Indirect Estimation of Student Net Flows and Dropout Rates:

Concepts and Examples

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Abstract

A new measure of dropping out, based on a modified demographic balancing equation, is a simple, robust measure that provides meaningful information about grade-by-grade attrition. The technique described in this article derives grade-specific net-flow rates and estimated measures of dropping out from graduation and grade-specific enrollment and retention counts. It is based on the demographic balancing equation, usable for small areas such as school districts, susceptible to adjustment for migration, and less susceptible to errors in administrative data sources than the most common current "dropout rate" used for school districts. Sample statewide calculations from Texas for three years (1998-99, 1999-2000, 2000-01) show stability in grade-specific measures for larger population groups and crucial grades. The statewide calculations for Native Americans in Texas show less stability, which may reflect the fact that net flows by population group measure the flow of classification in and out of categories as well as in and out of schools.

Indirect Estimation of Student Net Flows and Dropout Rates: Concepts and Examples

There is significant need for new, accurate measures of students flowing into and out of public schools as a way of estimating graduation and dropping out. More states are using standardized tests as a gatekeeper for high school graduation, and there is an ongoing debate over the alleged relationship between these tests and dropping out (Gayler, Chudowsky, Kober, & Hamilton, 2003). In part because of this debate, several researchers are developing measures of graduation (and dropping out) because existing measures are problematic (e.g., Greene, 2001; Swanson, 2004; Warren, 2003). Existing measures do not use demographic principles. Existing measures (and several in development) are either population-based (and not usable for small jurisdictions) or rely on administrative data without appropriate models for handling the effects of net migration or retaining students in grade.

The measure described below uses a variation of standard population models. Published administrative school records typically aggregate information by grade, not age, and it is very hard to calculate the mean length of time spent in each grade. One thus cannot readily calculate tables of school life from published administrative data. Yet grade-specific measures are still useful, and one can estimate student net flow and dropping out indirectly. The proposed method estimates net flow of students year by year, so that information about the potential effects of policies are available before a grade cohort has finished its K-12 career.

Background

Current controversies over graduation exams have spurred renewed interest in dropping out and graduation as key outcomes tied to specific policies. The series of federal reports on dropout rates, most recently Kaufman, Alt, and Chapman (2001), have relied heavily on the

Current Population Survey, using survey data to supplement administrative data sources. For several reasons, described later this in this section, population-based measures have significant advantages over measures that rely on administrative sources. Yet administrative sources are easier to obtain, and population-based measures are only usable for large areas such as states and cannot be easily applied to public schools alone. Thus, having a robust, meaningful measure that only needs administrative sources would provide a valuable source of information on dropping out at a time of increased debate over graduation exit exams and the effects of other high-stakes accountability policies (Swanson, 2004).

Exit Exams and Graduation

One relevant policy question tied to measures of graduation and dropping out is whether additional requirements for high school graduation—most specifically, exit exams—are reducing high-school graduation in individual states. Haney's (2000) work on Texas argued that the exit exam in Texas in the 1990s increased dropping out and did so with a disproportionate impact on African-American and Latino students. Amrein and Berliner (2002) argued that this consequence was true for high-stakes states more generally. Others have been less critical of the exams (e.g., Beatty, Neisser, Trent, & Heubert, 2001; Bishop, Mane, & Bishop, 2001; Carnoy & Loeb, 2003; Lillard & DeCicca, 2001; Warren & Edwards, 2003), acknowledging the difficulties with data collection, the limits of current measures of graduation and dropping out, and the potential conflation of exit test consequences with socioeconomic status and other increasing requirements (including higher course requirements).

Current Measures of Graduation and Dropping Out

There are two types of measures of student attainment or failure that are commonly used in the U.S. currently or are in some stage of development: population-based measures using Census data, on the one hand, and administrative-record measures that rely on published information about student enrollment and either dropout or graduation registers (e.g., Kaufman, et al. 2001; Kominski, 1990; Snyder & Hoffman, 2002; Young, 2003). Some are more sophisticated than others, and some have a clearer interpretation than others. None of these measures uses a mathematical demographic model as a basis for the measure.

