Technical Report

FROM REVOLUTION TO EVOLUTION: MARKET DYNAMICS IN SCHOOL VALUE-ADDED AND MARKETED PROGRAM OFFERINGS UNDER THE POST-KATRINA SCHOOL REFORMS IN NEW ORLEANS

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Abstract: Economic research shows that markets evolve, for example, in terms of their product quality, product differentiation, and marketing. We develop methods for product differentiation in schools and decomposing trends in these and other measures into key categories. We then apply these methods to the evolution of the New Orleans schools after the state put in place an array of market-based school reforms in the wake of Hurricane Katrina. We find that: (a) average product quality (measured by school value-added) improved markedly after the city's school reforms started, but then, in more recent years, began stagnating or declining; (b) the variation in school quality (vertical differentiation) spiked upwards, then gradually reverted back to pre-Katrina levels; and (c) self-reported (marketed) program offerings have become slightly more horizontally differentiated over time. These trends can be decomposed into two main parts: improvement of persisting schools (the *development effect*) and the differences in quality between takeover schools and new schools (the *takeover/opening effect*). The development effect was important in the early post-reform years, but the takeover/opening process has been the dominant force since around 2010. The slight trend in horizontal differentiation is driven by both the development and closure/takeover effects.

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I. Introduction

Market-based school reform has been a key theme of education policy going back a quarter-century. Today, more than one-fourth of all students, and half of those in urban areas, attend schools other than their assigned traditional public school (TPS) (Carlson & Cowen, 2015; Harris, Witte & Valant, 2017).[1] Forty-three states have charter laws and another 26 have voucher or tuition tax credit policies (Cowen & Toma, 2015).

While K-12 schooling is clearly becoming more market-driven, it is only recently that it has been possible to study anything resembling a full-scale free market in schooling. Most school districts, even with market reforms, still have only a handful of TPS alternatives, and in only a few are the majority of students attending schools other than TPS. This makes it difficult to understand how a free market in schooling would work at scale.

A growing number of districts, however, are also adopting a hybrid system that combines market-oriented elements with government performance-based contracting, sometimes called managed competition or the portfolio model. New Orleans is perhaps the earliest and most intensive example of this approach. In the aftermath of Hurricane Katrina, the State of Louisiana took control of almost all TPS in the city and eventually turned them all over to private charter school operators. School leaders were given considerable autonomy to operate schools, including having more flexibility over hiring, firing, compensation, benefits, and working conditions of personnel. Parents, as the consumers, had to choose the schools they preferred. New Orleans is as close to a free market, and especially a managed market, as has existed in the United States.

[1] This excludes home schooling.

We provide evidence on the evolution of this unusual New Orleans schooling market, starting before Katrina, and continuing through the installation of the package of school reforms. While there are many dimensions of schooling one could study, we focus on the evolution of product quality and differentiation. There are two types of product differentiation one can study: vertical differentiation, which refers to variation in product characteristics when consumers generally agree that more is better (i.e., product quality), and horizontal differentiation, which refers to variation in products when such agreement is lacking (i.e., product type). For example, the vast majority of people would prefer schools that impart more academic learning, other things equal, but not everyone would prefer an arts-focused education over STEM, for example.

We measure the quality of schools using value-added to student achievement and report the trends in average value-added level and the variation in school value-added. Past studies in North Carolina and Texas have found that, compared with TPS, mean school value-added is higher in charter schools and the variation seems to decline over time (Baude, Casey, Hanushek, & Rivkin, 2014; Ladd, Clotfelter & Holbein, 2017). Also, charter schools that close have lower-than-average value-added, and the replacement schools have higher-value-added than the closed schools (Baude et al., 2014). While this evidence seems to suggest that schooling markets work as intended, it is not clear whether the handful of charter schools in each of these samples is informative about how an entire market of charter schools would work. Also, with some charter school policies, the government still plays an important role, choosing what schools to open and which to close, through what amounts to a contracting process.

We go beyond past research on these market dynamics in New Orleans in two main ways. First, while the North Carolina and Texas studies focus on vertical differentiation, we add horizontal product differentiation, which is another potentially important outcome of market-based school reforms (e.g., Glomm, Harris, & Lo, 2004).[2] Previously, Arce-Trigatti, et al. (2016) proposed using a variation of the Gower index, which is used, for example, in the ecology literature to measure biodiversity (e.g., Anderson, et. al, 2010). We extend the idea and develop versions of the Gower index that address some problematic assumptions and apply this modified-Gower index to New Orleans schools. In particular, we examine how New Orleans schools differentiate themselves in terms of the extracurricular programs, instructional approach, and student services they list in a standardized marketing guide provided to parents and the general public.[3]

These analyses lead to our first three key findings about trends in vertical and horizontal product differentiation in New Orleans: (a) average school quality in New Orleans (measured by school value-added) improved markedly, but then, in more recent years, began stagnating or declining; (b) the variation in school quality (vertical differentiation) spiked upwards immediately after the reforms started, then gradually reverted back to pre-Katrina levels; and (c) horizontal differentiation may have increased slightly during the post-reform years (moving in the opposite direction as vertical

[2] Glomm, Harris, & Lo (2004) study the location of charter schools and theorize that more such schools should locate where parent preferences are more diverse; their results are consistent with that hypothesis, but they do not measure horizontal differentiation directly.

[3] Ladd, Clotfleter, and Holbein (2017) find that schools tend to segregate over time and this may be related to product differentiation. As Glomm, Harris, and Lo (2004) point out, preferences for school characteristics may be related to family demographics and they find, consistent with that theory, that charter schools tend to locate in school districts with more demographic diversity. Harris and Larsen (2015) also find more direct evidence that preferences vary by income. While product differentiation and segregation are closely related in these ways, other studies have examined school segregation in New Orleans (Weixler, Barrett, Harris, & Jennings, 2017).

differentiation). Conclusions (a) and (b) are based on difference-in-differences analysis comparing New Orleans to otherwise similar districts before and after the New Orleans school reforms started in 2005, while data limitations in our analysis of horizontal differentiation mean that conclusion (c) is based only on trends during the post-reform years. These results are robust to several alternative methods, though they do involve several caveats (e.g., about the validity and value of data from a school marketing guide).

In addition to our measures of product differentiation, a second contribution of this study is showing that changes in any school-level measure (such as average quality and differentiation) can be decomposed into two broad components: quality changes among persisting schools and the differences between schools being taken over and those being opened (i.e., the takeover/opening process). Each of these can be further divided into: the change in measure and the change in the share of students in each group of schools (persisting and takeover/opening). Since all changes or improvements must fit into one of these four categories, the analysis provides important evidence about the precise ways in which schooling markets function.

This study builds on two prior veins of research. Chin et al. (2017) describe a similar decomposition, building on prior economic research in other countries and sectors (Bartelsman, Haltiwanger and Scarpetta, 2013; Chandra, Finkelstein, Sacarny, and Syverson, 2016).[4] They find that the improvement in Newark schools was driven by "shifting enrollment" to higher-quality schools. A contribution of our study is the use of a somewhat different decomposition that is designed to disentangle the different ways in

[4] We developed our method independently of these other decomposition studies.

which enrollment can shift and, specifically, to isolate the role of school improvement among persisting schools from the opening/closing process as a whole.[5]

Using our proposed decomposition method, we find that the development effect among persisting schools was important in the first few years, but that all the improvement thereafter in mean value-added in New Orleans was due to the takeover/opening process. The value-added of schools that opened was higher than that of the schools taken over, for the entire period under analysis and for every sub-period except one. The changes in the share of students in takeover/opening schools (versus persisting schools) played a very small part, and only in the first few years. In contrast, in decomposing horizontal differentiation, we find no difference in the contributions of persisting and takeover/opening schools.

In Section II, we discuss theories of differentiation. This is followed, in Section III, by discussions of data. In Section IV, we explain our methods for estimating school value-added, but more importantly outline our approach to decomposing quality improvements and horizontal differentiation, and to measuring product differentiation with the modified Gower index. We then discuss in Section V our results and provide concluding comments.

II. Theories of Market Dynamics

This study is about the evolution of the schooling markets on school quality and differentiation, and the factors that drive them. After discussing the theory of product differentiation, we discuss economic theories about market dynamics, theories of differentiation that arise because of government-driven accountability that accompanied

[5] Other studies have also considered the role of entry and exit of schools without decomposing the sources (Baude et al., 2014; Ladd, Clotfelter & Holbein, 2017).

the New Orleans schooling market, along with non-economic theories. In general, the theoretical predictions are clearer for quality and vertical differentiation than they are for horizontal product differentiation.

II.A. Economic Theory of Vertical Differentiation

Similar to Glomm, Harris, and Lo (2004), Figure 1A illustrates a theoretical product space with a single horizontal dimension (h) and a single vertical dimension (v). Four circles represent schools A-D, each located in a different portion of the product space. The schools are listed alphabetically in order of quality, mirroring the school letter grading system that operates in Louisiana and a growing number of states. Supposing, for example, that the horizontal dimension is extracurricular activities, the figure indicates that schools A and D have few extracurricular activities compared with B and C.

The focus of this study is on market dynamics, which assumes that the distribution of firms in the product space may not remain static because prices, technology, and consumer preferences evolve. In particular, the fact that technology can improve productive efficiency means that product quality should increase over time (relative to price) and become more uniform over time as inefficient firms are forced out of the market, (ceteris paribus).[6]

Markets also tend to become more concentrated with a small number of firms obtaining a growing market share (Klepper & Graddy, 1990). This is also partly due to the exit of inefficient firms, combined with economies of scale and firm-specific technological change. Increasing market concentration may tend to reduce vertical differentiation because there are fewer firms.

[6] Input prices could rise in ways that counter technology change in particular sectors.

II.B. Economic Theory of Horizontal Differentiation

In contrast to vertical differentiation, economic theory does not yield clear predictions about the level or trends in horizontal product differentiation (Chamberlin, 1933; Spence, 1976; Dixit and Stiglitz, 1977).[7] In general, the degree of horizontal differentiation depends on the cost of differentiating and the distribution of consumer preferences across the product space. Economic theory also suggests that there is often no stable equilibrium on the horizontal dimension, which further undermines any theoretical prediction.

Horizontal and vertical differentiation are also intertwined. Quality, and some types of products, are more costly to produce, forcing firms into particular sections of the product space. Also, economies of scale and scope favor larger firms and higher levels of market concentration, which might increase quality at the expense of horizontal differentiation. While each individual firm can offer a variety of products, adding a product can lead to substitution and reduce profits in existing product lines.[8]

Product differentiation with government provision or regulation. The role of government is also likely to influence product differentiation. Economic theory and research predicts that in an industry like public schooling where the government fixes the price at zero and governments provide similar levels of funding to non-TPS choice

[7] Early work focused on spatial differentiation (Hotelling, 1929; Lancaster, 1979), with an emphasis on transportation costs, but this is largely irrelevant in New Orleans where locations are selected by the government and with a goal of geographic dispersion. Price differentiation is also irrelevant because schools cannot charge prices.

[8] An exception is that, with some products, firms may try to create brand loyalty and attract young consumers to cheaper and lower quality products in the hopes that they buy higher quality products from the same firm when they are older and have higher incomes. This logic can apply to schooling only to a limited extent as consumers only purchase schooling over a limited number of years.

schools,[9] the opportunities for vertical differentiation are clearly lower than in a free market. Traditional public schools, with their rules and regulations, are also thought to provide relatively homogenous schools. Charter schooling loosens the rules, but as this is an example of performance-based contracting, the government could decide to follow contracting rules that prevent market concentration and/or deliberately maintain product differentiation, offsetting any market tendency toward homogeneity.

Charter school contracts are generally rooted in the state school accountability systems that reward schools with contract renewals when they reach specific measurable performance thresholds. Once those minimum bars are met, schools have more autonomy to devote resources to differentiating themselves on other characteristics.[10] In any event, given how many schools have been closed or taken over years after the reforms were put in place in New Orleans, this contracting role appears to be powerful. If the government actually closes schools based on performance, then product quality will increase and vertical differentiation will decline in a manner similar to market accountability. The effect of government contracting on horizontal differentiation is much less clear.

