migrant share significantly increases student mobility among high-performing students at the end of the school year, yet no significant effect on mobility during the school year. Further, I find no significant effect of migrant share on high-performing student attrition from the sample neither during the school year nor at the end of 2017-18. Appendix Table 1 provides further evidence on differential attrition from the sample, repeating the analysis in Table 3 for students who stayed in the district until the end of 2017-18 school year. If there is indeed differential attrition from the district during the school year, one would expect significant correlations between the migrant share variable (and the age-appropriate migrant share variable) and existing student baseline characteristics. However, I find no such associations. Finally, Table 4 reveals no economically or statistically significant effects on existing student absences.

The top panel in Table 5 provides the results of the falsification exercise, looking at the 'pseudo' effects of migrant share on the outcomes of students in the same school and grade in 2016-17. If the results in Table 4 are indeed driven by the migrant influx instead of some unobserved, time-invariant heterogeneity across grades within school (e.g., teacher quality), one would expect no significant effects of the migrant influx during the school year before the hurricane. This is indeed the case. The estimated 'pseudo' effects are statistically insignificant in all cases, and the magnitudes are considerably smaller than the true effect sizes presented in Table 4.

5.1. Heterogeneous Effects

Table 6 presents the effects of migrant share on existing student outcomes estimated using equation (1)[22] broken down by existing student and school attributes including prior year

[22] Throughout the remainder of the paper, I present estimates obtained using equation (1), unless otherwise noted, for the sake of brevity. 2SLS estimates, which yield almost identical results, are available upon request.

ELA or math proficiency[23], grade level, race/ethnicity, English learner status, school poverty (as measured by the percentage of students receiving subsidized meals in the school), and school performance (as measured by the school accountability grade in 2016-17 school year[24]). The most striking finding in this table is that the detrimental effects on test scores presented in Table 4 are almost entirely driven by the effect of the influx on high-performing students who were proficient (scored at level 3 or higher) in ELA or math in the previous year. For example, a 5-percentage point increase in migrant share decreases the math (ELA) scores of high-performing students who were proficient in math (ELA) in the prior year by a statistically significant 0.08σ (0.065σ), compared to a statistically insignificant decline of roughly 0.01σ (0.02σ) for existing student who were not proficient.

The same pattern also holds for non-test outcomes. For example, a 5-percentage point increase in migrant share increases disciplinary incidents by 3.8 to 4.8 percentage points (or 37 to 49 percent of the dependent variable mean) among high-performing middle or high school students in contrast to a statistically insignificant increase of 2 to 3 percentage points (or 7 to 11 percent of the dependent variable mean) among lower-performing students. Similarly, the migrant influx led to a considerably larger increase in student mobility among high-performing students: A 5-percentage point increase in migrant share increases the likelihood that the student leaves the school before the start of 2018-19 school year by 5.6 to 6 percentage points (or 38 to 45 percent of the dependent variable mean) among high-performing students compared to a statistically insignificant increase of roughly 10 percent of the dependent variable mean among

[23] Florida Department of Education classifies student test scores into 5 distinct categories, with 1 being the lowest level of achievement. Students who score in achievement levels 3 or higher are considered proficient in the corresponding subject.
[24] Each summer, Florida Department of Education assigns grades (A to F) to schools based on a number of factors including the prior year test performance of their students, high school graduation rate, and acceleration success (middle school acceleration or college and career acceleration in high school).

low-performing students. A similar discrepancy is observed in the effects of the influx on absences, yet the estimated coefficient is statistically distinguishable from zero in only one case (out of 4) at 10 percent level.[25]

The second, third, and fourth panels of Table 6 break down the analysis by existing student race/ethnicity, English learner status, and grade level.[26] The effects are mostly comparable across the three racial/ethnic groups, yet some of the estimated coefficients are no longer statistically significant due to smaller sample sizes. The most interesting finding in the second panel is the differences in existing student "flight" by race/ethnicity. In particular, a 5-percentage point increase in Puerto Rican migrant share increases student mobility among White and Black students by 14 percent (of the dependent variable mean), yet has no economically and statistically significant effect on Hispanic students. The results also indicate that the adverse effects are much larger in magnitude and only statistically significant for non-English learners and that the negative test score effects are considerably larger for students in middle and high school grades.

The last two panels of Table 6 investigate the heterogeneous effects of the migrant influx on existing students by school poverty (as proxied by the percentage of students receiving subsidized meals) and school performance (as measured by the school accountability grade in

[25] One possible, albeit unlikely, mechanism that might drive the effects on high-performing students is regression to the mean where high-performing students in school cohorts (i.e., students in the same school and grade) that received a larger share of migrants experience regression to the mean (that is unrelated to the influx) to a larger extent than students in other grades in the same school. If this is the case, one would expect a similar "effect" on high-performing students in the same school-grade in the previous school year. The bottom panel of Table 5 checks this hypothesis and repeats the falsification exercise using only the students who were proficient in both ELA and math in 2015-16 school year. The results reveal no significant "effect" on migrant share in 2017-18 on the outcomes of high-performing students in 2016-17, refuting this possibility.

[26] I also examine differential effects by the nativity of existing students and whether the existing student was born in Puerto Rico or not. I find very similar effect of migrant share on existing student outcomes along these dimensions.

2016-17 school year[27]). The findings reveal two patterns. First, an increase in migrant share has a more detrimental effect on test scores in high-poverty (above the median of 70%) and low-performing schools (with a grade of C or lower in 2016-17). This is consistent with the hypothesis that resource reallocation in the aftermath of the influx could be more consequential in schools that are more resource-constrained[28], or could be driven by the fact that migrants who entered disadvantaged schools had higher educational needs than other migrants. Second, an increase in migrant share leads to a larger increase in existing student mobility in higher-performing schools and schools serving less disadvantaged student populations. For example, a 5-percentage point increase in migrant share leads to a 12 percent (of the dependent variable mean) increase in the likelihood that an existing student in an "A" or "B" school leaves the school before the beginning of the following school year compared to a statistically insignificant effect of 3 percent in schools with accountability grades of "C" or lower.

Finally, Appendix Table 3 breaks down the analysis further for the three subgroups for which the adverse effects are more evident (i.e., students in high poverty schools, low-performing schools, and non-English learners) by the prior achievement levels of the existing students in those settings. The overarching conclusion of this analysis is that the observed effects in all three settings are mainly driven by the adverse effects of the influx on high-performing students. In particular, I find that a 5-percentage point increase in migrant share decreases math

[27] Each summer, Florida Department of Education assigns grades (A to F) to schools based on a number of factors including the prior year test performance of their students, high school graduation rate, and acceleration success (middle school acceleration or college and career acceleration in high school).

[28] There is evidence in the literature suggesting higher variation in teacher effectiveness in high-poverty schools compared to schools in more advantaged neighborhoods (Sass et al. 2012), with comparable teacher effectiveness among the most effective teachers in the two settings, yet significantly lower teacher effectiveness among the least effective teachers in high-poverty schools. This could imply that the migrant influx leads to a much higher drop in teacher effectiveness in low-performing (or high-poverty) schools due to resource reallocation. Further, students from disadvantaged backgrounds could be more adversely affected by changes to school resources as their parents are less likely to compensate for the change in school input (e.g., Jackson, Wigger, & Xiong 2018), which could explain the stronger adverse effects for students in disadvantaged settings.

(ELA) scores of high-performing students by 0.11σ to 0.14σ (0.08σ), increases absence rates by 10 percent of the dependent variable mean, and increases disciplinary incidents by 43 to 57 percent in high-poverty and/or low-performing schools.