Graduation and dropping out as transitions

If one looks at the act of leaving school enrollment as a decrement process, dropping out and graduation are logical candidates for survival (also known as event-history) analysis (e.g., Singer & Willett, 2003). And, given the appropriate data, *initial* acts of school-leaving can be analyzed with longitudinal tools. School enrollment is more complex, in two ways. First, students do not just leave school. They also enter, re-enter, and move. Graduation and dropping out are part of a multi-state process whose transitions also include initial enrollment, returning to school, transferring between schools, and death. There are examples of multi-state life tables of schooling that accommodate the complex enrollment history of children (e.g. Land & Hough, 1989). However, multi-state life tables of schooling require appropriate data that are unavailable for tables of school life for individual school districts and states. An alternative framework, used in the proposed method, is to look at the collective net flow of students in and out of schooling.

Population-based measures

Three population-based measures of dropping out and high school graduation are feasible at the state and national level: the ratio of diplomas to the 17-year-old population; the proportion of a population with a high-school diploma (typically among 18 to 24-year-olds), and the proportion of a population out of school without a high-school diploma (commonly among 16 to 24-year-olds). (See Kominsky, 1990, for an earlier discussion of different measures from the U.S. Census Bureau’s perspective.) The advantages of using population-based measures are both a relatively clear interpretation of the latter two measures and also the ability to rely on the Census Bureau for technical expertise in estimating or surveying the population for all three measures. There are some technical disadvantages, however. Except for decennial census years, the latter two numbers rely on the Current Population Survey, which covers only the noninstitutionalized population (and thus differentially covers population groups by their propensity to be noninstitutionalized at the relevant ages, generally between 15 and 24). The Current Population Survey also relies on self-reported attainment and has changed its measures of educational attainment—specifically, what counts as high school graduation—several times in the last 15 years (Kaufman et al., 2001). For those measures that combine the regular diploma and other credentials, using a broad age range for young adults (e.g., the percentage of those 18 to 24 years old out of high school and with a diploma or other credentials) includes those who have just left schooling and also those who have had a chance to return for some credential; it thus underestimates eventual attainment for those who return for alternative credentials and simultaneously overestimates ordinary high-school graduation. The diploma-to-17-year-old ratio may be misleading where the average age at graduation moves up or down (though the distortion is minimal, compared to other measures). Most importantly, however, the population-based measures are only possible to calculate at the state, regional, and national levels (and they are problematic for small states, except for the decennial census). Population-based measures cannot currently (or foreseeably) be used to measure dropping out or graduation at the district or school level.

Administrative-record measures

While several measures of dropping out and graduation use administrative records and thus can apply to the district or school level, the ones in use or development have more technical problems than population-based measures, because they rely on the accuracy of administrative records and often fail to adjust for migration or changing sizes of cohorts.

The "dropout rate." The event dropout rate (used in a few reports in the 1960s and in federal reports since 1988) has been the ratio of counted dropouts to the 9th-grade to 12th-grade enrollment in a year. This dropout rate reflects changing cohort sizes and changing grade-retention (or flunking) patterns as well as any underlying attrition rate. It also depends on the accurate labeling of exiting students as dropouts (as opposed to transfers) and is thus vulnerable to administrative gaming, as investigations into fraud in Houston's schools have shown (e.g., Bailey, Franzen, Gonzalez, & Mason, 2003).

Longitudinal measures. True longitudinal tracking of students from 9th grade to graduation is attempted by Florida's Department of Education, which calculates 4-year and 5-year graduation proportions (Florida Department of Education, 2002). Accurate longitudinal tracking is the best measure for individual cohorts of students who begin schooling at a specific grade (in Florida's case, 9th grade). It is not sensitive to year-to-year changes in dropping out, however, and does not account for students who move between schools. Moreover, longitudinal tracking is restricted to states that have effective student databases. Even in states with electronic databases such as Florida, tracking individual students is problematic, because the databases are maintained for annual records rather than longitudinal tracking. Several researchers have noted discrepancies and problems when trying to turn annual school databases into longitudinal databases (e.g., University of Florida Maternal Child Health and Education Research and Data Center, 2001).

Quasi-longitudinal measures. Several researchers have tried quasi-longitudinal tracking, comparing the enrollment at grades 8 or 9 with the number of diplomas earned four or five years later. Greene calculates quasi-longitudinal graduation rates without adjustment for migration or changing rates of grade retention (see Greene, 2001; Greene & Forster, 2003; Greene & Winters, 2002). Swanson (2004) calculates quasi-longitudinal graduation rates with synthetic cohorts, again without adjustments for migration or changing rates of grade retention. Warren (2003) adjusts for migration at the state level using Current Population Survey data—a definite improvement but one limited to state-level analyses. There are other variations on quasi-longitudinal measures (e.g., Haney, Madaus, Abrams, Wheelock, Miao, & Gruia, 2004), but the technical concerns about migration between years remains.