II.C. Non-Economic Theories

The introduction of government as the contractor means that we can no longer rely on theories that apply to for-profit firms. The same can be said of the not-for-profit, non-governmental organizations (NGOs) that are common in charter schooling; in New Orleans

[9] We use the term choice schools here to refer to charter schools, vouchers, and tuition tax credits. Funding of traditional public schools and private schools can vary considerably and, in the latter case, prices are set by market forces.

[10] For this reason, we might also predict that high-performing schools, which easily meet government standards, differentiate themselves more than low-performing ones; alternatively, high-performing schools may be in such high-demand (with fixed costs to adding seats) that neither market nor government pressures have much influence (Harris, forthcoming). In a market setting with for-profit firms, high-demand schools might expand, so that they all firms have incentives to attract consumers. However, schools are rarely for-profit and they have little capacity to expand without opening new facilities or reducing quality.

all charter schools are run by NGOs. While they cannot create accounting profits, NGOs can be rent-seeking, leading to the same types of behaviors as for-profit firms (Steinberg, 2003). This creates a tension, especially where NGOs are trying to maintain "an unprofitable social mission alongside the constant… imperatives of operating within a market economy" (Sanders, 2015). NGOs find themselves in an increasingly competitive environment and seem to operate in a more business-like fashion in their "efforts to find more cost-effective and sustainable ways to address social problems" (Dees & Anderson, 2003). Like governments, therefore, NGOs may not respond to incentives the way economic theory predicts.

Rather than thinking of schools as firms, it also may be more useful to think of them as institutions. Sociologists' institutional theory predicts that organizations become more similar over time through a concept known as isomorphism (DiMaggio and Powell, 1983). Institutions may imitate one another (mimetic isomorphism), be pressured into similar designs (coercive isomorphism), or become similar due to professional standards (normative isomorphism). The latter might emerge in schooling, for example, because foundations, philanthropists, and education groups advocate for specific programs and practices that charter school leaders may feel obliged to follow.

II.D. Illustrations and Summary

The above forces for market dynamics can be illustrated by modifying Figure 1A. If the government ends the contracts of low-quality schools, or parents recognize low quality and push schools out through market forces, then it might close school D. This is represented by the X placed over school D in Figure 1B. The immediate effect of that move is to reduce the variance in school quality (vertical differentiation) and increase the

average. However, holding constant the total enrollment and enrollment in the remaining schools (and assuming all remaining schools are at full capacity), the district/authorizer needs to add a replacement school to accommodate the displaced students.[11] The particular replacement in Figure 1B, school E, has somewhat higher quality (at least at first) but sits in a very different part of the product space in terms of extracurricular activities. We chose this hypothetical pattern because we might expect the closure of a school with a particular mix of offerings to be interpreted as a failure of that mix, so that the authorizer and school leaders seek to avoid that unsuccessful mix in the future. In this example, quality differentiation declines while horizontal differentiation increases, but such an outcome is not guaranteed.

The same outcome could arise without government intervention. Potential school entrants, observing the exit of school D, might try to enter the market in a different part of the product space, offering greater potential for profits (or rents), or the government might close some schools because they are seeking schools in a different part of the product space (e.g., because some types of families voice concern about the available options in public meetings or news reports). This, too, could also yield the entry of school E.

To summarize, on the vertical dimension, we hypothesize that if market forces and government contracting are working as intended, then average quality should rise and vertical differentiation should decline (at least on measures that are part of government contracts), at least for a time. Predictions regarding evolution on the horizontal dimension are less clear and depends on factors such as variation in the evolution of preferences and political processes involving contract approvals and renewal.

[11] On the other hand, if schools are under capacity and seats remain available across existing schools, we might not expect a replacement to be introduced.

III. Data

III.A. Administrative Data

Data used in the school value-added analysis were provided by the Louisiana Department of Education (LDOE) and include a panel of student-level data that tracks enrollment and achievement in all Louisiana publicly funded schools. The student-level data also provides other information about race, gender, grade level, free or reduced priced lunch status, special education status and English language learner status. Our data go back to the 2002 school year, three years prior to Katrina, to generate school value-added measures.

State standardized tests (LEAP and iLEAP) are given in the spring to all students enrolled in grades 3-8. Test scores are standardized by test, year, grade, and subject (math and English language arts (ELA)) within Louisiana to have a statewide mean of 0 and standard deviation (s.d.) of one.

As shown in the appendix, the rate of missing student scores fluctuates in 2015 and 2016. While this may signal changes in the measurement error and/or bias in the value-added measures, the missing score rate is never higher than eight percent, therefore, it is unlikely this influences the results.

III.B. Parents' Guide and Reported School Offerings

We measure school marketing using The New Orleans Parents' Guide. The Parents' Guide is a yearly publication originally produced by a local non-profit group.[12] Schools are surveyed during the fall/winter for the edition to be published the following spring. A

[12] The production of the Parents Guide was taken over by the Orleans Parish School Board (OPSB) in 2017.

broad collection of school characteristics is featured in the guide, ranging from basic information such as the name of the principal, address, and a photo of the school, to a breakdown of programs and services offered, such as types of extracurricular activities, support services, and whether after-school care is available (see an example of a Parents' Guide page for one school in Appendix Figure A1).

With more than 100 data elements per school in the Parents' Guide, we narrowed the list to 66 using several criteria: (1) school characteristics that are topics of other school research (e.g., curricular focus and discipline model); (2) factors that literature has shown to be important to New Orleans families when choosing a school (e.g., band and football; Harris & Larsen, 2015); (3) those that could be objectively defined and proved to have high inter-rater reliability. We organized these into three categories (extracurricular programming, instructional approach, and student services), as well as sub-categories.

Two researchers were involved in the coding of the Parents' Guide. The process underwent several iterations to ensure accuracy and reliability across coders. Football, for example, was straightforward to code. Schools are labeled as having football if and only if they explicitly list it as one of their team sports. In some cases, given the open-ended nature of the Parents' Guide data, we grouped some extracurriculars together (e.g., chess club was considered an academically-oriented extracurricular activity).

Curricular focus was a more challenging variable because of the high number of options schools can choose from and the inclusion of several sections in the Parents' Guide that could indicate a certain curricular focus. We coded a school as having a specific curricular focus only if and only if it was explicitly mentioned in a school's name, mission

statement, or the open-ended "school features and programs" section of the Parents' Guide, so that it broadly described the aims of the schools.

In the initial pilot of the coding method, we identified variables where coding was more subjective. These variables included extracurricular activities (what constituted an academic extracurricular, for example), discipline, special education, and curricular models, community partnerships, and other programming, as they all required some level of judgment on the part of the coder. The coding of other variables was modified because the data were reported in inconsistent ways across schools (e.g., English as a Second Language (ESL) support staff was treated as binary rather than a count of ESL support staff on-site because the types of ESL staff included varied within the Parents' Guide). This was largely due to unevenness in the way the Parents' Guide data was collected which made it difficult to code consistently across years. Our pilot coding process was repeated, and the coding scheme refined, until a substantial level of agreement was achieved between coders across variables for randomly selected schools and years (Hallgren, 2012).

For the final dataset, the primary coder coded the full dataset, while a secondary coder double-coded a subset (12 percent) of the data. We use Cohen's kappa, which is commonly used for measuring inter-rater reliability where exactly two coders code the same overlapping set of data (Hallgren, 2012). Final inter-rater reliability statistics, shown in Appendix Table 1, are in the range of 0.62-1.00 with nearly all above 0.88. These data will serve as the basis for our descriptive analysis of horizontal school product differentiation.

IV. Methods

IV.A. Value-Added Estimation

To measure school quality, we estimate school value-added (SVA) measures that are now standard in the research literature:

$$A_{ist} = f(A_{i,t-1}) + \beta X_{ist} + \theta_{st} + \varepsilon_{ist} \quad (1)$$

where A_{ist} represents student achievement for student *i* in school *s* at time *t*, X_{ist} is a vector of student/family characteristics, θ_{st} represents value-added of school *s* in year *t*. ε_{ist} is a random error term, $A_{i,t-1}$ are the scores in the previous school year. We attribute student growth to the school with the last enrollment record (usually the test school).[13] After estimation of equation (1), we apply a post-estimation shrinkage adjustment following Herrmann, Walsh and Isenberg (2016).[14]

Note that school value-added is different from the contracted performance measures that are more typical of charter school contracts and state school accountability, which focuses on student outcome levels. Research suggests that value-added measures, like those represented by equation (1), are more valid measures of school quality (Chetty, Friedman & Rockoff, 2014).[15]

[13] Dosage model does not apply to our analysis because our data does not include within-year transfer information.

[14] The lagged prior achievement in cubic form, by subject (MATH/ELA/SCI/SS). Missing indicators for lagged scores, by subject. Race, gender, free or reduced price lunch (FRL), persistent-FRL, special education, and Limited English Proficiency in the post-score year are all included as covariates. We also include garde fixed effects and indicators for student mobility, the latter of which are interacted with the test grade to account for structural versus nonstructural moves.

[15] In this sample of schools, the letter grade is fairly highly correlated with school value-added (Harris & Liu, 2018).

IV.B. Decomposition of Value-Added Improvement

Prior evidence suggests a strong role for closure/takeover in improving school quality in our context of New Orleans (Bross, Harris, Liu, 2016), but it is useful to quantify its role relative to other factors. We show below that system-level improvement can be decomposed into two main parts: improvement of persisting schools (*development effect*) and the differences in quality between closure/takeover schools (exiters) and new schools (entrants), which we call the *takeover/opening effect*. These can be further decomposed into two parts: the changes/differences in quality and the shares of students attending each type of school. To see the difference of these two parts, note that if persisting schools improved, this would increase average market quality, but this would be amplified if more students moved into those schools.

Formally, suppose we are interested in decomposing the improvement between time *t* and *t+k*. In the starting year *t*, the average school productivity is the weighted sum across exiters and persisters; α_t^{Pers} is the proportion of students in persisting schools and θ_t^{Pers} is the average value-added of persisting schools (weighted by school size), while $\alpha_t^{Exiters}$ is the proportion of students in schools that close within the time period of interest and $\theta_t^{Exiters}$ is the average quality of those schools (weighted by school size); by construction, $\alpha_t^{Pers} + \alpha_t^{Exiters} = 1$, indicating that all students are in one of the two types of schools. This means that the average quality of all (publicly-funded) schools at time *t*, denoted θ_t, can be expressed as:

$$\theta_t = \alpha_t^{Pers}\theta_t^{Pers} + \alpha_t^{Exiters}\theta_t^{Exiters} \quad (2)$$

Similarly, the average school productivity in the ending year *t+k* is the weighted sum across entrants and persisters; α_{t+k}^{Pers} is the proportion of students in persisting schools

in t+k and θ_{t+k}^{Pers} is the weighted average value-added of persisting schools, while $\alpha_{t+k}^{Entrants}$ and $\theta_{t+k}^{Entrants}$ are the respective parameters for schools that enter the market during the k-year period and continue to operate through year t+k (similar to above, $\alpha_{t+k}^{Pers} + \alpha_{t+k}^{Entrants} = 1$). This yields average quality of all (publicly-funded) schools at time t+k, denoted θ_{t+k}:

$$\theta_{t+k} = \alpha_{t+k}^{Pers}\theta_{t+k}^{Pers} + \alpha_{t+k}^{Entrants}\theta_{t+k}^{Entrants} \quad (3)$$

Note that since the objective is to measure school quality between two specific years (t and t+k), schools that open after time t and exit before t+k are excluded entirely from the decomposition.

Total school improvement is $\theta_{t+k} - \theta_t$. Subtracting (2) from (3) and re-arranging terms yields a decomposition of average school productivity growth into four terms (see detailed steps in the appendix).

$$\theta_{t+k} - \theta_t = \underbrace{\alpha_t^{Pers}(\theta_{t+k}^{Pers} - \theta_t^{Pers})}_{development-value\ added\ change} + \underbrace{(\alpha_{t+k}^{Pers} - \alpha_t^{Pers})\theta_{t+k}^{Pers}}_{development-share\ change} + \underbrace{\alpha_t^{Exiters}(\theta_{t+k}^{Entrants} - \theta_t^{Exiters})}_{takeover/opening-value\ added\ change} + \underbrace{\left(\alpha_{t+k}^{Entrants} - \alpha_t^{Exiters}\right)\theta_{t+k}^{Entrants}}_{takeover/opening-share\ change} \quad (4)$$

The first pair of terms on the right side of (4) pertain to the development of persisting schools over time. The first term refers to the change in value-added of persisters, multiplied by the share of students in those schools at the beginning of the period.[16] The second term focuses on the change in the share of students in persisting schools (versus exiting schools), holding constant the change in value-added at θ_{t+k}^{Pers}.