5.2. Mechanisms Behind the Migrant Effects

In this empirical framework, there are two main mechanisms that could drive the observed adverse effects on existing students. First, the migrant influx could have a direct adverse effect on existing students through negative classroom spillovers. For example, large numbers of migrants entering classrooms could lead to disruptions in instruction or reduced instructional quality due to overcrowded classrooms. Second, the influx could affect other students in the school indirectly (even if they do not share classrooms with migrants) if school administrators reallocate resources (e.g., teachers) within-grades, across classrooms or across grades to accommodate the needs of migrants.[29]

While it is not feasible to directly test for classroom externalities using administrative data, I conduct an exploratory analysis using detailed course enrollment data that are linked to individual teachers. For example, if classroom externalities is the main driver of the observed effects, one would expect these effects to be larger for student groups that are more likely to be in the same classrooms as the migrants. Figure 3 examines the effects of migrant share on the average number of hurricane migrants in the ELA and math classrooms of existing students, broken down by the prior year achievement levels of existing students in ELA and math, school

[29] It is important to note that if school administrators reallocate resources across grades in a compensatory way (i.e., moving more resources to grades that receive higher share of migrants), then the estimated adverse effects of the migrant share presented thus far will likely underestimate the true effects. Another mechanism that could drive the overall effects of the migrant influx on existing students is resource reallocation across schools, yet this mechanism could not drive the observed effects in this study due to the empirical approach used in this study that exploits the within-school, across-grade variation in migrant share.

poverty, and school performance.[30] The findings in Panel (A) suggest that an increase in migrant share increases the exposure of low-performing students to migrants in their classrooms to a much larger extent than high-performing students. In particular, the estimates reveal that a 5-percentage point increase in migrant share increases the average number of migrants in the classrooms of lowest-achievers in ELA by roughly 1.75 students compared to an increase of 1 student for highest-achievers in ELA. Panel (B) shows that this discrepancy in exposure to migrant students between high-performing and low-performing students is more apparent in high-poverty and low-performing schools, for which the adverse effects in the first year are more severe. In contrast, an increase in migrant share leads to comparable migrant influxes into the classrooms of high-performing and low-performing students in more advantaged school settings (Panel (C)). I also find much larger discrepancies in migrant exposure between high- and low-achieving students in middle school where student achievement tracking is more common (results available upon request).[31] In particular, a 5-percentage point increase in migrant share in middle school increases the average number of migrant students entering the classrooms of low-performing students (not proficient in ELA or math) by 3.5 students, compared to an increase of roughly 1 migrant student in the classrooms of high-performing students.

I then investigate the extent to which schools reallocate resources (teachers in particular) when faced with a large migrant influx. For this exercise, I identify the teachers in all ELA and math courses each student in grades 4 through 8 took and estimate the effect of migrant share on

[30] In particular, I identify ELA and math courses in grades 4 through 8 in the course enrollment data using Florida's Course Code Directory (CCD), and for each student, I calculate the number of migrants entering the courses taken by the student averaged over all ELA and math courses. I then use this variable as an outcome in equation (1) and estimate the effect of the migrant share on the average number of entering migrants, broken down by the prior year achievement levels of the student.

[31] For example, middle and high school students in the anonymous district who score below the proficient level in ELA or math are required to take a regular course and a remedial course in that subject – instead of just one course – in the following year.

the likelihood of having at least one teacher (1) who was rated as "highly effective" (the highest teacher rating based on district-calculated value-added scores used in the district's high-stakes teacher evaluation system[32]) in the previous year; or (2) who was rated as "unsatisfactory" (the lowest rating) in the previous year or was new to the district in 2017-18 school year.[33] The results presented in Table 7 provide evidence suggesting that schools reallocate teachers within-grades, across-classrooms in a compensatory fashion, moving more effective teachers to the classrooms of lower-performing students that receive more migrants.

In particular, the estimated effects suggest that a 5-percentage point increase in migrant share reduces the likelihood of having a highly effective teacher by 7.73 percentage points (or by roughly 60 percent of the dependent variable mean) and increases the likelihood of being assigned to an "unsatisfactory" or a new teacher by 10.6 percentage points (44 percent of the dependent variable mean) for high-performing students who were proficient in both ELA and math in the prior year. In contrast, a similar increase in migrant share increases the likelihood of having a highly effective teacher by 12.35 percentage points (93 percent of the dependent variable mean) and reduces the likelihood of being assigned to an unsatisfactory or a new teacher by 8.9 percentage points (19 percent of the dependent variable mean) for students who were not proficient in both subjects. These reallocation effects are more pronounced for the highest-achievers (highest achievement level in both subjects) and the lowest-achievers. Migrant share

[32] Under the district's instructional personnel evaluation system, teachers' overall performance rating is determined by their instructional practice scores (67%) and value-added scores (33%). Teachers are classified into four distinct categories based on their value-added scores: (1) highly effective; (2) effective; (3) needs improvement; and (4) unsatisfactory. In the sample used in this analysis, roughly 5 percent of the teachers were rated as "highly effective" in the previous year and 18 percent were rated as "unsatisfactory" in the previous year or were new to the district in 2017-18 school year. State-calculated teacher value-added scores are not used in the district's teacher evaluation system and are not observed by principals or teachers.

[33] In particular, I use student level observations in this exercise where the outcome is an indicator that equals one if the student has at least one teacher with the corresponding attribute in an ELA or math course. The effects of migrant share are estimated using equation (1) controlling for school fixed-effects and the student covariates listed in the second panel of Table 3 along with the lagged ELA and math scores.

has no significant effect on the overall distribution of effective teachers across grades (first row of Table 7), providing evidence for within-grade, across-classroom reallocation.

Appendix Table 4 examines the effects of migrant share on teacher assignments in disadvantaged schools (accountability grade of "C" or lower *and* above median poverty) versus more advantaged schools (accountability grade of "A" or "B" *or* below median poverty) for high-performing and low-performing students, and shows that an increase in migrant share has a much larger effect on teacher reallocation in more resource-constrained settings. The results also suggest that resource reallocation is more pronounced in middle school where student achievement tracking is more common: a 5-percentage point increase in migrant share in middle school nearly doubles the likelihood of being assigned to an "unsatisfactory" or new teacher for high-performing students, and halves the same likelihood for low-performing students.

What could this reallocation imply for existing student outcomes? To answer this question, I examine the differences in teacher effects on current year test scores and disciplinary incidents between teachers rated as "highly effective" in the previous year and teachers rated as "unsatisfactory" in the previous year or who were new to the district. In particular, in a value-added framework I regress the test scores of students in grades 4 through 8 and disciplinary incidents of students in middle school (grades 6 through 8) on the prior year rating of the teacher assigned to that student, lagged dependent variable, school fixed-effects, and student demographics. The results indicate that students assigned to "highly effective" teachers score 0.23σ (0.08σ better in ELA) and are roughly 10 percent (of the dependent variable mean) less likely to be involved in a disciplinary incident[34] compared to students in the same school with

[34] While the teacher ratings used in this analysis are based solely on the test performance of students, there is evidence in the literature suggesting that high value-added teachers (based on test scores) also affect the non-test outcomes of their students (Jackson 2018).

similar prior achievement and disciplinary problems who were assigned to "unsatisfactory" or new teachers.[35] This finding provides evidence that teacher reallocation is an important factor behind the adverse effect of the migrant influx on high-performing students, especially in high-poverty or low-performing schools.[36]

These results, combined with the findings from the subgroup analysis, appear to imply that the short-term adverse effects are driven by a combination of negative classroom externalities and resource reallocation: For high-performing students, these two factors work in the same direction and lead to the observed adverse effects on the educational outcomes of these students. In contrast, for low-performing students, negative classroom externalities are likely offset by the compensatory resource reallocation across classrooms.

6. Second Year Effects

The findings presented in Table 1 reveal that roughly half of the hurricane migrants left the district before the beginning of 2018-19 school year. An important question then is the extent to which the first-year effects of the migrant influx persist in the second year. The top panel of Table 8 repeats the same analysis in Table 4, replacing the first year test scores, disciplinary incidents, and attendance of existing students with the outcomes in 2018-19 school year. In all cases, the results indicate precisely estimated zero effects - estimated coefficients in all cases are considerably smaller than the first year effects and, in some cases, have the opposite sign. For example, a 5-percentage point increase in migrant share increases math scores by a statistically

[35] Based on these numbers, if a 5-percentage point increase in migrant share increases the likelihood that a high-performing student is assigned to an "unsatisfactory" or new teacher (instead of a "highly effective" teacher) by 40 percent (as indicated by the results presented in Table 7), this would lead to a drop of 0.09σ in math scores and 0.032σ in ELA scores.

[36] It is important to note that the extent to which these estimates reflect teacher effects relies heavily on the extent to which the covariates included in the value-added model captures all the baseline differences between students assigned to different types of teachers. While providing evidence about the validity of value-added models is beyond the scope of this study, there is evidence in the literature suggesting that value-added models similar to the one used in this exercise successfully isolate the contribution of teachers on student outcomes (Chetty et al. 2014).

insignificant 0.5 to 1 percent of the standard deviation in the second year compared to a statistically significant 5.5 to 6 percent of the standard deviation decline in the first year.

Appendix Tables 5 breaks down the second-year analysis by student and school characteristics similar to Table 6. The overall weight of the evidence seems to suggest that the adverse effects of the migrant influx vanish entirely and even turn positive in the second year with a few exceptions. For example, the results suggest adverse effects of migrant share in 2017-18 on ELA scores and absence rates in high-poverty and low-performing schools, yet positive test score effects in lower-poverty schools in the second year.

There are several mechanisms that could explain the null effects in the second year. One possibility is differential attrition from the sample wherein the students who were most adversely affected by the migrant influx leave the district at the end of the first year. To investigate this mechanism, the bottom panel of Table 8 repeats the analysis in Table 4 conditional on observing the student in the sample in 2018-19 school year. If it is indeed differential attrition that is driving the second-year effects, one would expect significantly different first-year effects that are smaller in magnitude in this exercise. The estimated effects are almost identical to the first-year effects reported in Table 4, providing evidence against this hypothesis.