Because there is not yet a measure of graduation and dropping out that is robust at the level of an individual district or small state and that is satisfactory both on technical grounds and as a clear measure of dropping out, there are certain to be minor variations of the measures described above. But the concerns expressed here—the inability of population measures to apply to small states or individual districts and the difficulties with administrative records—will apply to all of them. There is a need for a technically-robust set of measures of student flow in and out of schools that is sensitive to year-to-year changes, that one might separate from net migration, and that might be used to identify discrepancies in administrative records (or be robust to errors in those records).

Method

This section describes the necessary data sources and algorithm of measuring student flow in and out of schools during individual grades. The unique aspect of this measure is its use of a demographic model. In the case of schools, published administrative records typically disaggregate information by grade, not age, and one has no information about the length of time spent in each grade. Thus, one cannot readily calculate life-table measures for school life. Yet grade-specific measures are still useful, and one can estimate student net flow indirectly using an algorithm based on standard demography, if one reconceptualizes age intervals as grades.

Data sources

The information necessary to estimate grade-specific net flow includes student enrollment by grade at two points in time, the intersurvey number of graduates, and an intersurvey measure of the students in each grade who are in that grade for the first time. Except for the first-time-in-grade count, the Common Core of Data has provided everything for all public school districts in the U.S. since 1986. One can estimate first-time-in-grade (or promotion) counts using grade-specific retention data, as described below.

Derivation of Algorithm

The proposed algorithm uses a version of the variable-growth-rate concept that Preston and Coale (1982) developed and Coale (1985) simplified.[1] One starts with the balancing equation of demographics, growth = births – deaths + net in-migration, whether expressed as raw counts or as rates (or flows). This equation is a demographic tautology applied to any population. One can state the same equation for a specific age interval or, for schooling, a bounded stage (such as a grade): growth = promotions into grade – promotions out of grade + net in-migration. One can reorder the terms of that definition:

$$\mathrm{NM}(x,a,b) = \mathrm{N}(x,b) - \mathrm{N}(x,a) + \mathrm{PR}(x,a,b) - \mathrm{PR}(x\text{-}1,a,b) \quad [\mathbf{1}],$$

where $\mathrm{NM}(x,a,b)$ is the raw count of net in-flow into enrollment in grade x between time a and b, $\mathrm{N}(x,a)$ is the enrollment in grade x at time a, and $\mathrm{PR}(x,a,b)$ is the number of students promoted *out of* grade x (to grade $x+1$) between time a and time b. Equation **1** is a simple description of net flows (and flow rates, when divided by the average enrollment). With enrollments grade-by-grade at two points in time, what is necessary is an estimation of $\mathrm{PR}(x,a,b)$ from available data: how many students were promoted?

To simplify calculations, consider the case where all students are promoted or retained at the end of the period in question, at time b. Let $\mathrm{pr}(\mathrm{x})$ be the promotion rate *out of* grade x, to grade $x+1$. One can consider $\mathrm{N}(x,b)$ to be the sum of those promoted out of grade $x-1$ at time b and the sum of those retained in grade x at time b. Then

$$\mathrm{N}(x,b) = \mathrm{PR}(x,a,b) + \big(\mathrm{N}(x,a) + \mathrm{NM}(x,a,b)\big)*\big(1-\mathrm{pr}(x,b)\big) \; [\mathbf{2a}] \text{ or}$$

$$\mathrm{PR}(x,a,b) = \mathrm{N}(x,b) - \big(\mathrm{N}(x,a) + \mathrm{NM}(x,a,b)\big)*\big(1-\mathrm{pr}(x,b)\big) \; [\mathbf{2b}].$$