[16] Since this is the weighted average of value-added for persisting schools in each period, this can reflect change in the allocation of students across low- and high-value-added persisting schools, though in general the role of such shifts is very small.

The second pair of terms is similar, but for the takeover and opening of schools. The key difference is that $\theta_t^{Exiters}$ and $\theta_{t+k}^{Entrants}$ pertain to the difference in value-added between two different sets of schools, whereas θ_t^{Pers} and θ_{t+k}^{Pers} pertain to the same set of schools (at different points in time). Overall, we can view the first and third terms as reflecting improvement in persisting schools and the second and fourth terms as the market and other forces that lead students to enroll in schools.

The simplest scenarios are when total enrollment is time constant and/or when closures are offset exactly by new entrants. Under these conditions, $\alpha_{t+k}^{Pers} - \alpha_t^{Pers}$ is relatively stable over time and equation (4) is reduced mainly to the first and third terms only (the second and fourth terms will be zero).[17] But if the market size is expanding (contracting) then, even if the number of students in persisting schools is constant over time, the share will be declining (increasing). This is especially relevant in the New Orleans context where $\alpha_{t+k}^{Entrants} - \alpha_t^{Exiters} > 0$ and substantively large, due to post-Katrina population return and rebuilding.

This decomposition is somewhat different from that of Chin et al. (2017).[18] It is not possible in their analysis to determine to what degree entering schools are more effective than exiting schools. Also, we provide a more fine-grained decomposition that concretely displays the source of the improvement, isolating the role of the market share parameters from the change in value-added. While both decompositions are mathematically correct,

[17] One assumption here is that the school size of persisting schools is fixed over time. Otherwise, if the persisting schools are of higher quality, then the growing enrollments might be concentrated in the (expanding) persisting schools.

[18] In Chin et al. (2017), their "within" term is identical to our "development – value-added change." Our "development – share change" is a combination of their "between" and "cross" terms. As discussed in the text, the main difference is that we are primarily interested in the difference between entering and exiting schools as an indication of how well the market is functioning, therefore, we combine these into the takeover/closure terms in equation (4).

and are useful for different purposes, equation (4) above seems better designed to address our focus and to the purpose of understanding the policy mechanisms.

It is also important to note that there might be some ways in which each of the development and takeover/closure mechanisms has indirect effects on the other terms in equation (4). In particular, the incentive effect of potential takeover should exert a positive effect on persisting schools (at least those near the takeover threshold). Similarly, the difference between the quality of entering and exiting schools could influence the market share in persisting schools. If parents have information indicating that the quality of persisting schools as a group is better, they may gradually switch into those schools.

In what follows, we apply this decomposition to the school improvement occurring in New Orleans to help explain the measurable improvement previously identified by other research (Harris & Larsen, 2018).

IV.C. Measuring Product Differentiation

This study is focused on measuring the evolution of schooling markets on multiple dimensions and decomposing this into component parts. In the case of school quality, which typically has only one dimension,[19] we can measure the variation in school performance with common measures such as the standard deviation. Other measures are necessary when there are multiple dimensions and/or dichotomous measures. Since horizontal differentiation involves as many as 66 characteristics in our case involving both continuous and dichotomous variables, we need a different metric.

Suppose we have *S* schools and *C* dichotomous characteristics (e.g., whether a school has a football team or offers art as an extracurricular activity). No two schools are

[19] Quality could have multiple dimensions, but this is more likely with horizontal differentiation.

likely to be exactly the same. However, a differentiated market is one where schools are more spread out in this *C*-dimensional space. For example, when two schools are identical on 65 characteristics but differ on the other one, the two schools occupy different cells in the product space, but these schools are nearby cells compared with another pair that shares only one characteristic in common.

In research on biology and ecology, researchers use a Gower index to measure biodiversity (e.g., Anderson, et. al., 2010). We use a modified Gower measure of how similar schools are in the product space.[20] Specifically, we calculate the index for each pair of schools, *i* and *j*, on each characteristic, dividing by the number of characteristics. We then add up these measures for each pairwise combination of schools and divide by the number of pairwise combinations to obtain our index $D_{ij} \in [0,1]$. In the above case, with two schools that are identical except on one characteristic, the Gower measure would be nearly zero. This measure also has the useful property that it distinguishes more-differentiated from less-differentiated markets no matter how large *C* is relative to the number of schools.

Formally, we calculate the following Gower measure:

$$D_{ij} = \frac{\sum_c d_{ijc}}{C} \tag{5a}$$

For dichotomous measures:

$$d_{ijc} = 0 \;\; if \; x_{ic} = x_{jc} \tag{5b}$$

For continuous measures:

$$d_{ijc} = \frac{|x_{ic} - x_{jc}|}{(\max(x_c) - \min(x_c))} \tag{5c}$$

[20] Throughout the rest of the paper, we avoid using the word "dissimilarity" because this has a particular meaning in education research on segregation.

Finally, D_{ij} is averaged across all possible pairs of schools (N) by year or

$$D_s = \frac{\Sigma_{ij} D_{ij}}{N} = \frac{\Sigma_{ij}((\Sigma_C d_{ijc})/C)}{N} \quad (5d)$$

where $min\, D_u = 0$ and $max\, D_u = 1$. Arce-Trigatti, Lincove, Harris, and Jabbar (2016) also use a Gower measure to study dissimilarity in New Orleans, but they are focused on the clustering of schools within the market and include only cross-sectional analysis rather than market dynamics.

The first challenge we encounter with the above unweighted Gower measure is that some categories in our sample have a larger number of school characteristic options than others. For example, in our data, there are 12 sports. Since every characteristic is given the same weight in the standard unweighted Gower measure, this means that sports, as a category, is implicitly given more weight than other kinds of school characteristics.

A second limitation of the Gower measure is that some school characteristics are mutually exclusive. For example, a school cannot have STEM and the arts as its main theme or focus. Schools who do not mention a specific curricular model, such as STEM or College Prep, are coded as missing, for example. At the extreme, a category that only includes mutually exclusive categories has a maximum Gower index of $1/C$, which is less than or equal to the maximum when the characteristics are non-mutually exclusive, so that the mutually exclusive characteristics are given less implicit weight (holding constant the number of characteristics, discussed in the prior paragraph).

To address these two problems, we adjust the unweighted Gower measure by placing each one of the 66 characteristics into a group $g \in [1, G]$ s.t. $G < C$ and calculating a separate Gower measure for each group of characteristics (D_g), e.g., a Gower measure of differentiation just in extracurriculars. Then, we calculate a *weighted* average of each of the

separate Gower measures across the groups (D_w). Formally, this modifies the Gower index to be:

$$D_w = \sum_g \gamma_g D_g = \sum_g \gamma_g \left(\frac{((\sum_C d_{ijcg})/c_g)}{N} \right) \quad (6)$$

where γ_g and C_g are the weight and number of characteristics, respectively, for each group g. In our analysis we equally weight all the categories ($\gamma_g = 1/G$), as shown in Table 1.[21] Compared with the unweighted Gower index D_u, the weighted version D_w reduces the arbitrarily small weight placed on categories where the options are mutually exclusive and the arbitrarily large weight for categories with a large number of (non-mutually exclusive) characteristics.

The broader problem with this approach, however, is that all of the various types of weights are somewhat arbitrary. For example, prior research suggests that academic quality is very important to families (Hanushek et al., 2007) and another study, also using New Orleans data, finds that, in addition to academic quality, extracurricular activities are important (Harris & Larsen, 2015). The Gower measure does not account for this variation in preferences and instead assigns weights essentially arbitrarily. To address this problem, we estimate a variation of the unweighted Gower measure that is limited only to characteristics that Harris and Larsen (2015) found to be important to New Orleans families, recognizing that we can only do this for characteristics that are included in that study of parent preferences.

[21] To avoid confusion in the notation, equation (6) shows $\sum d_{ijcg}$ which is summed over c_g.

IV.D. Difference-in-Differences

In some parts of the analysis, it is possible to estimate the causal effect of the New Orleans reforms on quality and vertical differentiation using difference-in-differences analysis. We specifically estimate the following model:

$$Y_d = \alpha Post + \beta(NOLA_d \times Post) + \mu_d + \varepsilon_d \quad (7)$$

where Y_d is either the mean or s.d. of school value-added, $Post$ is an indicator for the post-reform period; $NOLA_d$ is an indicator for whether the district is New Orleans; μ_d is a vector of district fixed effects; and ε_d is an iid white noise error (clustered at the district level). We also report parallel trends tests, and estimate event study versions of (7).

This approach cannot be applied to the horizontal differentiation analysis because we do not have Parents' Guide data before the reforms or for other districts. In that case, we simply describe the post-Katrina trends.

V. Results

Below, we describe changes in school quality and decompose that improvement using equation (4) above. This is followed by analysis of vertical product differentiation and robustness checks regarding the calculation of school value-added. Finally, we present the trends in horizontal product differentiation using the modified Gower indices.

V.A. Trends in NOLA Average School Value-Added

Figure 2 shows the trends in average school value-added (SVA) in New Orleans relative to the rest of Louisiana by year, for math and ELA separately. The y-axis reflects that we re-scaled school value-added each year, dividing each school's value-added by the

statewide standard deviation in *school-level* value-added.[22] We include all schools which offer at least one grade from 4 to 8 for at least one year and therefore have at least one school value-added measure. All trend lines and estimates also weight value-added based on the number of students in the respective schools.

Our analysis reinforces earlier, more anecdotal, evidence that New Orleans schools were very low-performing before the reforms (Sacerdote, 2012). New Orleans schools were about 0.8 SVA standard deviations (s.d.) below the statewide average in 2005. Since the SVA s.d. was roughly 0.17,[23] this means that New Orleans schools in the pre-Katrina era generated about (0.8)(0.17)=0.14 student-level s.d. less achievement annually compared with the average Louisiana school.

The city's SVA rose quickly from that low baseline: for the first eight years after the reforms, SVA gradually increased in both subjects, to the point of meeting or exceeding the state average for several years. In ELA, this improvement continued to the most recent years; however, in math, SVA peaked in 2013 and then declined.[24] This is consistent with the Harris and Larsen (2018) results, which also show a peak effect of the New Orleans reforms in 2013, as well as similar levels of improvement over time.[25]

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[22] The purpose of this standardization is to account for changes over time due to the test scale and other factors affecting the variance across all schools, including those outside New Orleans. This is important because we see some signs that the statewide kernel density plots change over time in a way that seemed unlikely to reflect changes in the variation of actual performance. Our re-scaling is based on the implicit assumption that the variance in actual statewide performance is constant across years.

[23] This means that a school that was one standard deviation above the state school-level mean generated 0.17 *student-level* standard deviations more than the average school.

[24] The decline in SVA, especially with regard to math achievement in the last several years, has received public attention and been attributed to several factors. The decline in math scores roughly coincided with changes in the state standardized tests, as a result of the state's shift to a Common Core-aligned test. While this affected all schools in the state, one New Orleans CMO leader argued that NOLA schools were unprepared for this shift, and the higher level of content on the tests.

[25] The magnitudes of the effects are difficult to compare because value-added measures are in annual effects while the results in Harris and Larsen (2018) are cumulative across years.