Second, the null effects in the second year could be driven by the change in the size and educational needs of migrants in schools after the first year. For existing students who remained in the district in 2018-19 school year, I find that a 5-percentage point increase in migrant share in 2017-18 increases the migrant share the student experiences in 2018-19 by only 0.7 percentage points, suggesting a significant decline in migrant share in the second year. Further, I find statistically significant, albeit smaller in magnitude, adverse effects of migrant share on second year test scores in schools where less than 20 percent of hurricane migrants left the district at the end of 2017-18 school year. In contrast, I find precisely estimated zero effects in schools where the majority of hurricane migrants left the district, providing suggestive evidence that the departure of hurricane migrants could have played a role in the observed null effects in the second year.[37] The null effects could also be explained by the changes in the educational needs of hurricane migrants. There is evidence in the literature suggesting that migrant achievement improves considerably in the years following their entry into the host community (e.g., Figlio & Özek, in press). This was also the case among the hurricane migrants: Migrants who stayed in the district in 2018-19 experienced test score gains of 0.45σ in math and 0.31σ in ELA, which could have reduced the need for school administrators to reallocate resources in the second year and mitigated the adverse effects on existing students.

Finally, additional funding and resources provided to the district by the state and the U.S. Department of Education, most of which arrived by the end of the first year, could have alleviated the negative effects in the first year. For example, school districts in Florida received $95.8 million in federal reimbursements to cover costs of taking in the Puerto Rican migrants in the aftermath of Hurricane Maria at the beginning of 2018-19 school year, which could have helped the district, for instance, hire new teachers to better accommodate the needs of hurricane migrants in the second year.

7. Concluding Remarks

]In this study, I examine the effects of internal migration driven by severe natural disasters on host communities using the large migrant influx of students from Puerto Rico into Florida public schools following Hurricane Maria. I find that an increase in migrant share

[37] It is important to note that the extent to which the discrepancy in second year effects between the two school settings can be attributed to differences in migrant attrition rates relies on how much the decision of leaving the district is correlated with school-level attributes (e.g., resources, peer characteristics).

significantly reduces existing student test scores in the first year, increases disciplinary incident rates in middle and high school, and increases the likelihood that existing students leave their schools before the start of the following school year. The results indicate that these first-year adverse effects are primarily driven by the effect on students who were high-performing in the prior year. I also find evidence suggesting that schools reallocate resources in a compensatory fashion when faced with a large migrant influx, assigning more effective teachers to classrooms with lower-performing students that receive more migrants, which could explain the adverse effects on higher-performing students in the first year. The adverse effects in the first year completely vanish in the second year. These findings suggest that the current cost estimates associated with severe natural disasters likely underestimate the true cost of these disasters. Further, they provide evidence that a large, unexpected migrant influx affects the educational outcomes of existing students through channels other than changes in peer quality, raising concern about using unexpected migratory flows to identify peer effects in education.

That said, there are several factors that could limit the external validity of these findings. For example, severe natural disasters typically create migration that is less predictable (and more transitory) than other climate change related incidents such as droughts or sea level rise. As such, the effects of climate migration due to severe natural disasters on host communities could be different than the effects of climate migration in general. Second, the effects of Hurricane Maria migrants could be more severe than other cases of internal climate migration due to natural disasters in the United States since Hurricane Maria migrants came from a region that is linguistically distinct than the host community that received them, yet I find significant short-term adverse effects in schools with higher shares of Spanish-speaking students, refuting this hypothesis. Finally, the effects of natural disaster-induced internal migration in developing countries that are more resource-constrained could be more severe than the effects of internal migration in a developed country, which I examine in this study.

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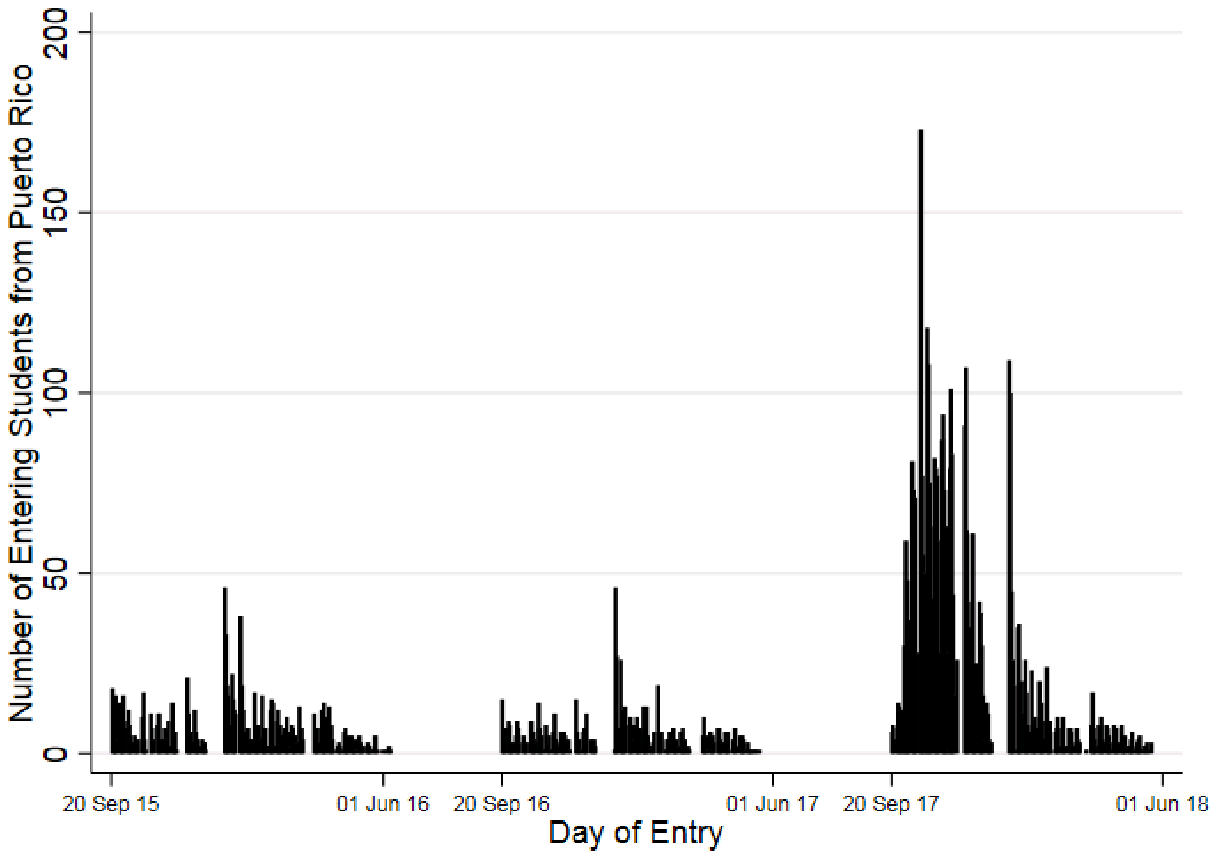
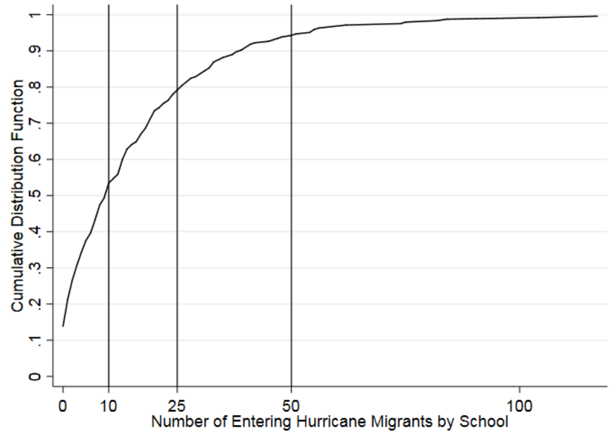
Figure 1 - Distribution of Puerto Rican Migrants in the Aftermath of Hurricane Maria Compared to Puerto Rican Migrants During the Same Time Frame in Prior Two School Years



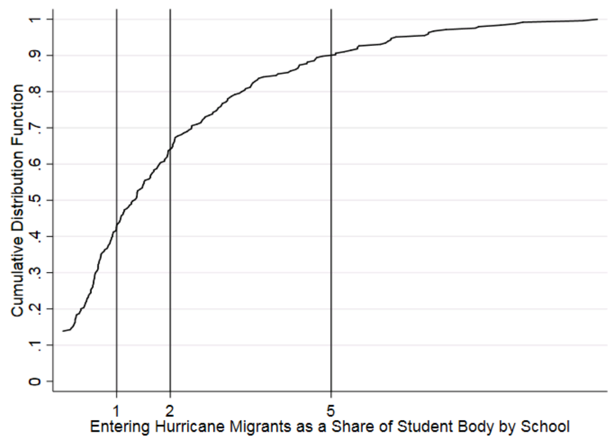
Notes: The figure presents the number of Puerto Rican students who entered the anonymous district for the first time between September 20, 2017 and June 1, 2018 by entry day, along with the number of Puerto Rican students who entered the anonymous district during the same time frame in the prior two school years.