Equations [**1**] and [**2b**] can be calculated iteratively from grade-specific enrollment and retention data, if the enrollment count is close to the start of a school year (such as October enrollment figures in the Common Core of Data). There are two additional assumptions required. One concerns the promotions *into* the lowest grade (kindergarten). In the samples described later, the assumption is that all kindergarteners who are not retained are automatically promoted into kindergarten from preschool (or "promoted" from home). In addition, one must make an assumption about the relationship between official retention rates, calculated for students who were enrolled at some point in the prior academic year (or a shorter interval), and the retention rates of students who migrate into the jurisdiction over the summer (or otherwise outside the frame of the jursidiction's retention calculation). In this article, calculations assume that the reported retention proportions are identical for all relevant populations included in $\mathrm{N}(x,b)$. With those assumptions, from enrollment figures at two points (typically the early fall of two successive years), grade-specific retention rates, and the numbers of graduates between those two points for enrollment figures, one can estimate grade-specific flow rates for students absent the growth in first-time-in-grade enrollments (and graduation, for grade 12).

*Interpretation of nm(*x*)*

Net-flow (the left side of equation **1**) is a residual category, and it includes most ways that students enter and leave a school population: transferring in, returning from dropout status, transferring out, dropping out, and dying. (When the estimate is for a population subgroup, such as by race/ethnicity, disability, or free-lunch status, one additional possibility is reclassification of the student.) This measure of net flow does not solve the question of which students schools are “responsible for” retaining and graduating. It simply describes the net flow. One can make an assumption to get closer to the rate that describes students leaving school on a semi-permanent basis: because mortality for elementary and secondary ages (6-18) is under 0.1% and the mid-teen years are the low point in most populations for migration (Centers for Disease Control, 2004; Rogers & Castro, 1981), one can use the net-flow rate for earlier grades (in the examples used later, the averaged net flow for grades 2-7) as an estimate of net migration and mortality combined and measure variation from that average, nm'(*x*), as an estimate of net flow due to dropping out and returning in school beyond 7th grade.

Sample Calculations

This section shows the results of the method when applied to jurisdictions with appropriate data sources. The Texas Education Agency (2002) provides retention data by grade at the state (and local) level. October enrollment by grade and graduation data is available from the Common Core of Data. Table 1 summarizes the estimation of the net-flow of students for each grade, nm(*x*), in Texas for the interval between October 2000 and October 2001.

Table 1. Net flow calculations for Texas public schools, 2000-01

Grade	Enrollment October 2000	Enrollment October 2001	Retention rates, 2000-01 (%)	NM(x) (final estimate)	PR(x) (final estimate)	nm(x)	nm'(x)
					293168		
K	294217	302859	3.2	17926	302451	0.0609	0.0461
1	320752	323133	6.3	7526	307597	0.0235	0.0086
2	316896	319249	3.6	6778	312022	0.0214	0.0065
3	316535	320083	2.5	5903	314377	0.0186	0.0038
4	313731	318842	1.4	5216	314481	0.0166	0.0018
5	311638	317320	0.9	3763	312562	0.0121	-0.0028
6	308392	317578	1.6	5113	308489	0.0166	0.0017
7	310696	316287	2.5	1220	304119	0.0039	-0.0109
8	304419	310762	2.1	11937	309713	0.0392	0.0243
9	360704	366895	17.4	-32070	271452	-0.0889	-0.1038
10	287355	293235	8.1	-18429	247143	-0.0641	-0.0790
11	248570	260674	5.9	-19229	215810	-0.0774	-0.0922
12	219943	226429	4.7	5992	215316	0.0272	0.0124
2000-01 diplomas:		215316		Average, grades 2-7:		0.0149	

Sources: Common Core of Data; Texas Education Agency.