V.B. Decomposition of School Value-Added Growth

This section decomposes overall value-added growth according to equation (4). As above, the analysis focuses on the 120 NOLA schools which offered at least one grade from 4 to 8. (Since we are focused only on post-reform improvement, the years are restricted to 2007 and beyond). This sample includes 31 schools which do not have school value-added measures available for certain years they were in operation. For example, schools opened with a grade span might not have school value-added measure (offer grade 4-8) until their first cohort promote to grade 4. Thus, our analysis implicitly identifies schools as "opening" in the first year they have a value-added score, since the school has no experience in grade 4-8.[26] The results are similar when dropping schools with delayed availability of value-added, with some small exceptions noted later.[27]

V.B.1. Decomposition by Development and Takeover/Opening Effect

We decompose the overall improvement with the change in SVA into the four components shown in equation (4). The top row of Table 1 Panel A shows that there were 20/24/37 schools in the exiter/persister/entrant categories, respectively, for the 2007-2016 period. The fact that there were more entrants than exiters reflects the gradual post-Katrina population return and rebuilding effort. By 2016, there were far more new schools than old ones. Note that schools that opened after 2007 and closed before 2016 are omitted in this

[26] Similarly, this method identifies schools as "closed" in the last year they have a value-added score, since the school stops offering grade 4-8. However, it is fairly rare for schools to remain open after dropping tested grades and subjects. For this reason, the timing of closure in our analysis more closely aligns with the standard definition of closure than does the timing of opening.

[27] This additional analysis restricts the analysis to the 89 New Orleans schools that offer at least one grade from 4 to 8 in all its operation years. The results of this robustness check are available upon request.

analysis and the above counts of the number of schools; this is because such schools make no contribution to the change in student outcomes between 2007 and 2016.[28]

Table 1 Panel B shows that the improvement over the entire 2007-2016 span was entirely driven by the fact that the state RSD took over the low-performing schools that it initially opened post-Katrina, and opened new charter schools that were of higher quality. The combined takeover/opening effect is +1.56+0.00=1.56 school-level s.d.. In contrast, over this period, the schools that were open in 2007, and persisted throughout, actually saw declining performance (-0.23-0.03=0.26 school-level s.d.), offsetting the improvement from the takeover/opening process. (From here onward, s.d. refers to the school-level standard deviation unless otherwise specified.)

For both the development and takeover/opening effects, the contribution of student re-allocation (changes in shares of students) is very low. While this might seem to suggest that market forces were not working to shift students to better schools, note that these shares reflect only the movement between persisting and takeover/opening school *categories*, not whether students were moving from low- to high-value-added schools in general or across schools within those categories. When students move to better schools within each type, this shows up in the weighing of SVA by school size within the specific category. Other research suggests that New Orleans students were in fact moving to better schools (Maroulis et al., forthcoming; Harris & Larsen, 2015).

Table 1 Panel C decomposes the effect further, showing only the changes in the value-added (θ) terms in equation (4) and ignoring the shares of students in different

[28] This is also why the sum of the number of schools in each category is higher when looking at the sub-periods. Some of those schools dropped in the 2007-2016 analysis get added back in when looking at short periods.

categories. The last three columns of the first row show that schools entering after 2007 and staying open until 2016 had SVA around the state average (+0.02 s.d.), while exiters were far below the state average (-3.79 s.d.), for a net improvement of +3.81 s.d.. The third column shows that SVA in persisting schools declined by 0.39 s.d.. This reinforces the strong role of the takeover/opening effect.

V.B.2. Decomposition by Sub-Period

Each panel in Table 1 breaks the result down into three time periods: 2007-2010, 2010-2013, and 2013-2016. This part of the analysis is important for two main reasons. First, when we carry out this analysis for a long period of time (2007-2016), 39 schools get dropped entirely because they opened after 2007 and closed before 2016; these schools do not fit into any of the three categories (exiter/persister/entrant) and analysis by sub-periods brings these schools back into the analysis. Second, we are interested in how each source of improvement may have contributed in different ways during different time periods. For example, the effectiveness of the charter authorization process may have changed over time in ways that the 2007-2016 analysis cannot reflect.[29]

The results look somewhat different when we look at the sub-periods. In particular, while the takeover/opening effect was main source of improvement above in most periods, the development effect is almost the sole source of improvement during the 2007-2010 period (+1.45-0.11=1.34 s.d.). Moreover, the sum of the results across the sub-periods for

[29] For the same reason, the sum of the contributions made by each component across sub-periods does not sum to the 2007-2016 contributions. Moreover, the sum of the results across the sub-periods for the development effect is more positive (1.34-0.25-0.37=0.72) than it is for 2007-2016 as a whole (-0.23-0.03= -0.26). This is mainly because of the 39 schools that entered after 2007 and were taken over before 2016. Such schools do not contribute to the 2007-2016 change because that analysis is designed to measure the change between t and t+k only, but some of these 39 schools do contribute to some of the sub-periods (e.g., a school that opened in 2010 and was taken over in 2012 would be an exiter school in the 2010-2013 period). More generally, sum of the effect from each component across sub-periods is not equal to effect calculated for the entire period (2007-2016).

the development effect is more positive (1.34-0.25-0.37=0.72) than it is for 2007-2016 as a whole (-0.23-0.03= -0.26).

It is important to clarify why the sub-period results differ from the whole period. The sum across sub-periods is not very informative about 2007-2016 improvement because, as noted, the development of schools that close before 2016 does not contribute to the performance of the system in 2016. But the difference is still noteworthy because it suggests that schools did improve at first. In fact, essentially all schools dramatically improved from their first year of operation to the second. But much of this improvement was not evident because so many of the schools were subsequently closed or taken over.

The sub-period analysis also has the effect of shifting some schools that are closures for the 2007-2016 period to the persister category (because they did not have to persist very long to survive until the end of the shorter sub-period). Since every school sees a first-year bump in productivity, and little improvement thereafter, this makes the development component look more positive in the sub-periods.

We show this first-year bump in Figure 3A. The x-axis re-centers each school's starting year to Year 1 and tracks its progress until it either closes or the data run out (we also grouped schools based on the number of years we can observe their value-added, which affects whether they show up as an exiter or not in the other tables and figures). The figure shows clearly that all types of schools improved in their first year, especially those that we can only observe for a short period. Since the group with few years includes those that closed quickly and those that opened recently, but which run out of data, Figure 3B is instead restricted only to schools that were taken over. The same general first-year pattern

holds there as well.[30] It would therefore be wrong to conclude from the negative development effect (-0.26) that New Orleans schools opened and then generally got worse over time. Rather, they got better quickly and then seem to stagnate.

These figures also highlight another pattern: the schools that started with above-average value-added trended downward after the first year, while those starting with very low value-added improved more in the first year and were less likely to decline to levels below where they started. This means that even the schools that were eventually taken over improved a great deal at first. While this gives the appearance of regression to the mean, this is not a likely explanation for the pattern.[31]

Panel C of Table 1 shows that the improvement of persisting schools ($\theta_{t+k}^{Pers} - \theta_t^{Pers}$) drops significantly across sub-periods. Again, this is partly because, in each period, ($\theta_{t+k}^{Pers} - \theta_t^{Pers}$) captures growth of persisting schools during different operation stages. In 2007-2010, all RSD schools are newly opened, ($\theta_{t+k}^{Pers} - \theta_t^{Pers}$) captures their growth in the first three years of operation. The improvement is the highest because Figure 3A shows that all types of schools improved greatly in their first year. In 2010-2013, some persisting schools were opened right after hurricane and have already operated for several years before 2010. In this case, ($\theta_{t+k}^{Pers} - \theta_t^{Pers}$) captures the growth of persisting schools from roughly three years of operation to six years of operation, well after the initial first-year improvement.

[30] The fact that the schools opened for just a few years had much lower value-added reinforces the idea that the RSD took over low-performing schools.

[31] If regression to the mean were the explanation, we would expect to see convergence from the beginning. Instead, the groups initially *diverge* from one another, from the first to the second value-added observation, followed by convergence. Also, there is an alternative explanation, especially for the decline in the top line; the schools that stayed open longest probably realized after their initial contract renewals that their test scores were so high that they could divert resources to other non-test outcomes or reduce effort. In any event, the degree of convergence is small, for the years we can observe.

We examined the dynamics of new and exiting schools in Figure 4. The "entrants" line reports the upward trend of first-year value-added of newly opened schools by their first operation year (or the first year a value-added measure was available), indicating that the supply of charter schools and/or the charter authorization process may have improved over time.[32] The "exiters" line reports the last-year value-added of closure/takeover schools. The quality of exiting schools improves roughly in parallel with the new entrants, which is unsurprising given that each year's exiters were once entrants, usually 3-5 years prior. The entrant group has higher performance in all but one year (2010), suggesting that the overall process of opening/closing/takeover was consistently effective in raising average school performance.

To this point, the results with the full sample of schools have been nearly identical to those when we restrict to schools that have a value-added estimate in every year. Figure 4 is a partial exception because a disproportionate share of schools that were expanding one grade per year opened in the early years. With few observations remaining in these early years in the restricted sample, there are was only one exiter in 2007 and none in 2008. Also, the value-added of the opening schools line spikes up more in 2009. These differences have little bearing on our conclusion, however, because we see the same result in the later years where the sample in each group of schools are larger.

V.B.3. Additional Analysis: Value-Added Trends by Sector

[32] See Bross and Harris (2016) for more on the authorization process. Given that the process for charter approvals changed little over this time period, the former interpretation is more plausible. The supply of charter schools might also have improved for at least two other reasons. First, later entrants have some advantage such as avoiding mistakes made by earlier entrants and/or benefiting from informed parents and teachers. Second, the improvement in conditions in the city, after the initial destructive hurricane, combined with the reduced uncertainty that the reforms would continue, might have made the city more attractive to charter applicants. Finally, note that there is a dip in the initial performance of entrants in 2010, but very few schools opened that year and they had very small enrollments.

This section decomposes the value-added trend by sector (state-controlled versus district schools). Note that, in the aftermath of Hurricane Katrina, the Orleans Parish School Board (OPSB) was able to quickly open schools, either as direct-run (traditional) schools or as charter schools. Moreover, because these schools were high-performing pre-reform, almost none of them were taken over. (Some direct-run OPSB schools were turned into charter schools, but these were "conversions" and did not involve a change in school leadership in the way that the term takeover does.)

This implies that the schools we saw in Figure 3A, which had persisted throughout the entire 2007-2016 span are mostly OPSB schools. Figure 5 shows this more explicitly by breaking the results down into four groups: OPSB-direct, OPSB-charter, RSD-direct, and RSD-charter. (Note that, as each point reflects all of the schools in each sector, these patterns combine persisters and entrants/exiters, and include all schools in the city in each year.) This confirms that OPSB schools not only had high test levels, but high SVA right from the start; and that the SVA declined somewhat over time.[33] Moreover, the RSD schools started off low-performing and then improved considerably. For both direct-run and charter, the trends are very similar.

V.C. Vertical Product Differentiation

The above focus on the evolution of *average* quality is an important first step into the analysis of the next topic: vertical differentiation. If low-performing schools were being driven out by either market forces or contracting, as suggested by Bross and Harris (2017)

[33] One might also wonder why OPSB SVA spiked immediately after the reforms. Note that the set of schools governed by OPSB after the reforms was dramatically smaller than the set before the reforms. Prior to Katrina, OPSB governed all but a handful of schools in the city. Also, OPSB schools hired back many of their pre-Katrina leaders and teachers, giving them a head start on the OPSB schools.

and the above analysis, then we should observe not only an increasing average, but a declining variation.[34]

As expected, the variation in SVA declined from 2007 onward. Figure 6 shows the ratio of SVA s.d. between New Orleans and the rest of Louisiana. There was a sharp upward spike in the SVA s.d. in 2007, as the school system was being broken up, and then a gradual decline back to the pre-Katrina distribution.[35] (To avoid confusion between this and the prior section, note that the *s.d. of SVA* discussed here is different from the earlier references to *average SVA, standardized to s.d. units*.)

The fact that vertical differentiation is now slightly lower than pre-Katrina, almost a decade after the reforms started, is noteworthy. Critics argue that school districts are thought to produce homogenous schools (and at a relatively low level of performance) and certainly this was the case in New Orleans where SVA was far below the state average (Harris & Larsen, 2018). Market and government accountability can apparently reduce this variation as the lowest performers are pushed out of the market. The drop in the variance, from the pre-reform period, to the most recently available post-reform year, is very small, however. This suggests either that traditional school districts generate more variety and quality than might typically be believed, that markets are less effective in eliminating low-performers than their advocates suggest, or some combination of the two.