Figure 2 - Distribution of Puerto Rican Migrants Across Schools

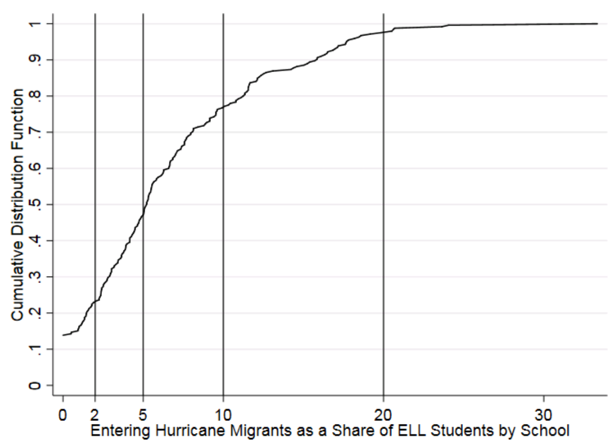
(A) Number of Migrants



(B) Migrants as a Share of Student Body



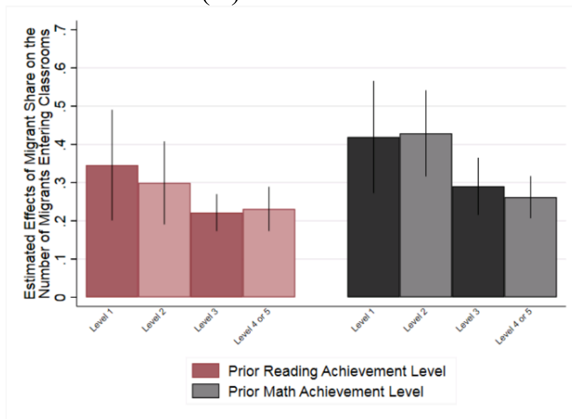
(C) Migrants as a Share of English Learner Students



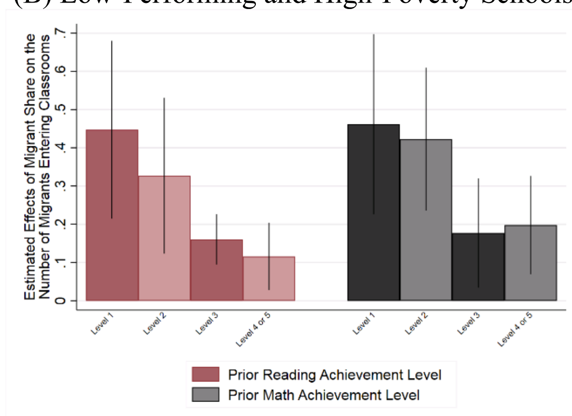
Notes: Figures present the cumulative distribution of (1) the number of Puerto Rican hurricane migrants by school in Panel A; (2) the share of Puerto Rican hurricane migrants by school in Panel B; and (3) the share of Puerto Rican hurricane migrants among English learner students by school in Panel C. The migrant shares in Panels B and C are multiplied by 100.

Figure 3 - Effects of Hurricane Migrant Share on the Number of Migrants Entering Classrooms, by Existing Student Prior Test Performance, School Poverty and School Performance

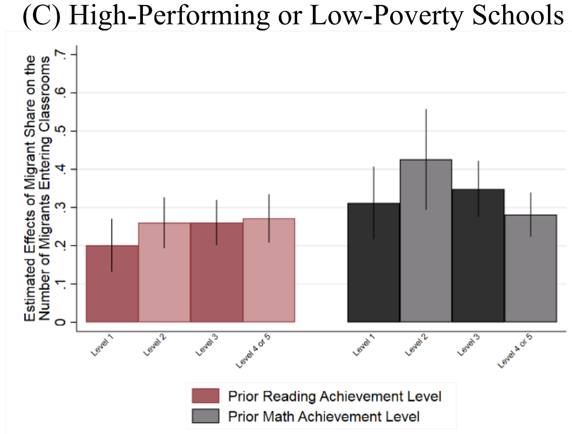
(A) All Schools



(B) Low-Performing and High-Poverty Schools



(C) High-Performing or Low-Poverty Schools



Notes: Bars in each figure represent the effect of migrant share on the number of migrants entering the classrooms of each student averaged across courses in English language arts and math between grade 4 and 8, broken down by school grade and student prior achievement. Spikes in each figure provide the 95% confidence interval for the corresponding estimate. Low-performing (high-performing) schools are defined as those with 2016-17 school grades of "C" or lower ("A" or "B") and high-poverty (low-poverty) schools are defined as those with above (below) median share of subsidized meal recipients. All regressions control for the baseline student characteristics listed in Table 1, and standard errors are two-way clustered at the school-by-grade level. The migrant share in each regression is multiplied by 100.

Table 1 - Differences in Student Characteristics and Outcomes between Puerto Rican Hurricane Migrants, Puerto Rican Migrants in Prior Two Years, and Existing Students

	(I)	(II)	(III)
	Hurricane Maria Migrants	Migrants in Prior Two Years	Existing students
Student characteristics			
Receives subsidized meals	95.06	82.55	68.78
	(21.66)	(37.96)	(46.34)
White	0.651	0.793	27.23
	(8.046)	(8.873)	(44.51)
Hispanic	98.67	99.05	40.27
	(11.45)	(9.712)	(49.04)
Black	0.651	0.159	25.35
	(8.046)	(3.981)	(43.50)
Special education	16.26	19.62	11.53
	(36.91)	(39.72)	(31.93)
English learner	83.89	74.14	13.96
	(36.77)	(43.80)	(34.66)
English non-native	94.16	88.79	30.92
	(23.45)	(31.56)	(46.22)
U.S. born			82.14
			(38.30)
Male	51.19	52.35	51.59
	(49.99)	(49.96)	(49.97)
Age (in days)	4014.6	3953.2	4346.8
	(1349.9)	(1339.6)	(1347.0)
First year outcomes			
ELA score	-1.316	-1.345	0.058
	(1.030)	(1.056)	(0.966)
Math score	-1.048	-1.118	0.051
	(1.055)	(0.982)	(0.975)
% absent days (0-100)	8.359	10.46	5.608
	(9.314)	(11.01)	(7.118)
Disciplinary incident	4.861	6.928	11.72
	(21.51)	(25.40)	(32.17)
Before the start of following school year -			
Left the school (excluding terminal grades)	61.78	45.06	24.41
	(48.60)	(49.77)	(42.95)
Left the district (excluding 12th grade)	48.67	29.22	12.45
	(49.99)	(45.49)	(33.02)
Second year outcomes			
ELA score	-1.004	-1.132	0.087
	(1.074)	(1.064)	(0.945)
Math score	-0.680	-0.824	0.052
	(1.074)	(1.030)	(0.971)
% absent days (0-100)	7.343	9.758	5.195
	(7.748)	(9.590)	(6.939)

Disciplinary incident	7.596	13.40	9.369
	(26.50)	(34.08)	(29.14)
Number of students	3,991	1,891	194,616

Notes: Standard deviations in parentheses. Column (I) presents the average outcomes of Hurricane Maria migrants from Puerto Rico in the first year after they entered the anonymous district (top panel) and other characteristics (bottom panel); column (II) presents the statistics for the migrants from Puerto Rico who entered the district after the September 21st of the prior two school years; and column (III) presents the statistics for the existing district students at the beginning of 2017-18 school year. The last row provides the number of students in the first year the migrants entered the school district. Indicator variables are multiplied by 100.

Table 2 – Estimated Associations between Existing Student Characteristics and the School Hurricane Migrant Share

Prior year outcomes	
ELA score	-0.047***
	(0.013)
Math score	-0.043***
	(0.012)
Disciplinary incident	-0.508
	(0.326)
% absent days (0-100)	0.193**
	(0.080)
Other student characteristics	
Born in Puerto Rico	1.687***
	(0.170)
White	-3.430***
	(0.558)
Black	-3.396***
	(0.716)
Hispanic	7.185***
	(0.487)
Male	11.304
	(13.795)
English non-native	4.321***
	(0.425)
U.S. born	-0.307
	(0.325)
Received subsidized meals	6.418***
	(1.059)
Special education	-0.207
	(0.518)
English learner	2.887***
	(0.398)
Age (in days)	-98.204*
	(53.310)

Notes: Standard errors, clustered at the school-by-grade level, are given in parentheses. The estimated coefficients represent the coefficient on the migrant share variable (in percentage points) in regressions where the dependent variable is the corresponding student or school-by-grade characteristic with and without school fixed-effects. *, **, *** statistical significance at 10, 5, and 1 percent levels. Indicator variables are multiplied by 100.