Figure 1. Calculation of student net flow, 2000-01, Texas public schools

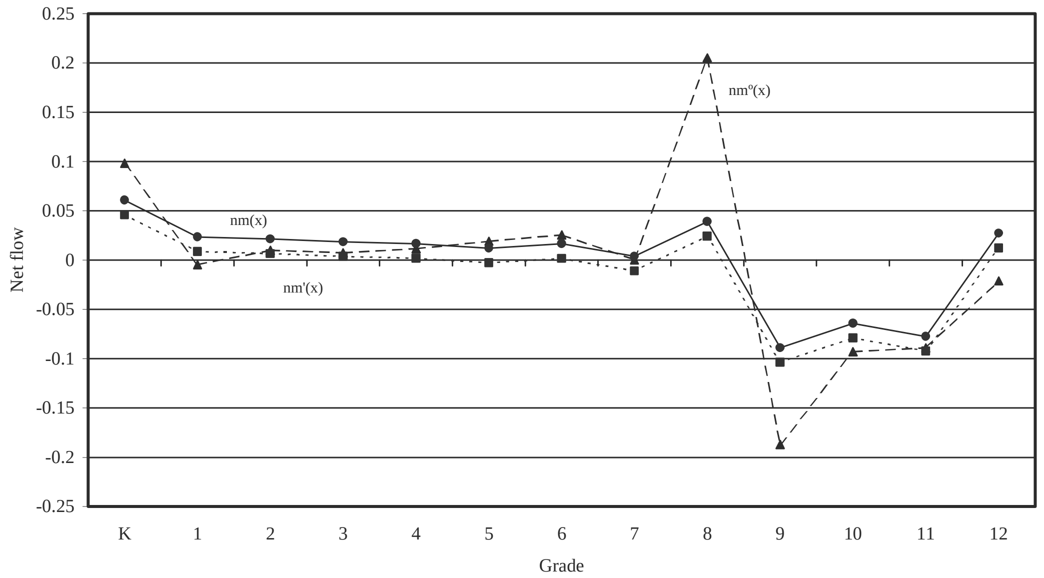


Figure 1 displays three lines: nm(x), nm'(x) (the deviation of nm(x) from the average nm(x) for grades 2-7), and the estimate of net flow one would make *if one did not account for retention*, nm^o(x). The dashed line with triangle points shows nm^o(x), calculated without including grade-level retention data, and reveals the misestimate one risks when not adjusting for retention. In essence, that misestimate is the result of using only enrollment and graduation data and assuming that all enrollees are first-time-in-grade students. The unadjusted (dashed) line overinflates the implied dropout rate at 9th grade and implies that there is a large net influx of students at 8th grade. The dotted line with squares is nm'(x), the deviation of grade-specific net flow from the grade 2-7 average net flow. In this year, for Texas, the average nm(x) for grades 2-7 is 0.0149. Respective averaged nm(x) for white, African-American, Hispanic, Asian-American, and Native American second- through seventh-grade students in Texas in 2000-01 are 0.0020, 0.0127, 0.0245, 0.0616, and 0.0502. The resulting nm'(x) line implies that net attrition in the high-school years was greatest in ninth grade, with nm'(10) = -0.104. Ninth grade also had the highest retention rate, 17.4 percent (see Table 1).