IV.C.2. Difference in Differences

[34] Given that there are many sources of improvement, the closure/takeover process by itself is not enough to guarantee a decline in SVA variance. In theory, it could have been, for example, that the decline in average SVA among persisters was concentrated in a small number of schools who essentially replaced the closed schools in the left tail of the distribution. However, the analysis that follows rejects this.

[35] In the Appendix we provide more detail with kernel density plots for both New Orleans and all other publicly funded schools in the state.

The above analysis provides descriptive evidence regarding changes in the average and variation in school value-added over time. We also carried out difference-in-differences analyses comparing New Orleans and the rest of the state following equation (7), akin to Harris and Larsen (2018).

As expected, given the above results, Table 2 suggests that there were large and statistically significant increase in school value-added in New Orleans compared with the rest of the state, and small declines in the standard deviation of school value-added. The first column focuses on the average SVA with two pre-reform years and two post-reform years averaged together in the DD. The second column provides the analogous results for the s.d. Finally, the last two columns show that the apparent spike in the s.d. of SVA in 2007 was statistically significant.

IV.D. Robustness Checks for SVA Estimation and Vertical Differentiation

One challenge in interpreting the trends in both the average and s.d. of SVA is that the SVA estimates in 2007 are based on pre-tests from 2006.[36] The former year, in particular, has a high rate of missing data. Even those students who did return to New Orleans in 2006, while they have scores, were taking the tests under different conditions. In addition to the trauma and disruption, the state made the scores of hurricane-affected students low-stakes that year. Taken together, this means that: (a) the number and composition of students contributing to the estimates changed over time in ways that might affect the trend in the SVA mean[37]; and (b) the relationship between contemporaneous and

[36] When calculating the value-added each year, we attribute scores to schools based on the school of attendance in the current year, even if they were attending different schools the prior year. This means, in particular, that the value-added estimates for New Orleans in 2007 are based on lag scores from 2006, from tests taken while students were evacuated.

[37] In particular, Harris and Larsen (2018) show that early-returnees, 2006 and 2007, had higher test scores and were more socioeconomically advantaged.

lagged achievement may be different, effectively changing the value-added model, even for those who do have non-missing scores in both years.

As further evidence of (a), we calculated the 2006 scores missing rates (Appendix Figures A2 and A3) and the school-level variance in missingness of the lagged scores (Appendix Figure A4), in both cases in New Orleans compared with the rest of the state. In all of these cases, New Orleans looks different relative to the rest of the state, especially in 2007.

We therefore re-estimated the results in several ways. First, we restricted the SVA estimates to the sample of students with complete data from 2006-2009 (balanced panel) as a test for the effects of missingness. To address problem (b), we estimated a version of the SVA model that replaced the 2006 score with the predicted score based on 2005 (pre-hurricane) scores, and then restricted the sample again to those that had actual scores in 2007-2009 and a predicted score in 2006. This increases the sample size because so many more students have 2005 scores; it also addresses the fact that the scores were low-stakes in 2006, but high-stakes in 2005.[38]

The results from these two alternative methods show results similar to what we reported earlier. Average SVA is again increasing for both subjects, although Appendix Figure A6 and A7 show a smaller spike in mean 2007 SVA compared with Figure 2. The variation in SVA is also still highest in 2007 and gradually declining in subsequent years (Figure A8 and A9). The spike and decline in SVA variation is more attenuated, however.

[38] We predicted the 2006 model by regressing 2005 scores on 2004 scores (the same as equation (1) but without the school effects) and then applied this model to 2006 scores. One potential flaw in this approach is that it does not account for the differences in school that students experienced in 2006; the average student evacuated to a school with high SVA (Sacerdote, 2012). The identifying assumption in this model is that the differences in school quality students experienced is orthogonal to school quality upon return to New Orleans schools. (Note that this approach does account for differences in school quality in 2005 and before since those school effects are reflected in the 2005 scores.)

From 2007-2009, Figure 6 shows a decline in the ratio from 3.3 to 2, while the balanced panel results suggest a decline from 2 to 1.3 (Figure A8), somewhat smaller than Figure 6 but clearly with the same pattern. Since the pattern is the same and we cannot use this method in later years (the balanced panel eventually runs out of scores), we use the original estimates as our main results. The SVA s.d. results are similar when using predicted 2006 scores (Figure A9).

V.E. Horizontal Product Differentiation and Marketing

In this section, we continue our examination of the evolution of the schooling market, but switch our focus from vertical to horizontal product differentiation. First, we describe trends in the frequency of different characteristics. Next, we apply the modified-Gower measures introduced earlier. Finally, since we can decompose all changes into development effects and closure/takeover effects, we apply the same framework above to changes in the Gower measures to determine the factors contributing to these trends.

V.E.1. General Trends in School Characteristics and Programs

We have three broad categories of product characteristics, with eleven subcategories (see Table 1). We first created figures describing trends in the average number of schools with each characteristic. Recall that we only have Parents' Guide data for New Orleans and only in the post-reform period, therefore we only analyze simple trends within the city.

These New Orleans trends, shown in Appendix Figure A10, show that the average number of reported extracurricular activities grew at all grade levels. They grew especially quickly at the high school level, more than doubling from an average of three per school to around eight. Band and football have been found to be particularly important to New

Orleans families (Harris & Larsen, 2015); we see growth in the offering of these two extracurricular activities, especially in the elementary grades. The percentage of high schools with both band and football programs was already relatively high at the beginning of the data (in 2011).[39] In this respect, elementary/middle schools were simply catching up.[40]

We see some decline in the percentage of schools reporting extended school hours, but a slight increase in those with extended instructional days (i.e., weekend and summer classes). Possible reasons for this include the fact that a large share of students also had long bus rides and therefore, with extended days, had little time to see their families (Lincove and Valant, 2018). Also, schools may have come to believe that packing more instructional time into the same days was an ineffective way to promote learning.

Perhaps the starkest trend, however, with regard to time in school, is the sharp increase in offering after-school care. Schools may have reduced school hours and increased after-care to reduce costs, while also accommodating those families who wanted their children home earlier. The extracurriculars programs might also have been offered only in the after-care and might not have been available to all students.

School discipline has been an active topic of conversation in New Orleans, where schools have a reputation for strict discipline. There is some evidence that the number of suspensions and expulsions increase in the early and middle years of the reforms, but have since declined to near pre-reform levels (Hernández, 2019). Schools can work to prevent

[39] For consistency in variables across years, we start our analyses in 2011. Parents' Guide data collection in prior years was less consistent, and therefore harder to code longitudinally.
[40] We considered the possibility that this gradual increase in horizontal product differentiation was due to increasing student enrollment levels. While the Gower indices are independent of enrollment size, it could be that some large-group activities, such as team sports became more common as more schools reached the minimum size necessary to support these activities.

behavioral incidents, and respond to them, in different ways. A growing share of both elementary/middle and high schools reported Positive Behavioral Interventions and Supports (PBIS) and Restorative Justice (Barrett & Harris, 2018). These strategies might alter learning environments and/or reduce both the number of behavior incidents and the severity of punishments.

In terms of curriculum, elementary/middle and high schools increasingly advertise themselves as "college prep." Arts integration also saw a slight upward trend, in keeping with the growth of extracurricular activities. With increases in these and other programs, it is not surprising that fewer schools had no listing for curricular focus. They were becoming less narrowly focused over time, based on what they reported.

Essentially all schools list "inclusion" as one element of their special education programs, probably because this is required by federal law. However, a growing share of schools also advertised more specific special education programs, such as adaptive physical education, resource rooms, gifted/talented, and others. This may have been driven by a lawsuit filed in 2010 that documented poor treatment of special education students and lack of compliance with federal law.

We see a sharp increase in student support services, especially nurses and counselors. Mental and physical health needs of students in New Orleans, with its high rate of violence, are higher than in most cities.

V.E.2. Product Differentiation: Gower Measures

The above results provide evidence about the trends in total school offerings, but this is not informative about school differentiation per se because each trend discussed above treats each characteristic separately. Horizontal product differentiation is about how

far apart each school is from another in the product space, which requires calculating the distance between each school and each other school, separately. We report three types of Gower measures for this purpose, which vary according to how the characteristics are weighted: (a) the *unweighted Gower* measure includes all measurable school characteristics equally weighted, based on equations (5a)-(5d); (b) the *weighted Gower* also includes all measurable characteristics, but weights each broad category (extracurricular programming, instructional approach, and student support services) equally, based on equation (6); and (c) the *restricted Gower* is the same as (a) but reduces the set of characteristics to those that research shows are most important to families.[41] Figures 7A-7B report each of these three for elementary and high schools, respectively.

In general, post-reform New Orleans schools are more similar than dissimilar. With a maximum dissimilarity of 100 percent, our results across all years range from 8-24 percent dissimilarity. Elementary and high schools have similar levels of differentiation. The unweighted Gower index shows the highest level of similarity across the three measures. While the difference between the unweighted and weighted version is not large, the difference does suggest that accounting for mutually exclusive categories and/or arbitrarily large numbers of specific characteristics (e.g., with extracurricular activities) can affect the measures. Limiting to those characteristics that research shows families are most interested in (Harris & Larsen 2016) seems to matter even more, however. Differentiation is roughly twice as great in the restricted set of measures as in the full set. While we cannot

[41] At the elementary/middle school level these characteristics include number of extracurricular activities, band, football, before/after care, and extended school year. At the high school level we consider: football, band, number of sports (excluding football), and weekend classes.

be sure of the reasons, this is consistent with the theory that schools are deliberately trying to differentiate themselves on what matters most to parents.

As a study of the evolution of the market, we are mainly interested in the trends over time and these are generally flat, but slightly upward sloping in all the measures, indicating gradual differentiation. One potential source of bias in these measures is that the Parents' Guide changed what was reported each year. As the survey of schools itself becomes more detailed, measured horizontal differentiation might increase (if the added categories happen to be ones where differentiation is relatively high). Several reported categories in the Parents' Guide do change slightly over our seven years of data, but the characteristics included in the limited set were collected and reported on consistently throughout. This gives us confidence that what we are observing is, in large part, due to schools marketing themselves in increasingly diverse ways, as opposed to changes in data structure.

The increase in horizontal differentiation could also be due to changes in the student population as families returned after Hurricane Katrina. However, it is not obvious that the early returnees would have different preferences than the later returnees. Other research suggests that the demographics of students in publicly-funded schools in New Orleans were largely unchanged after the storm (Harris & Larsen, 2018).

In short, we find that schools are more similar than not in all years on the horizontal dimension, but they may be marketing themselves as slightly more differentiated over time. These results are robust across all three Gower-based measures.

V.E.3. Decomposition of Horizontal Product Differentiation

As in the analysis of vertical product differentiation, we can decompose our analyses of the Gower indices in the two parts indicated in equation (4). In contrast to the vertical differentiation results, however, we find no clear difference in horizontal product differentiation between persisting and takeover/opening schools.

VI. Conclusion

No market is fixed. They evolve over time as existing firms seek new ways to compete with one another and pursue technological improvement as struggling organizations merge with more efficient ones and as consumer tastes change. All the various theories we considered predict that, when a market first emerges, vertical differentiation will decline, especially in markets like schooling where prices are essentially fixed. Market forces and/or government contracting can push out low-performing schools, and schools may simply try to imitate one another for other reasons emphasized by sociologists. Our results are consistent with that prediction. New Orleans experienced arguably the most market-based reform seen in the U.S. in the last century and this increased average school value-added substantially. After an initial upward spike in the variation in quality (vertical differentiation), there was a sharp drop, so that vertical differentiation is now slightly lower than pre-Katrina levels.

It is more difficult to predict the evolution of horizontal product differentiation, as well as perhaps more difficult to measure it. Our Gower-based measures show a slight upward trend in this form of differentiation, but this may exaggerate the variation in actual offerings, as the Parents' Guide is a marketing tool rather than an actual reflection of what is happening within the schools.

Our decomposition method helps to understand the sources of change in these and other measures. Prior research on New Orleans has concluded that at least 40 percent of the city's overall improvement was due to the closure/takeover of low-performing schools and finding new school operators to replace them (Bross & Harris, 2016). Our analysis here suggests that it is actually higher than that. The success of the closure/takeover process masked the fact that persisting schools were actually declining in performance throughout most of the nine-year span we studied.