Table 3 – Estimated Associations between Existing Student and School-by-Grade Characteristics, the School-by-Grade Hurricane Migrant Share, and the Share of Age-Appropriate Hurricane Migrants by School-Grade

	School-by-Grade Hurricane Migrant Share		Age-Appropriate Hurricane Migrant Share by School-Grade	
	(I)	(II)	(III)	(IV)
School fixed-effects	No	Yes	No	Yes
Prior year outcomes				
ELA score	-0.037***	0.004	-0.045***	0.003
	(0.008)	(0.003)	(0.008)	(0.004)
Math score	-0.035***	0.004	-0.041***	0.008
	(0.008)	(0.006)	(0.008)	(0.005)
Disciplinary incident	-0.124	0.020	-0.042	0.047
	(0.114)	(0.096)	(0.114)	(0.102)
% absent days (0-100)	0.174***	-0.048***	0.186***	-0.030*
	(0.025)	(0.015)	(0.026)	(0.017)
Other student characteristics				
Born in Puerto Rico	1.232***	-0.046	1.287***	-0.041
	(0.079)	(0.045)	(0.083)	(0.046)
White	-2.240***	0.030	-2.566***	0.007
	(0.209)	(0.071)	(0.213)	(0.070)
Black	-2.391***	-0.084	-2.062***	-0.113*
	(0.255)	(0.064)	(0.252)	(0.066)
Hispanic	4.866***	0.042	4.902***	0.077
	(0.257)	(0.079)	(0.260)	(0.080)
Male	0.152***	-0.052	0.167***	0.021
	(0.053)	(0.086)	(0.056)	(0.087)
English non-native	2.930***	-0.185**	3.093***	-0.133
	(0.195)	(0.086)	(0.199)	(0.093)
U.S. born	-0.151	-0.015	-0.211**	-0.028
	(0.101)	(0.053)	(0.106)	(0.054)
Received subsidized meals	3.611***	0.010	4.065***	-0.014
	(0.363)	(0.066)	(0.373)	(0.066)
Special education	0.321***	0.030	0.298***	0.022
	(0.057)	(0.056)	(0.057)	(0.059)
English learner	1.613***	0.044	1.750***	0.037
	(0.120)	(0.087)	(0.127)	(0.098)
Age (in days)	-1.774***	0.080	-1.611**	0.498
	(0.593)	(0.489)	(0.653)	(0.530)
School-by-grade characteristics				
Number of existing students	-1.134	0.974	-0.995	0.927
	(1.354)	(0.977)	(1.455)	(1.064)
% teachers…				
who were highly effective	0.050	0.191	0.028	0.159
	(0.179)	(0.239)	(0.197)	(0.258)
with <3 years of experience	0.013	-0.343	0.090	-0.291
	(0.244)	(0.297)	(0.271)	(0.320)
who are new to the district	-0.041	-0.069	-0.038	-0.036
	(0.223)	(0.300)	(0.244)	(0.325)

Notes: Standard errors, clustered at the school-by-grade level, are given in parentheses. The estimated coefficients represent the coefficient on the migrant share variable (in percentage points) in regressions where the dependent variable is the corresponding student or school-by-grade characteristic with and without school fixed-effects. School-by-grade migrant share is defined as the number of Puerto Rican hurricane migrants who entered the school-grade between September 20, 2017 and the end of 2017-18 school year divided by the number of existing students in the school-grade at the beginning of 2017-18, multiplied by 100. *, **, *** statistical significance at 10, 5, and 1 percent levels. Indicator variables are multiplied by 100.

Table 4 – Effects of Hurricane Migrant Share on Existing Student Outcomes in 2017-18

	OLS		2SLS	
	(I)	(II)	(III)	(IV)
School fixed-effects	Yes	Yes	Yes	Yes
Student characteristics	No	Yes	No	Yes
Math score	-0.011**	-0.010*	-0.013**	-0.012**
(*N*=64,298)	(0.005)	(0.005)	(0.006)	(0.006)
ELA score	-0.009**	-0.008**	-0.007**	-0.007**
(*N*=87,352)	(0.003)	(0.003)	(0.003)	(0.003)
Disciplinary incident	0.128	0.134	0.162*	0.168*
(mean of *Y* = 12.03, *N*=167,730)	(0.084)	(0.084)	(0.088)	(0.088)
Disciplinary incident – middle or high school	0.529**	0.537**	0.542**	0.545**
(mean of *Y* = 17.23, *N*=99,584)	(0.260)	(0.263)	(0.269)	(0.271)
% absent days (0-100)	-0.007	-0.008	-0.006	-0.007
(mean of *Y* = 5.65, *N*=167,730)	(0.024)	(0.023)	(0.026)	(0.025)
Left school before the start of 2018-19	0.357***	0.366***	0.288**	0.294**
(mean of *Y* = 23.16, *N*=141,951)	(0.128)	(0.128)	(0.133)	(0.132)

Notes: Standard errors, clustered at the school-by-grade level, are given in parentheses. The first two columns present the coefficient on the migrant share variable (in percentage points) for the corresponding outcome of interest controlling for school fixed-effects without (column (I)) and with (column (II)) student covariates. The third and fourth panels present the 2SLS results instrumenting for the migrant share variable with the age-appropriate migrant share variable. Student covariates in columns labeled as (II) and (IV) include the characteristics provided in the second panel of Table 3 along with the lagged dependent variable. The F-stats in 2SLS regressions range between 2,786 and 9,440. *, **, *** represent statistical significance at 10, 5, and 1 percent levels. Regressions where the dependent variable is the indicator for leaving school before the start of 2018-19 school year exclude students in the terminal grades of their schools. Indicator variables are multiplied by 100.

Table 5 – Falsification Exercise: The Pseudo Effects of Hurricane Migrant Share on Existing Student Outcomes in 2016-17

	(I)	(II)
School fixed-effects	Yes	Yes
Student characteristics	No	Yes
Math score	-0.003	-0.003
(*N*=62,313)	(0.007)	(0.006)
ELA score	-0.000	-0.000
(*N*=84,932)	(0.004)	(0.004)
Disciplinary incident	0.017	0.038
(mean of *Y* = 11.94, *N*=164,094)	(0.101)	(0.101)
Disciplinary incident – middle or high school	-0.058	-0.040
(mean of *Y* = 12.03, *N*=167,730)	(0.277)	(0.279)
% absent days (0-100)	0.020	0.023
(mean of *Y* = 17.32, *N*=96,468)	(0.018)	(0.019)
Left school before the start of 2017-18	-0.155	-0.127
(mean of *Y* = 21.86, *N*=123,946)	(0.127)	(0.126)
	High-Performing Students	
Math score	-0.008	-0.010
(*N*=27,148)	(0.008)	(0.008)
ELA score	-0.000	-0.002
(*N*=32,829)	(0.004)	(0.004)
Disciplinary incident	-0.084	-0.063
(mean of *Y* = 11.94, *N*=33,862)	(0.194)	(0.194)
Disciplinary incident – middle or high school	-0.380	-0.389
(mean of *Y* = 12.03, *N*=21,574)	(0.384)	(0.386)
% absent days (0-100)	-0.002	0.002
(mean of *Y* = 17.32, *N*=33,862)	(0.023)	(0.023)
Left school before the start of 2017-18	-0.006	0.011
(mean of *Y* = 21.86, *N*=23,103)	(0.547)	(0.547)

Notes: Standard errors, clustered at the school-by-grade level, are given in parentheses. The first two columns present the coefficient on the migrant share variable (in percentage points) assigned to students in school *s* and grade *g* in 2016-17 school year in regressions where the outcome is the corresponding outcome of interest in 2016-17 controlling for school fixed-effects without (column (I)) and with (column (II)) student covariates. Student covariates in column labeled as (II) include the characteristics provided in the second panel of Table 3 along with the lagged dependent variable. The bottom panel repeats the same analysis for high-performing students who were proficient in both subjects in 2015-16 school year. *, **, *** statistical significance at 10, 5, and 1 percent levels. Indicator variables are multiplied by 100. Regressions where the dependent variable is the indicator for leaving school before the start of 2017-18 school year exclude students in the terminal grades of their schools.