Figure 2. Texas grade-specific net flows (nm(x)), by race/ethnicity, 2000-01

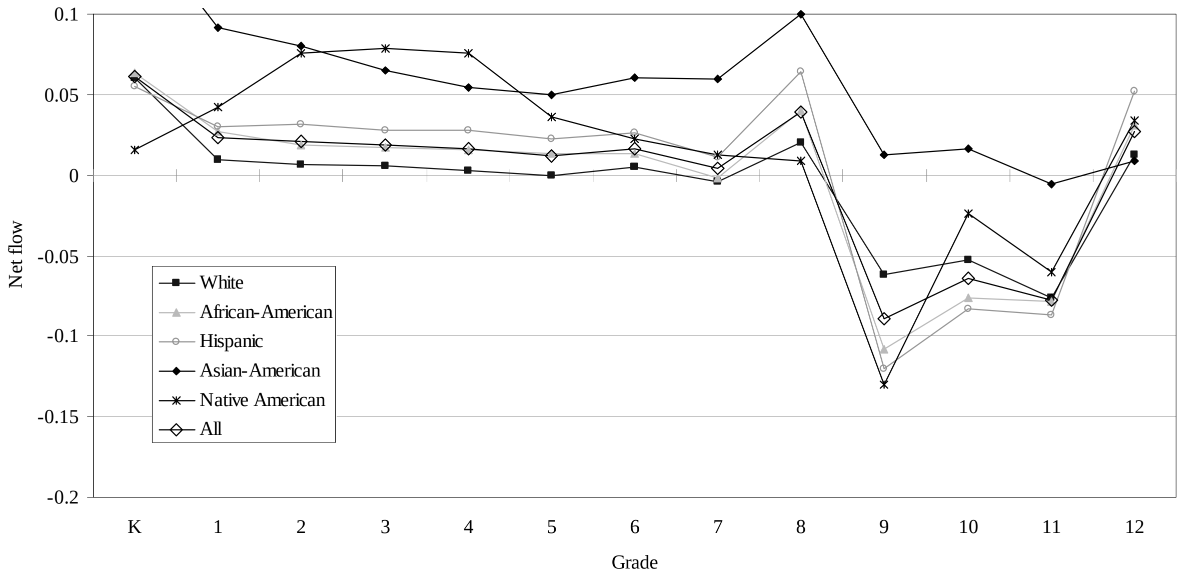
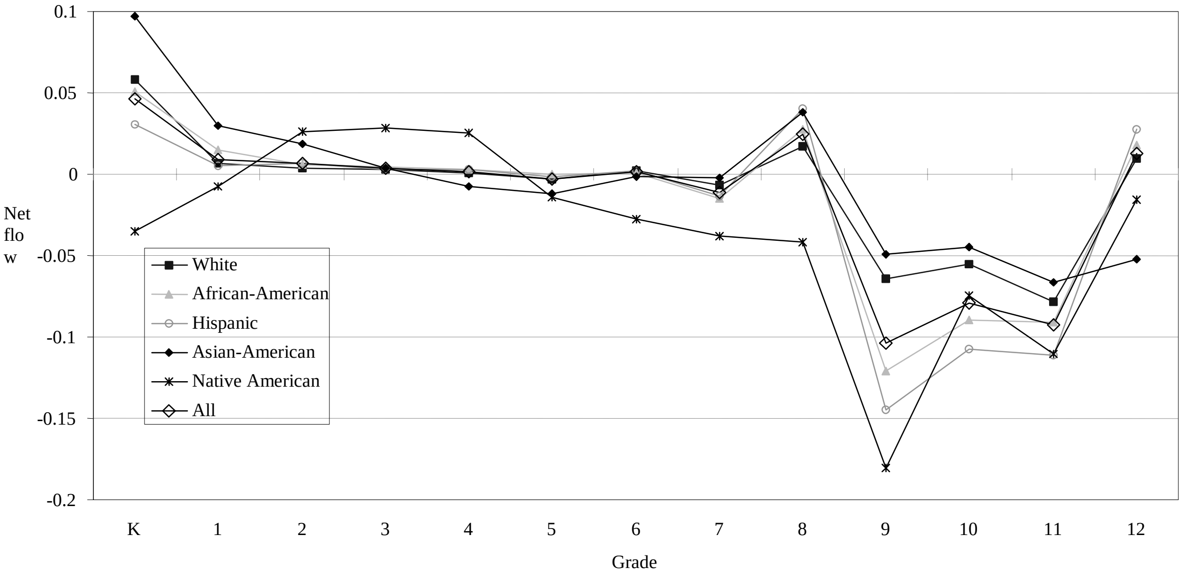