Given the significant impact of the closure/takeover process on mean SVA and vertical differentiation, it is somewhat surprising that it did not leave a clear mark on horizontal differentiation. Evidently, the pattern shown in Figure 1B, with hypothetical school E replacing school D in a different part of the product space did not occur. It could be that multiple competing pressures were at work, with those working toward differentiation being offset by other forces inducing similarity. For example, schools were closed because of low quality, which means that replacement schools may have focused on quality first. This highlights the interconnection between horizontal and vertical product differentiation.

These empirical findings are important for understanding how market-based school reforms affect schooling options. This study also makes contributions to the research methods for understanding how schooling markets evolve, especially with regard to product differentiation. These methods can be applied to cities and states that are less market-driven and to other economic sectors.

Appendix

$$\theta_t = \alpha_t^{Pers}\theta_t^{Pers} + \alpha_t^{Exiters}\theta_t^{Exiters} \qquad (2)$$

$$\theta_{t+k} = \alpha_{t+k}^{Pers}\theta_{t+k}^{Pers} + \alpha_{t+k}^{Entrants}\theta_{t+k}^{Entrants} \qquad (3)$$

This yields:

$$\theta_{t+k} - \theta_t = \alpha_{t+k}^{Pers}\theta_{t+k}^{Pers} + \alpha_{t+k}^{Entrants}\theta_{t+k}^{Entrants} - \alpha_t^{Pers}\theta_t^{Pers} - \alpha_t^{Exiters}\theta_t^{Exiters}$$

$$= \alpha_{t+k}^{Pers}\theta_{t+k}^{Pers} - \alpha_t^{Pers}\theta_t^{Pers} + \alpha_{t+k}^{Entrants}\theta_{t+k}^{Entrants} - \alpha_t^{Exiters}\theta_t^{Exiters}$$

Adding $\alpha_t^{Pers}\theta_{t+k}^{Pers} - \alpha_t^{Pers}\theta_{t+k}^{Pers} = 0$ and $\alpha_t^{Exiters}\theta_{t+k}^{Entrants} - \alpha_t^{Exiters}\theta_{t+k}^{Entrants} = 0$ to the right side yields:

$$\theta_{t+k} - \theta_t = \alpha_{t+k}^{Pers}\theta_{t+k}^{Pers} - \alpha_t^{Pers}\theta_t^{Pers} + (\alpha_t^{Pers}\theta_{t+k}^{Pers} - \alpha_t^{Pers}\theta_{t+k}^{Pers}) + \alpha_{t+k}^{Entrants}\theta_{t+k}^{Entrants} - \alpha_t^{Exiters}\theta_t^{Exiters} + (\alpha_t^{Exiters}\theta_{t+k}^{Entrants} - \alpha_t^{Exiters}\theta_{t+k}^{Entrants})$$

Re-arranging terms yields equation (4):

$$\theta_{t+k} - \theta_t = \underbrace{\alpha_t^{Pers}(\theta_{t+k}^{Pers} - \theta_t^{Pers})}_{development-value\ added\ change} + \underbrace{(\alpha_{t+k}^{Pers} - \alpha_t^{Pers})\theta_{t+k}^{Pers}}_{development-share\ change} + \underbrace{\alpha_t^{Exiters}(\theta_{t+k}^{Entrants} - \theta_t^{Exiters})}_{takeover/opening-value\ added\ change} + \underbrace{(\alpha_{t+k}^{Entrants} - \alpha_t^{Exiters})\theta_{t+k}^{Entrants}}_{takeover/opening-share\ change}$$

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Appendix Figure 1: Parents Guide Example

Morris Jeff Community School

Address: 2239 Poydras Ave.
Phone: (504) 373-6258
Fax: (504) 308-3620
Principal: Patricia Perkins
Website: www.morrisjeffschool.org
School District: Recovery School District (RSD
Charter Organization: Morris Jeff Community School, Inc.
Board Chair: Aesha Rasheed

PK K 1 2 3 4 5 6 7 8 9 10 11 12

Mission Statement: *Morris Jeff Community School will offer an education that is a source of freedom and possibility for children, permitting them to develop their talents fully, become effective citizens in our democracy, and attain the foundation they need to excel in high school, college, and beyond.*

Grades Served: PK-4 (building to 8th grade)

Applications Due: March 31, 2012 {oneApp}

Application Process: Follows RSD OneApp enrollment process. RSD will match students to schools based on parent preference and available spaces. After application due date, contact the RSD Family Resource Centers to enroll (see page A-12 for a full explanation of the RSD OneApp process).

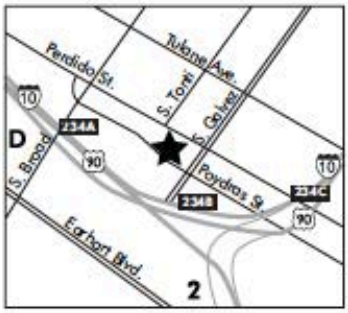
Requirements: open enrollment, no academic entrance requirements

Transportation: yellow school bus

Health Services: part-time school nurse; full-time social worker

Special Education Model: inclusionary educational practices; special education coordintaor

Before and Aftercare: available from 7 a.m. and until 6 p.m. for a fee



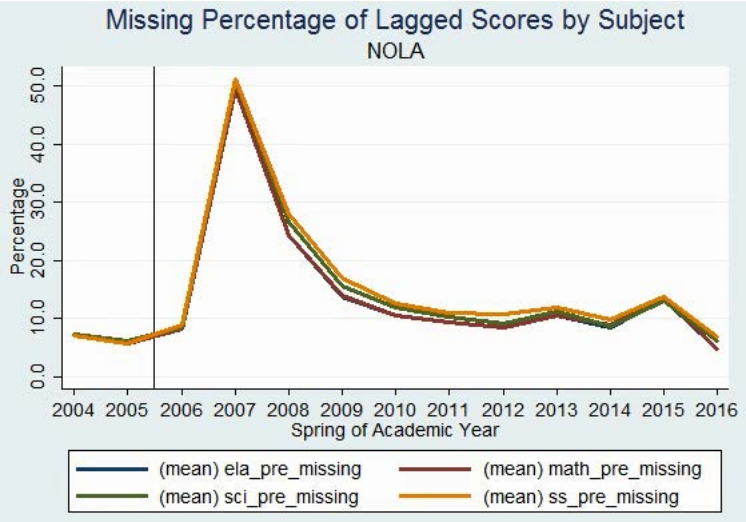
School Features and Programs:		
Extended School Day:		
Extended School Year:	✓	classes through June
School Garden:		
World Languge Instruction:	✓	Spanish
Weekend Classes:		
Tutoring Sessions:	✓	
Uniforms:	✓	avg. cost=$40
Parent Group:	✓	Morris Jeff Family Partnership
Arts Education: (2010 School Arts Survey)	✓	

Other School Programs/Features: candidate school for International Baccalaureate Primary Years Programme, cross-disciplinary units of study invoke student curiosity and meaningful engagement in learning; Spanish instruction, arts, and physical education embedded in everyday learning; strong community investment in daily life of the school

Extracurricular/Afterschool Activities: arts, gardening, tutoring

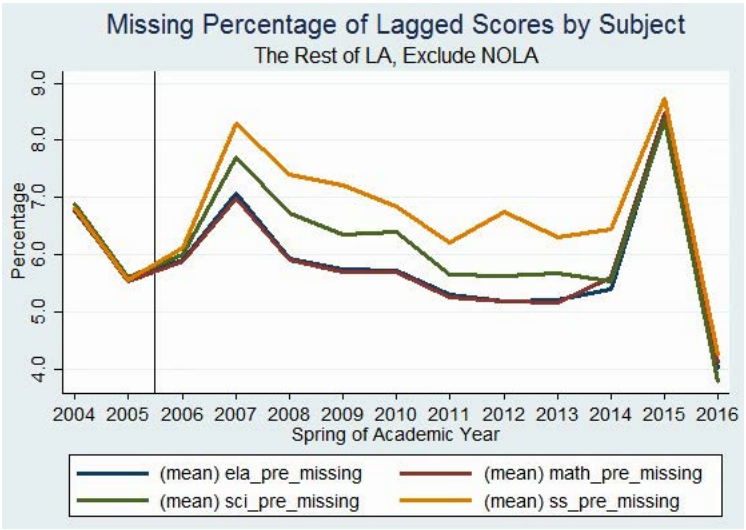
Team Sports: under development

Appendix Figure 2: 2006 Missing Test Data (NOLA only)



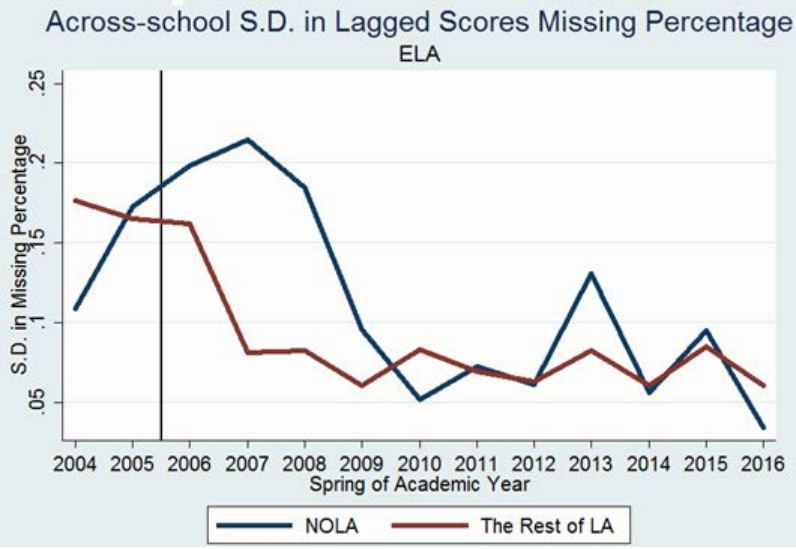
Notes: This figure reports 2006 scores missing rates in New Orleans by subject (student level). The analysis addresses potential error in the school-value-added calculations.

Appendix Figure 3: 2006 Missing Test Data (Louisiana)



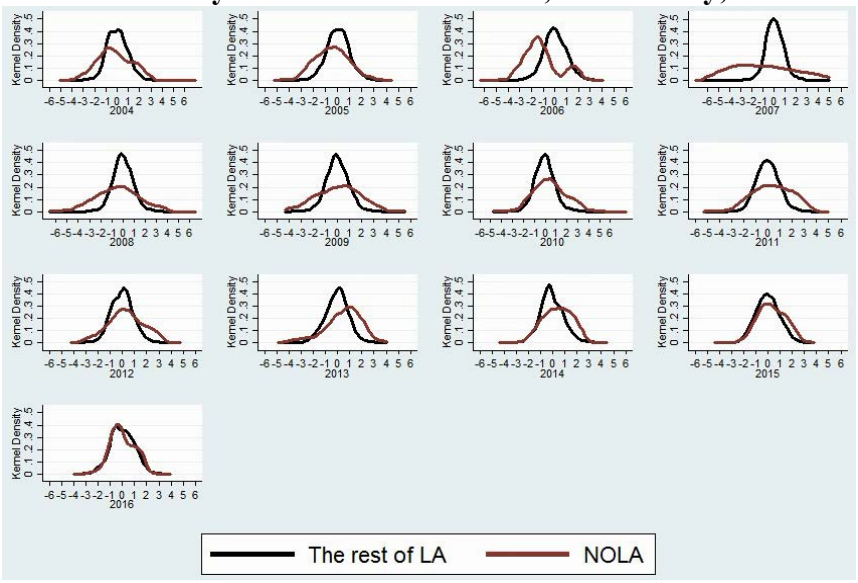
Notes: Analogous to Appendix Figure 1, this figure reports 2006 scores missing rates in the entire state of Louisiana by subject (student level). The analysis addresses potential error in the school-value-added calculations.