Table 6 – Effects of Hurricane Migrant Share on Existing Student Outcomes in 2017-18, by Existing Student and School Characteristics

	ELA score	Math score	% absent days (0-100)	Disciplinary incident: middle or high school	Left school
Prior year proficiency					
Not proficient in ELA	-0.004	-0.008	-0.044	0.596	0.438
	(0.004)	(0.007)	(0.042)	(0.464)	(0.404)
Mean of Y			6.35	27.57	22.28
Proficient in ELA	-0.013***	-0.014**	0.036	0.949***	1.218***
	(0.004)	(0.006)	(0.022)	(0.349)	(0.437)
Mean of Y			4.66	9.54	13.33
Not proficient in math	-0.003	-0.002	-0.041	0.393	0.510
	(0.004)	(0.007)	(0.029)	(0.674)	(0.475)
Mean of Y			6.12	28.55	24.16
Proficient in math	-0.011***	-0.016**	0.035*	0.765**	1.124**
	(0.004)	(0.006)	(0.020)	(0.356)	(0.516)
Mean of Y			4.27	10.36	14.94
Race/ethnicity					
White	-0.011**	-0.007	0.002	0.333	0.631***
	(0.005)	(0.008)	(0.025)	(0.294)	(0.226)
Mean of Y			5.19	10.83	22.69
Hispanic	-0.007	-0.011*	-0.013	0.624*	0.168
	(0.004)	(0.006)	(0.028)	(0.318)	(0.159)
Mean of Y			6.33	16.40	23.58
Black	-0.005	-0.009	-0.030	-0.008	0.715***
	(0.005)	(0.008)	(0.033)	(0.527)	(0.270)
Mean of Y			5.39	28.19	26.73
English learner status					
English learner	-0.003	-0.005	-0.014	-0.183	0.190
	(0.007)	(0.007)	(0.025)	(0.569)	(0.245)
Mean of Y			5.77	19.72	26.10
Non-English learner	-0.009***	-0.012**	-0.009	0.602**	0.374**
	(0.003)	(0.006)	(0.028)	(0.275)	(0.149)
Mean of Y			5.63	16.99	23.26
Grade level					
Elementary (KG-5)	-0.004	-0.003	-0.009		0.293**
	(0.004)	(0.005)	(0.012)		(0.136)
Mean of Y			4.91		25.92
Middle or high (6-12)	-0.013***	-0.022	-0.019		0.516
	(0.005)	(0.014)	(0.092)		(0.360)
Mean of Y			6.21		21.72
School poverty					
Above median (≥70%)	-0.008**	-0.014**	0.018	0.398	0.225
	(0.004)	(0.006)	(0.028)	(0.336)	(0.161)

Mean of Y			6.02	21.36	24.54
Below median (<70%)	-0.005	0.004	-0.032	0.153	0.425**
	(0.005)	(0.011)	(0.034)	(0.286)	(0.205)
Mean of Y			5.26	13.78	22.80
School grade in 2016-17					
C or lower	-0.008*	-0.015*	-0.019	0.375	0.109
	(0.004)	(0.008)	(0.032)	(0.415)	(0.202)
Mean of Y			6.34	21.57	23.93
A or B	-0.008	-0.002	-0.017	0.593	0.448***
	(0.006)	(0.007)	(0.015)	(0.541)	(0.170)
Mean of Y			5.10	14.61	18.85

Notes: Standard errors, clustered at the school-by-grade level, are given in parentheses. Each entry represents the coefficient on the migrant share variable in 2017-18 (in percentage points) for the corresponding outcome of interest in 2017-18 and the student subgroup. All regressions control for school fixed-effects and the student covariates listed in the second panel of Table 3 along with the lagged dependent variable. *, **, *** statistical significance at 10, 5, and 1 percent levels. Indicator variables are multiplied by 100. Regressions where the dependent variable is the indicator for leaving school before the start of 2018-19 school year exclude students in the terminal grades of their schools.

Table 7 - Effects of Hurricane Migrant Share on Teacher Assignments in ELA and Math Courses in the First Year, by Student Prior Test Performance

	Teacher Characteristics	
	“Highly Effective” in 2016-17	“Unsatisfactory” in 2016-17 or new to the district
Overall	0.151	0.559
	(0.733)	(0.844)
Mean of Y	13.45	34.31
Prior achievement		
Highest level in ELA and math	-2.112**	2.321*
	(1.014)	(1.313)
Mean of Y	11.99	21.17
Proficient in ELA and math	-1.546*	2.118*
	(0.860)	(1.093)
Mean of Y	13.04	24.31
Not proficient in ELA and math	2.470***	-1.778*
	(0.851)	(0.973)
Mean of Y	13.35	47.33
Lowest level in ELA and math	2.814***	-2.349**
	(0.946)	(1.019)
Mean of Y	12.99	49.64

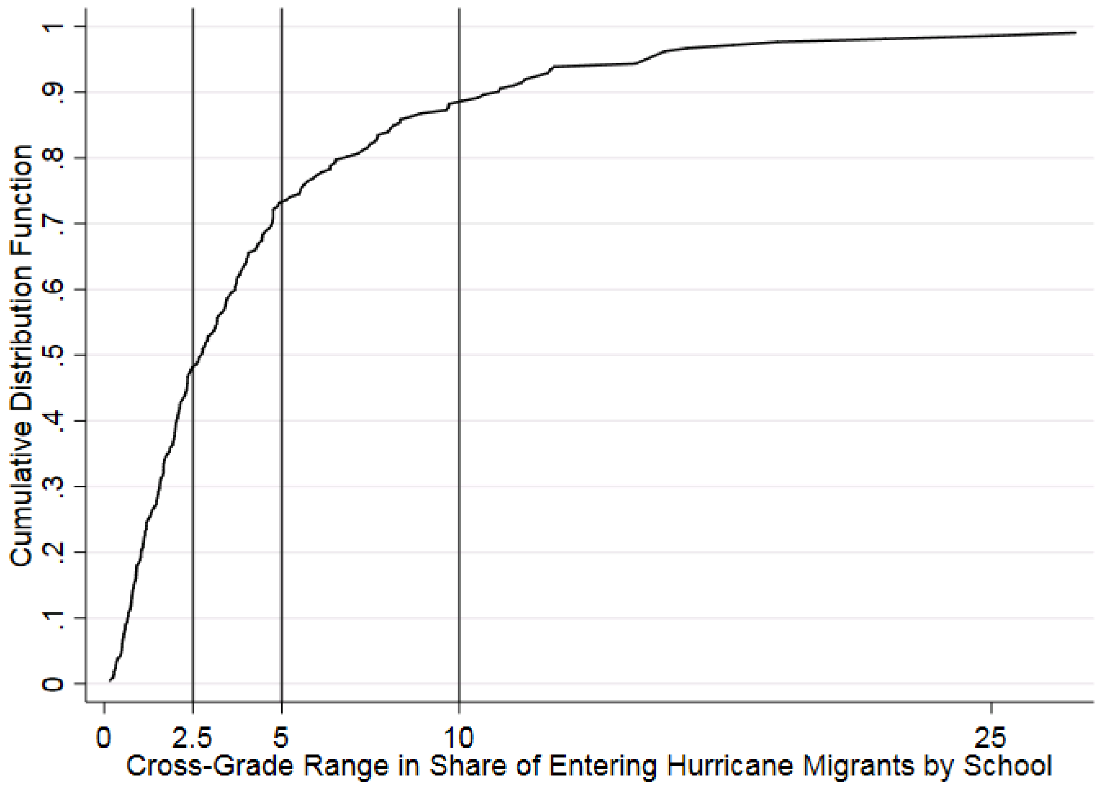
Notes: Standard errors, clustered at the school-by-grade level, are given in parentheses. Each coefficient presents the effect of a 1-percentage point increase in migrant share on the likelihood of having at least one teacher in an ELA or math course with the corresponding attribute, broken down by prior year achievement. All regressions control for school fixed-effects and the student covariates listed in the second panel of Table 3 along with the lagged ELA and math scores. *, **, *** statistical significance at 10, 5, and 1 percent levels. Indicator variables are multiplied by 100.