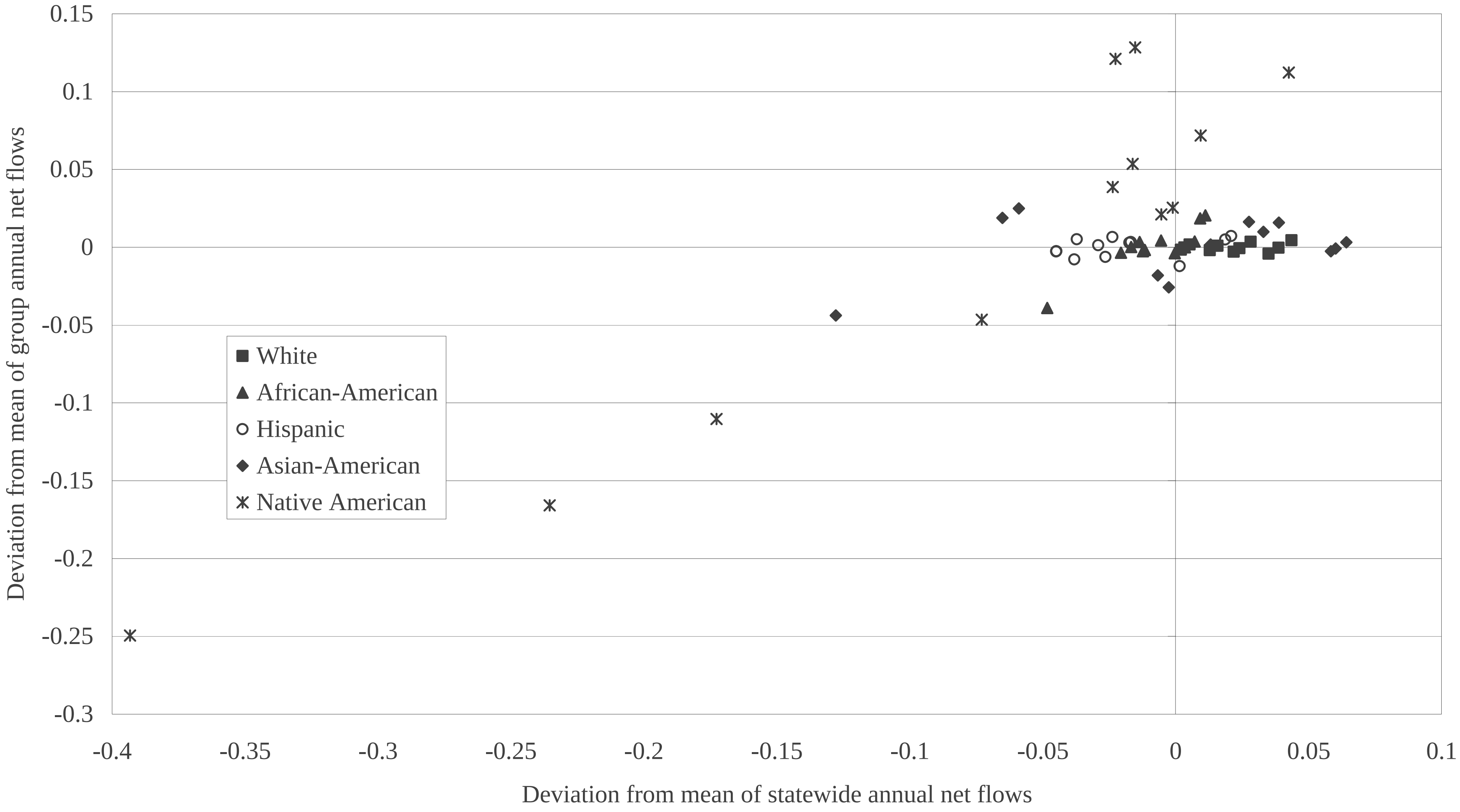
Figure 3. Texas grade-specific net flows adjusted for mean 2-7 flow (nm'(x)), by race/ethnicity, 2000-01



Figures 2 and 3 show group-specific sets of nm(*x*) and nm'(*x*), respectively, for Texas public schools in 2000-01. Unadjusted, each set of nm(*x*) suggests very different sets of net flow. In fifth grade, for example, the estimated net flow for Asian-American students in Texas in 2000-01 was 0.050, while it was 0.000 for white students in Texas, and each racial/ethnic group is separated by at least 0.01. After adjusting for the average net flow in grades 2-7, the net flows for all groups are between -0.015 and 0 for fifth grade (see Figure 3). With all subgroups, the greatest attrition in the adjusted net flows is between ninth and eleventh grades (inclusive).

Figure 4 shows variation of grade-specific nm'(*x*) for grades 9-12 and five race/ethnicity groups in Texas, for three years in 1998-2001, around the averaged annual nm'(*x*) for the statewide student population in that grade and around the averaged annual nm'(*x*) for that group and grade for 1998-2001. For example, Hispanic nm'(9) for 2000-01 was -0.145, -0.037 away from the statewide three-year average of annual nm'(9) (-0.108) and 0.005 away from the Hispanic three year average of annual nm'(9) (-0.150), creating the point (-0.037,0.005). The horizontal axis represents grade-specific deviation from the smoothed statewide nm'(*x*), and the vertical axis represents grade-specific deviation from the smoothed group-specific nm'(*x*). Except for Native Americans, all high-school deviations were less than 0.05 from the smoothed group-specific, grade-specific nm'(*x*), and of the other four population groups in grades 9-11, only Asian-American 10th graders in 1998-99 were more than 0.02 from the smoothed group-specific, grade-specific nm'(*x*) (-0.0257).