Appendix Figure 4
Variance in Missing Data in SVA Analysis



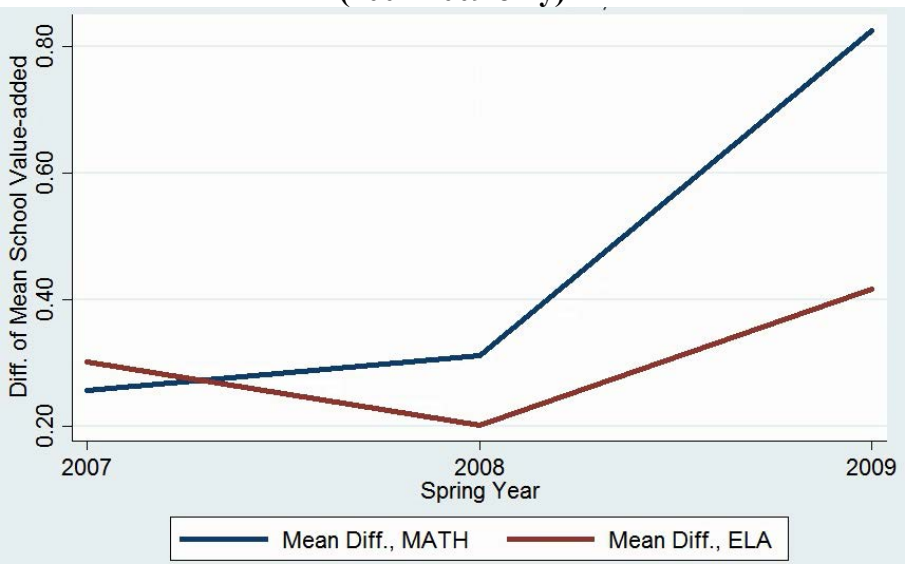
Notes: This figure reports school-level variance in missingness of 2006 scores in New Orleans and the rest of Louisiana, taking ELA as an example.

Appendix Figure 5
Kernel Density of School Value-added, Elementary, MATH



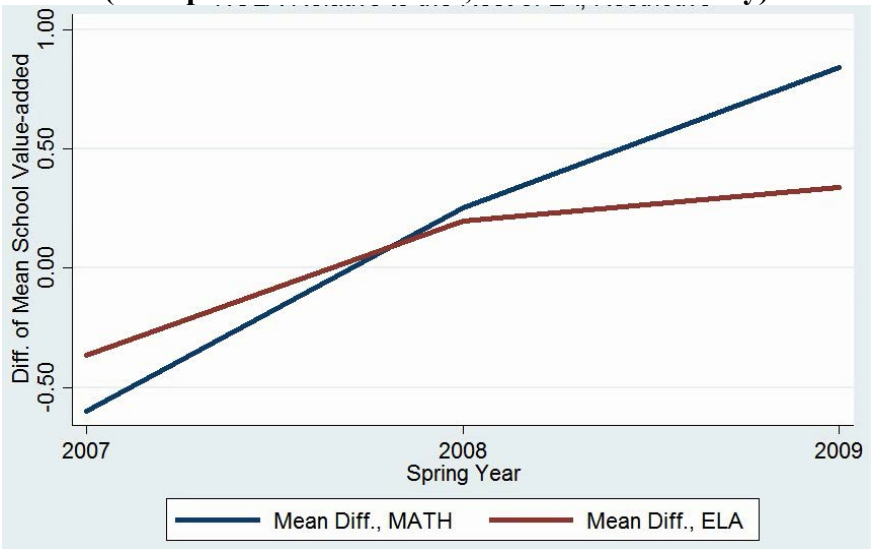
Notes: The figure compares the kernel density of school value-added measures for New Orleans and the rest of the state, by year. The value-added measures are obtained from equation (1). See other details on the method of estimation in the main text.

Appendix Figure 6
***Average* School Value-Added Trend based on Balance Panel**
(2007-2009 only)



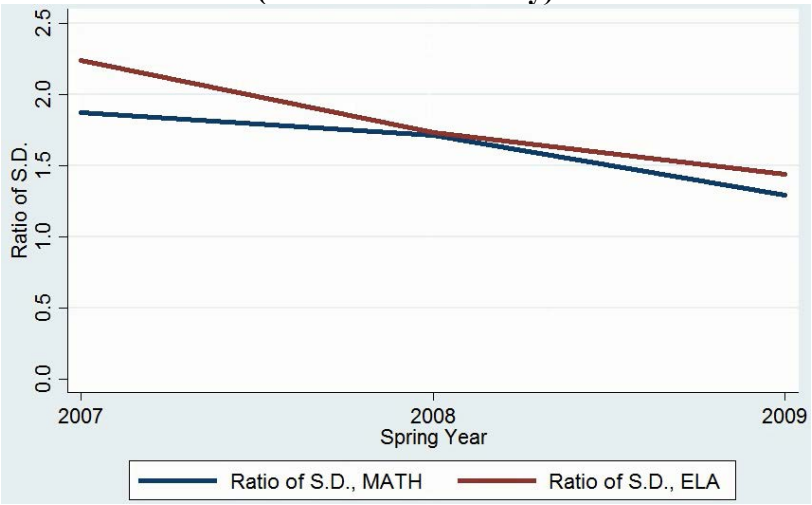
Notes: The school value-added measures in this case use only the sample of students who have scores in all years from 2006-2009, i.e., the balanced panel. This is intended to address the missing data in 2006, shown in the prior figures.

Appendix Figure 7
***Average* School Value-Added Trend based on Balance Panel**
(2006 predicted from 2005; 2007-2009 SVA only)



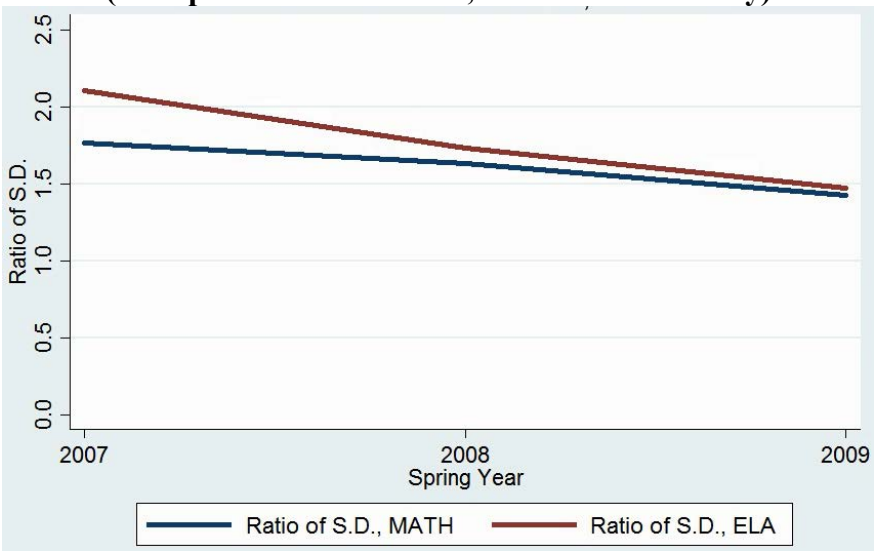
Notes: For this figure, we estimated a version of the school value-added model (equation (1)) that replaced the 2006 score with the predicted score based on 2005 (pre-hurricanes) scores, and then restricted the sample again to those that had actual scores in 2007-2009 and a predicted score in 2006.

Appendix Figure 8
***Variation* in NOLA School Value-Added based on Balance Panel**
(2007-2009 SVA only)



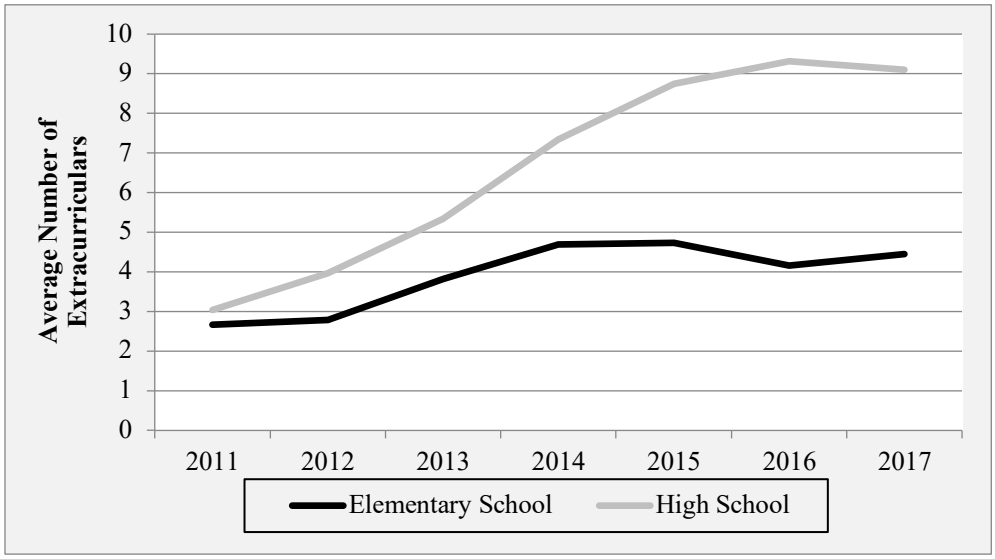
Notes: As in Appendix Figure 6, this robustness check uses school value-added estimates from the sample of students who had complete scores from 2006-2009. In this case, we focus on the cross-school variation in value-added.

Appendix Figure 9
***Variation* in NOLA School Value-Added based on Balance Panel**
(2006 predicted from 2005; 2007-2009 SVA only)

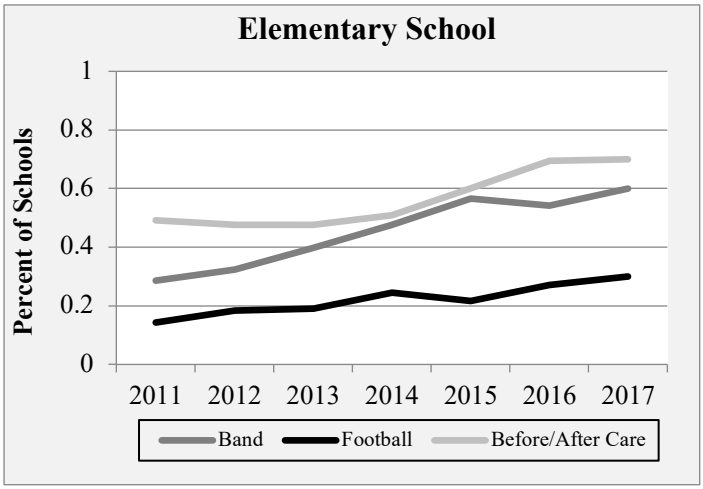


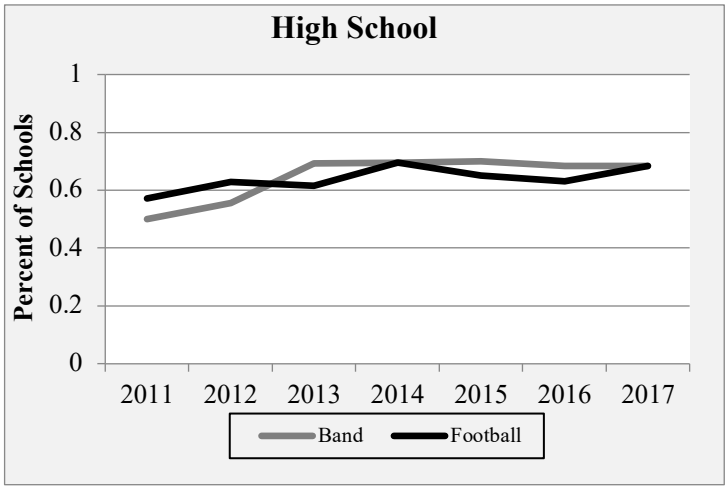
Notes: As in Appendix Figure 7, we estimated a version of the SVA model that replaced the 2006 score with the predicted score based on 2005 (pre-hurricanes) scores, and then restricted the sample again to those that had actual scores in 2007-2009 and a predicted score in 2006.