Table 8 – Effects of Hurricane Migrant Share on Existing Student Outcomes in 2018-19

	(I)	(II)
School fixed-effects	Yes	Yes
Student characteristics	No	Yes
Math score	0.001	0.002
(*N*=47,515)	(0.006)	(0.006)
ELA score	-0.004	-0.004
(*N*=69,338)	(0.004)	(0.004)
Disciplinary incident	-0.061	-0.057
(mean of *Y* = 9.56, *N*=142,323)	(0.082)	(0.082)
Disciplinary incident – middle or high school	-0.204	-0.198
(mean of *Y* = 13.56, *N*=79,787)	(0.303)	(0.300)
% absent days (0-100)	0.018	0.017
(mean of *Y* = 5.24, *N*=142,323)	(0.016)	(0.016)
First-year effects conditional on staying in the sample in second year		
Math score	-0.010*	-0.009*
(*N*=61,260)	(0.005)	(0.005)
ELA score	-0.010***	-0.009***
(*N*=83,564)	(0.003)	(0.003)
Disciplinary incident	0.143*	0.146*
(mean of *Y* = 12.01, *N*=142,323)	(0.083)	(0.083)
Disciplinary incident – middle or high school	0.641**	0.627**
(mean of *Y* = 17.89, *N*=79,787)	(0.311)	(0.316)
% absent days (0-100)	-0.018	-0.020
(mean of *Y* = 5.03, *N*=142,323)	(0.014)	(0.014)

Notes: Standard errors, clustered at the school-by-grade level, are given in parentheses. The first two columns present the coefficient on the migrant share variable (in percentage points) for the corresponding outcome of interest controlling for school fixed-effects without (column (I)) and with (column (II)) student covariates. Student covariates in column labeled as (II) include the characteristics provided in the second panel of Table 3 along with the lagged dependent variable. The top panel presents the second-year effects of migrant share whereas the second panel presents the first-year effects conditional on observing the student in the second year. *, **, *** represent statistical significance at 10, 5, and 1 percent levels. Indicator variables are multiplied by 100.

Appendix Figure 1 – Distribution of the Cross-Grade Range in Puerto Rican Migrant Share by School

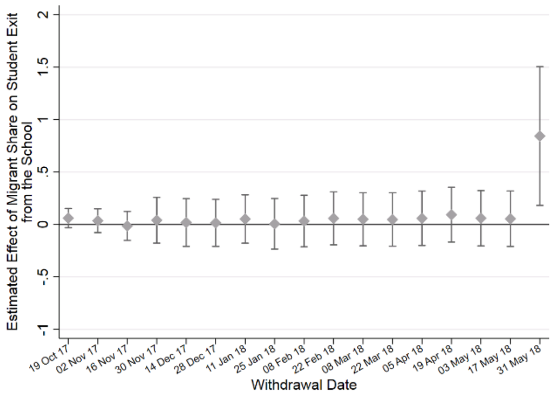


Notes: Figure presents the cumulative distribution of the cross-grade range in the share of Puerto Rican hurricane migrants by school. The migrant share is multiplied by 100.

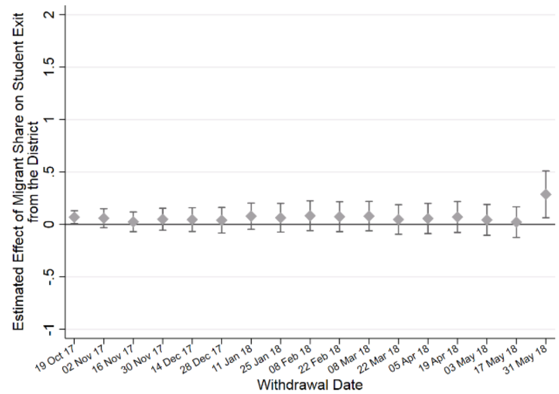
Appendix Figure 2 – The Effects of Migrant Share on Student Mobility During the 2017-18 School Year

All Students

(A) Outcome: Left the School in 2017-18 School Year by Withdrawal Date

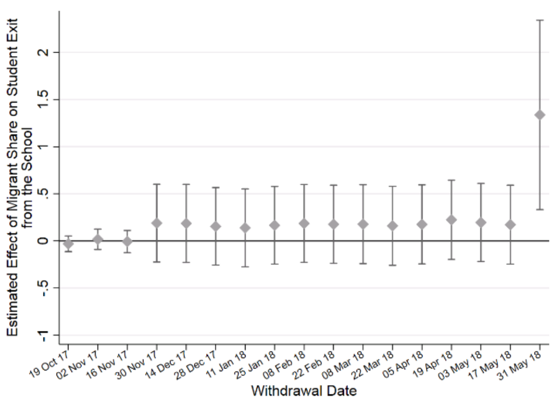


(B) Outcome: Left the District in 2017-18 School Year by Withdrawal Date

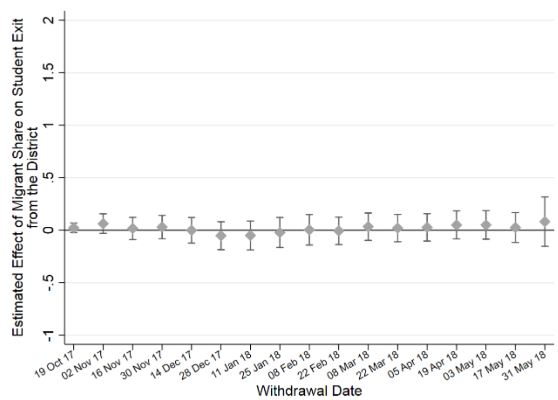


High-Performing Students

(C) Outcome: Left the School in 2017-18 School Year by Withdrawal Date



(D) Outcome: Left the District in 2017-18 School Year by Withdrawal Date



Notes: Each bar in Panel A presents the estimated coefficient (along with the 95% confidence interval) on the migrant share variable (using equation (1)) in regressions where the dependent variable is an indicator that equals 1 if the student left the school they attended at the beginning of 2017-18 school year by the date given on the x-axis (the last entry on the x-axis represents the end of school year). Panel B repeats the same analysis replacing the outcome with an indicator that equals 1 if the student left the district by the date given on the x-axis. Panels (C) and (D) repeat the same analysis for high-performing students who were proficient in both subjects in the previous school year. Regressions exclude students who were in the terminal grades of their schools.

Appendix Table 1 – Estimated Associations between Existing Student and School-by-Grade Characteristics, the School-by-Grade Hurricane Migrant Share, and the Share of Age-Appropriate Hurricane Migrants by School-Grade, Conditional on Staying in the District until the end of 2017-18 School Year

	School-by-Grade Hurricane Migrant Share		Age-Appropriate Hurricane Migrant Share by School-Grade	
	(I)	(II)	(III)	(IV)
School fixed-effects	No	Yes	No	Yes
Prior year outcomes				
ELA score	-0.036***	0.003	-0.037***	0.003
	(0.008)	(0.003)	(0.008)	(0.004)
Math score	-0.035***	0.004	-0.0342***	0.008
	(0.008)	(0.006)	(0.0088)	(0.006)
Disciplinary incident	-0.132	0.014	-0.1589	0.010
	(0.111)	(0.096)	(0.1207)	(0.103)
% absent days (0-100)	0.176***	-0.052***	0.1811***	-0.059***
	(0.022)	(0.014)	(0.0236)	(0.015)
Other student characteristics				
Born in Puerto Rico	1.204***	-0.058	1.304***	-0.047
	(0.077)	(0.048)	(0.082)	(0.053)
White	-2.294***	-0.002	-2.452***	-0.036
	(0.211)	(0.072)	(0.222)	(0.074)
Black	-2.381***	-0.073	-2.612***	-0.110
	(0.259)	(0.065)	(0.278)	(0.072)
Hispanic	4.918***	0.068	5.312***	0.106
	(0.256)	(0.081)	(0.270)	(0.086)
Male	0.174***	-0.034	0.192***	0.014
	(0.054)	(0.086)	(0.059)	(0.093)
English non-native	2.930***	-0.212**	3.216***	-0.187*
	(0.195)	(0.088)	(0.206)	(0.099)
U.S. born	-0.145	-0.015	-0.229**	-0.030
	(0.101)	(0.055)	(0.108)	(0.060)
Received subsidized meals	3.666***	0.020	3.877***	-0.011
	(0.367)	(0.068)	(0.391)	(0.070)
Special education	0.324***	0.024	0.303***	0.006
	(0.058)	(0.057)	(0.060)	(0.062)
English learner	1.581***	0.050	1.712***	0.036
	(0.119)	(0.091)	(0.127)	(0.103)
Age (in days)	-1.489***	0.067	-1.816***	0.063
	(0.494)	(0.473)	(0.548)	(0.511)
School-by-grade characteristics				
Number of existing students	-1.281	0.721	-0.912	0.658
	(1.344)	(0.879)	(1.527)	(0.996)
% teachers…				
who were highly effective	0.050	0.191	0.028	0.159
	(0.179)	(0.239)	(0.197)	(0.258)

with <3 years of experience	0.013	-0.343	0.090	-0.291
	(0.244)	(0.297)	(0.271)	(0.320)
who are new to the district	-0.041	-0.069	-0.038	-0.036
	(0.223)	(0.300)	(0.244)	(0.325)

Notes: Standard errors, clustered at the school-by-grade level, are given in parentheses. The estimated coefficients represent the coefficient on the migrant share variable (in percentage points) in regressions where the dependent variable is the corresponding student or school-by-grade characteristic with and without school fixed-effects for students who stayed in the district until the end of 2017-18 school year. School-by-grade migrant share is defined as the number of Puerto Rican hurricane migrants who entered the school-grade between September 20, 2017 and the end of 2017-18 school year divided by the number of existing students in the school-grade at the beginning of 2017-18, multiplied by 100. *, **, *** statistical significance at 10, 5, and 1 percent levels. Indicator variables are multiplied by 100.