Figure 4. Deviations of grade 9-12 net flows from state and group means, by group, Texas public schools, 1998-2001



Discussion

The initial use of this method to estimate student net flows with Texas data from 1998-2001 suggests that indirect estimation of net flows is feasible, estimates general net migration that is consistent with other sources, and results in reasonably stable estimates. In 18 combinations of years and population groups, estimates of NM(x) and PR(x) all converged within 8 iterations, using a least-squared difference criteria and a threshold of 5 estimated students (summed across grades and both measures). The average of grade 2-7 net flows (0.0149), as an estimate of mortality, net migration, and transfers, is consistent with a state population growing with considerable net in-migration, if somewhat less than Texas' annualized 2.1 percent growth rate in 1990-2000 (Murdock, White, Hoque, Pecotte, You, & Balkan, 2002).

Figure 4 suggests the general stability of estimates of nm'(*x*). With the exception of Native Americans, year-to-year differences of grade-specific net flows are low, with all annual estimates within 0.050 of the averaged group-specific estimate for 1998-2001, and with most within 0.020 of the averaged estimate. The exceptions are four net flows for twelfth grade and one net flow for tenth grade (Asian-American students in 1998-99). The figures for Native American students represents an anomaly. It may reflect inconsistency in race/ethnicity classification, since one route in and out of a subgroup category is reclassification, and there is no verification check for Common Core of Data figures (Swanson, 2004).

There are several advantages to the proposed algorithm. First, it is based on demographic principles (and an extension of the balancing equation). That base allows the algorithm to be used at a local level, because the algorithm does not depend on population information to adjust for migration over several years. Unlike the longitudinal tracking currently in use in Florida, the proposed method does not eliminate the experiences of students who move into a jurisdiction after a baseline grade. Also, the algorithm directly and clearly addresses the problem of grade retention. Estimated net flows for Texan eighth graders were still positive for 2000-01 (see Figures 1 and 3), but the obvious distortion is minimal (and can be accounted for by slight underestimation of ninth-grade retention). In addition, the proposed method allows for estimation of net flow year by year, so information about the potential effects of policies are available before a grade cohort has finished its K-12 career. Finally, the proposed method uses net-flow data from earlier grades to estimate the effect of general population migration, potentially allowing for the identification of net flows in 8th through 12th grade that are not the result of general migration patterns and thus more likely to be a measure of students leaving and returning to formal schooling.

There are several potential difficulties with the method described here. States often have different ways of calculating key measures, and sometimes those definitions change. For example, in Texas, the method of estimating grade retention in high schools changed after 1997, with the denominator changing from a single count of students enrolled both at one point in the fall and then in the following year, for the earlier calculations, to all students enrolled at some point in the fall semester (and continuing to the next year) (Texas Education Agency, 2002). In North Carolina, grade retention is calculated based on last-day-of-school enrollment compared to the next fall (as opposed to Texas' method of using the prior fall's enrollment as the base—excluding those who transferred out) (North Carolina Department of Public Instruction, 2003). For the sample calculations presented here, the assumption is that retention rates are the same for the population for which a district calculates it and *also* for any other students in the school district at the beginning of the school year.

Not explored in this article is the potential to construct a synthetic cohort based on the data retention, net flows, and graduation from a period (such as a year). The choices involved in a synthetic cohort involves primarily the treatment of retained students. Is the synthetic cohort a

Markov chain, where students retained in one year have an equal chance of outcomes from that point forth? Such a simplifying assumption does not reflect the real world of schools, but there must be <u>some</u> assumptions made about such a model.

A key question for this measure is whether the use of October enrollment counts are sufficiently close to the beginning of the school year to warrant the use of equation **2b**. The assumption of end-of-period promotion simplifies the estimation, but it may bias the estimate by the starting point of the school year. (In some states, such as in Florida, the school year now starts before mid-August.) In addition, one must be careful that reported diplomas come from K-12 programs (and do not include adult-education programs for this purpose) and that enrollment is not an average enrollment over the year or some other definition that the state used. Other potential problems come from model assumptions. The most friable is the tentative choice of the average nm(x) for grades 2-7 as the baseline net flow from which to look for variation within a population. Nonetheless, the algorithm described here is a novel method of estimating student net flows, including dropping out, that is reasonably robust at the state level and may be useful at the local, district level. With some adaptation, it could also be used to estimate attrition and growth in higher education.

Note

[1] One could also calculate nm(x) using residual data from a group of grades from x up through the end of 12th grades, in a method parallel to what Hill (1987) suggests to test migration estimation.

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