Appendix Table 2 – Effects of Hurricane Migrant Share on Existing Student Disciplinary Problems in Middle and High Schools in 2017-18

	OLS		2SLS	
	(I)	(II)	(III)	(IV)
School fixed-effects	Yes	Yes	Yes	Yes
Student characteristics	No	Yes	No	Yes
Disciplinary incident	0.529**	0.537**	0.542**	0.545**
(mean of *Y* = 17.23, *N*=99,584)	(0.260)	(0.263)	(0.269)	(0.271)
Received suspension	0.088	0.099	0.117	0.123
(mean of *Y* = 12.48, *N*=99,584)	(0.217)	(0.220)	(0.227)	(0.229)
Received in-school suspension	0.043	0.052	0.070	0.075
(mean of *Y* = 10.97, *N*=99,584)	(0.207)	(0.209)	(0.217)	(0.218)
Received out-of-school suspension	-0.071	-0.063	-0.082	-0.076
(mean of *Y* = 4.34, *N*=99,584)	(0.139)	(0.138)	(0.146)	(0.144)

Notes: Standard errors, clustered at the school-by-grade level, are given in parentheses. The first two columns present the coefficient on the migrant share variable (in percentage points) for the corresponding outcome of interest controlling for school fixed-effects without (column (I)) and with (column (II)) student covariates. The third and fourth panels present the 2SLS results instrumenting for the migrant share variable with the age-appropriate migrant share variable. Student covariates in columns labeled as (II) and (IV) include the characteristics provided in the second panel of Table 3 along with the lagged dependent variable. The F-stats in 2SLS regressions range between 2,786 and 9,440. *, **, *** represent statistical significance at 10, 5, and 1 percent levels. Indicator variables are multiplied by 100.

Appendix Table 3 – Effects of Hurricane Migrant Share on Existing Student Outcomes in 2017-18, by Existing Student and School Characteristics

	ELA score	Math score	% absent days (0-100)	Disciplinary incident: middle or high school	Left school
School grade: C or lower					
Proficient in both subjects	-0.016***	-0.027***	0.096**	0.864***	0.914
	(0.005)	(0.010)	(0.042)	(0.295)	(0.761)
Mean of Y			4.42	9.96	16.04
Proficient in neither	0.003	-0.004	-0.047	-0.461	0.285
	(0.007)	(0.010)	(0.058)	(0.777)	(0.744)
Mean of Y			6.38	34.40	24.83
School poverty: above median					
Proficient in both subjects	-0.015***	-0.022***	0.073***	1.118***	0.999
	(0.005)	(0.007)	(0.025)	(0.312)	(0.655)
Mean of Y			4.39	9.71	15.79
Proficient in neither	-0.005	-0.006	-0.053	-0.277	0.222
	(0.005)	(0.007)	(0.037)	(0.718)	(0.582)
Mean of Y			6.33	32.71	24.66
Non-English learner					
Proficient in both subjects	-0.013***	-0.016***	0.052**	0.815**	1.331**
	(0.004)	(0.006)	(0.023)	(0.350)	(0.524)
Mean of Y			4.15	7.98	14.03
Proficient in neither	-0.004	-0.003	-0.070	0.309	0.640
	(0.005)	(0.008)	(0.043)	(0.822)	(0.710)
Mean of Y			6.20	32.70	24.75

Notes: Standard errors, clustered at the school-by-grade level, are given in parentheses. Each entry represents the coefficient on the migrant share variable in 2017-18 (in percentage points) for the corresponding outcome of interest in 2017-18 and the student subgroup. All regressions control for school fixed-effects and the student covariates listed in the second panel of Table 3 along with the lagged dependent variable. *, **, *** statistical significance at 10, 5, and 1 percent levels. Indicator variables are multiplied by 100.

Appendix Table 4 - Effects of Hurricane Migrant Share on Teacher Assignments in ELA and Math Courses in the First Year, by Student Prior Test Performance and School Poverty and Performance

	Low-Performing and High-Poverty Schools	
	Teacher Characteristics	
	"Highly Effective" in 2016-17	"Unsatisfactory" in 2016-17 or new to the district
Proficient in ELA and math	-0.408	3.481**
	(0.517)	(1.752)
Mean of Y	6.67	33.38
Not proficient in ELA and math	4.091***	-2.830**
	(1.266)	(1.362)
Mean of Y	8.87	51.63
	High-Performing or Low-Poverty Schools	
Proficient in ELA and math	-1.856	1.012
	(1.231)	(1.459)
Mean of Y	15.03	21.41
Not proficient in ELA and math	1.021	-0.541
	(1.139)	(1.172)
Mean of Y	17.35	42.57

Notes: Standard errors, clustered at the school-by-grade level, are given in parentheses. Each coefficient presents the effect of a 1-percentage point increase in migrant share on the likelihood of having at least one teacher in an ELA or math course with the corresponding attribute, broken down by prior year achievement, school performance, and school poverty. Low-performing (high-performing) schools are defined as those with 2016-17 school grades of "C" or lower ("A" or "B") and high-poverty (low-poverty) schools are defined as those with above (below) median share of subsidized meal recipients. All regressions control for school fixed-effects and the student covariates listed in the second panel of Table 3 along with the lagged ELA and math scores. *, **, *** statistical significance at 10, 5, and 1 percent levels. Indicator variables are multiplied by 100.

Appendix Table 5 – Effects of Hurricane Migrant Share on Existing Student Outcomes in 2018-19, by Existing Student and School Characteristics

	ELA score	Math score	% absent days (0-100)	Disciplinary incident: middle or high school
2016-17 proficiency				
Not proficient in ELA	-0.006	0.005	0.014	-0.365
	(0.005)	(0.007)	(0.043)	(0.535)
Mean of Y			6.61	21.10
Proficient in ELA	-0.002	-0.001	0.042	0.228
	(0.004)	(0.006)	(0.027)	(0.300)
Mean of Y			4.44	7.11
Not proficient in math	-0.008	0.002	0.030	-0.108
	(0.006)	(0.008)	(0.042)	(0.734)
Mean of Y			6.03	24.36
Proficient in math	-0.001	0.001	0.047*	0.202
	(0.005)	(0.007)	(0.025)	(0.306)
Mean of Y			4.04	8.42
Race/ethnicity				
White	0.006	0.009	0.024	-0.521*
	(0.006)	(0.009)	(0.029)	(0.297)
Mean of Y			4.72	7.58
Hispanic	-0.007	-0.001	0.009	-0.138
	(0.006)	(0.007)	(0.019)	(0.361)
Mean of Y			5.85	13.03
Black	-0.004	0.010	0.063*	-0.672
	(0.006)	(0.010)	(0.036)	(0.657)
Mean of Y			5.16	23.22
Grade level				
Elementary (KG-5)	0.001	0.006	0.014	
	(0.005)	(0.006)	(0.014)	
Mean of Y			4.42	
Middle and HS (6-12)	-0.010	-0.009	0.062	
	(0.008)	(0.018)	(0.061)	
Mean of Y			5.97	
English learner status				
English learner	-0.005	0.001	-0.027	-0.094
	(0.008)	(0.009)	(0.024)	(0.837)
Mean of Y			5.39	15.55
Non-English learner	-0.003	0.003	0.035*	-0.198
	(0.004)	(0.006)	(0.019)	(0.282)
Mean of Y			5.22	13.37
School poverty				
Above median	-0.008*	-0.005	0.053**	-0.341
	(0.005)	(0.007)	(0.021)	(0.489)
Mean of Y			5.66	17.97

Below median	0.013**	0.024**	-0.003	-0.235
	(0.006)	(0.011)	(0.029)	(0.272)
Mean of Y			4.80	9.76
School grade in 2016-17				
C or lower	-0.011**	-0.004	0.060*	-0.152
	(0.005)	(0.009)	(0.031)	(0.523)
Mean of Y			6.14	17.14
A or B	0.001	0.005	0.003	-0.329
	(0.006)	(0.009)	(0.016)	(0.566)
Mean of Y			4.67	11.16

Notes: Standard errors, clustered at the school-by-grade level, are given in parentheses. Each entry represents the coefficient on the migrant share variable in 2017-18 (in percentage points) for the corresponding outcome of interest in 2018-19 and the student subgroup. All regressions control for school fixed-effects and the student covariates listed in the second panel of Table 3 along with the lagged dependent variable. *, **, *** statistical significance at 10, 5, and 1 percent levels. Indicator variables are multiplied by 100.