Appendix Figure 10
Advertised Extracurricular Activities



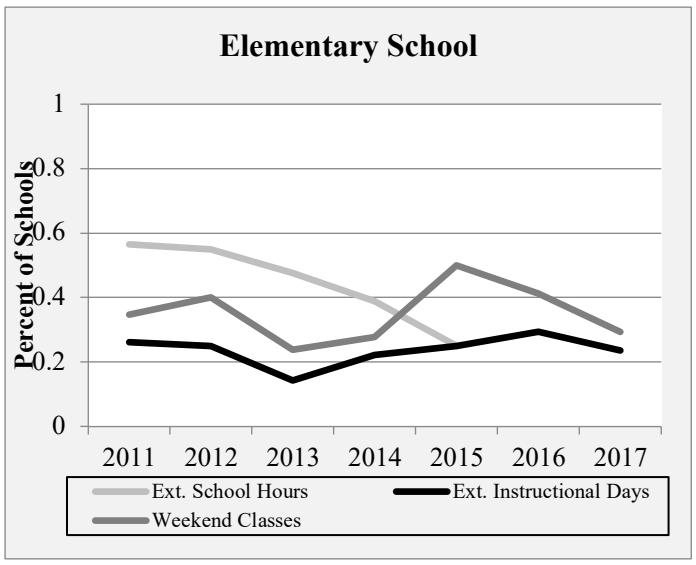
Advertised Band and Football

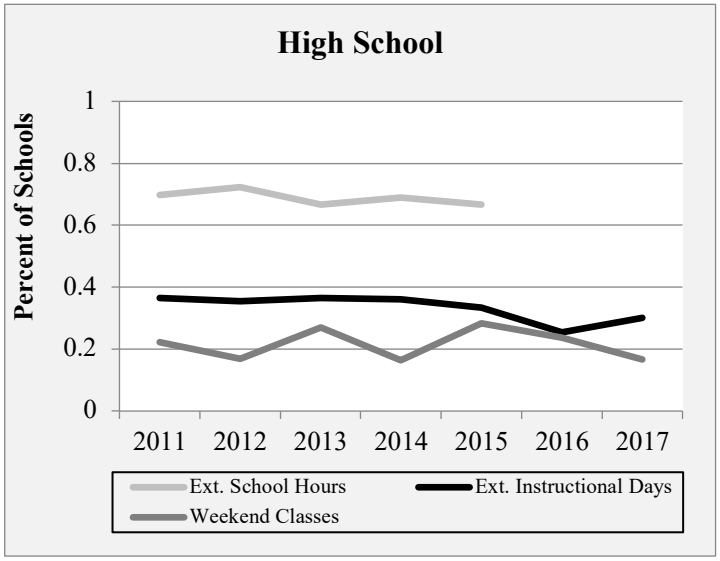




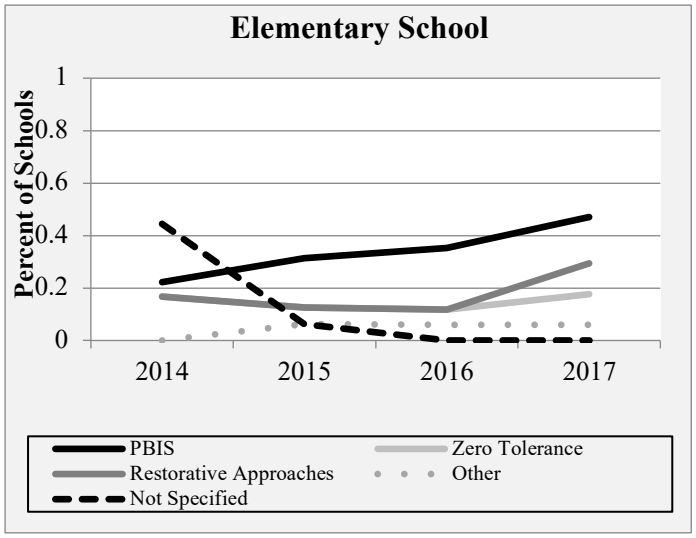
Appendix Figure 10 (cont.)

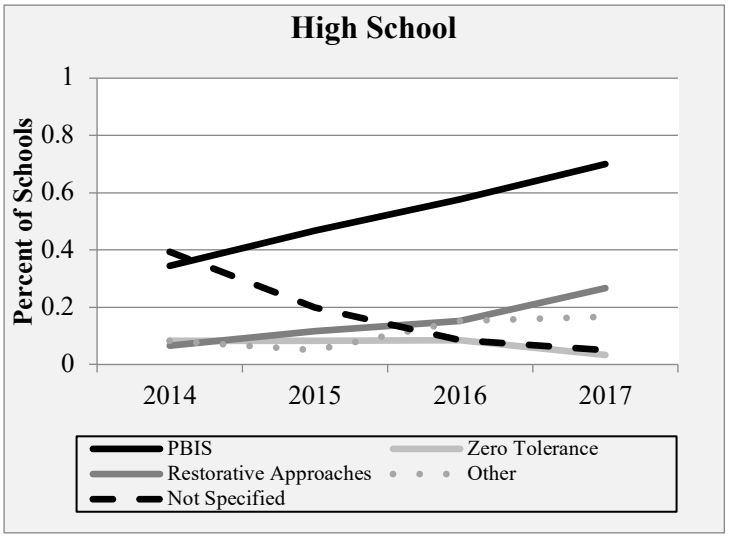
Advertised Extended Hours





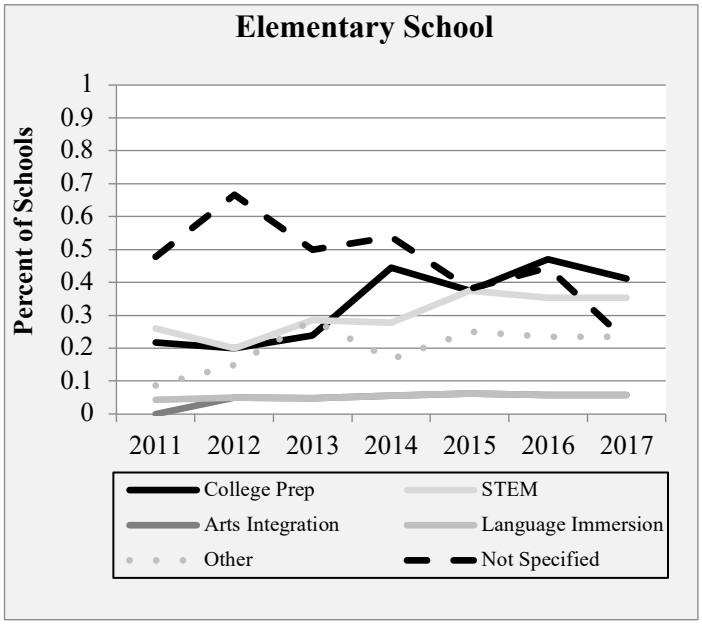
Advertised Discipline Policies

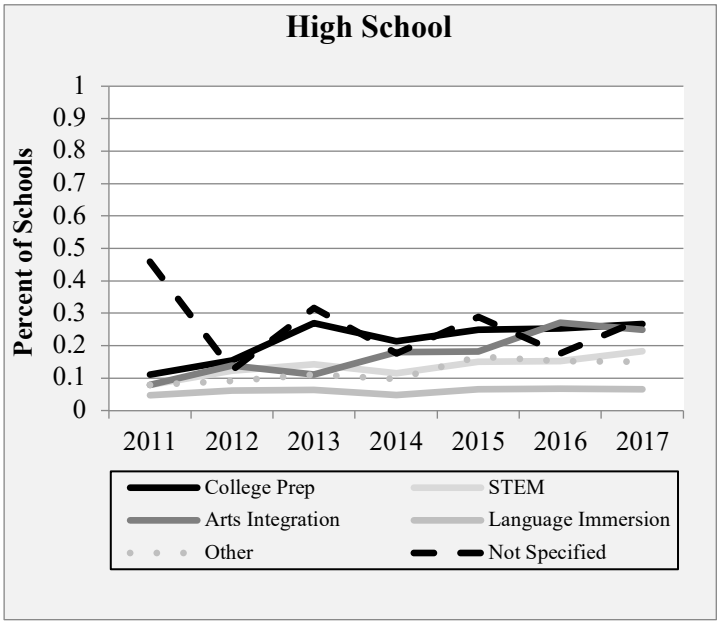




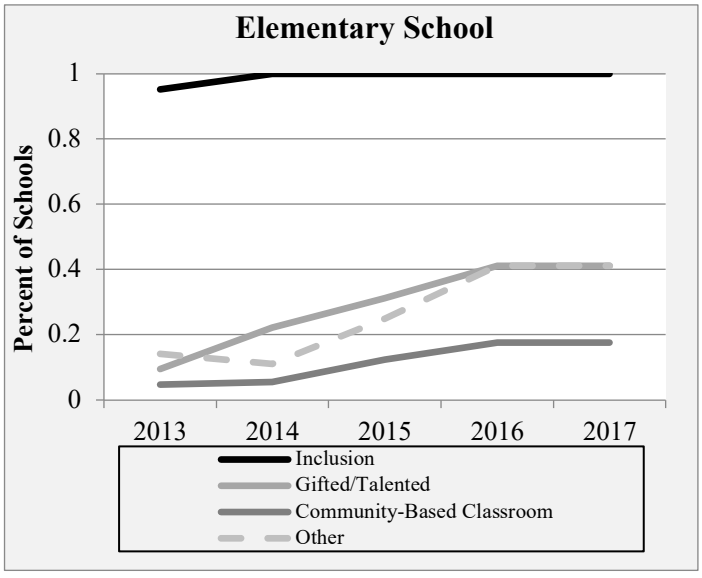
Appendix Tab le 10 (cont.)

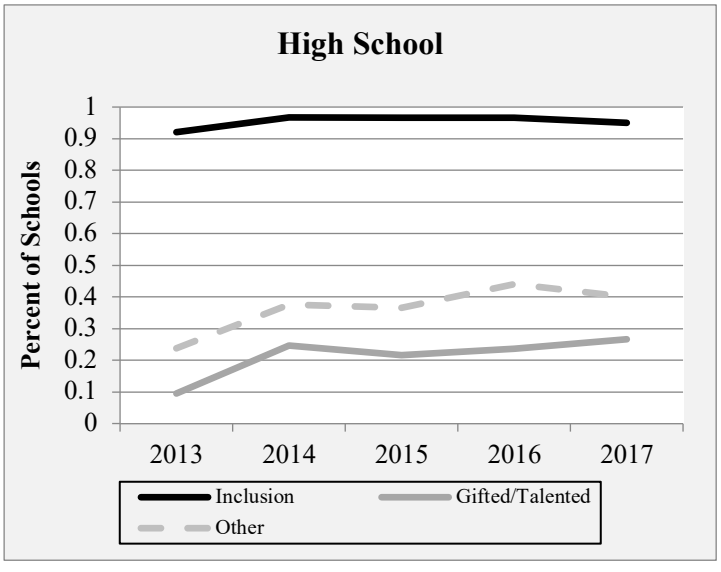
Advertised Curricular Focus





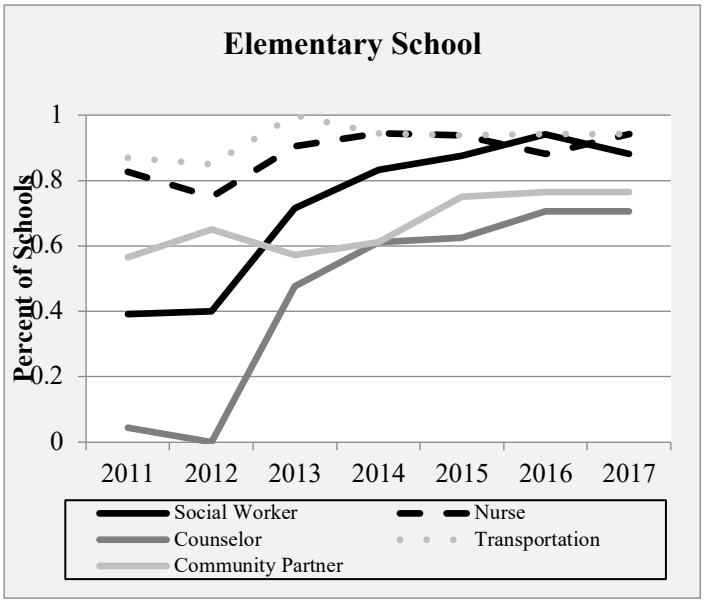
Advertised Special Education Services

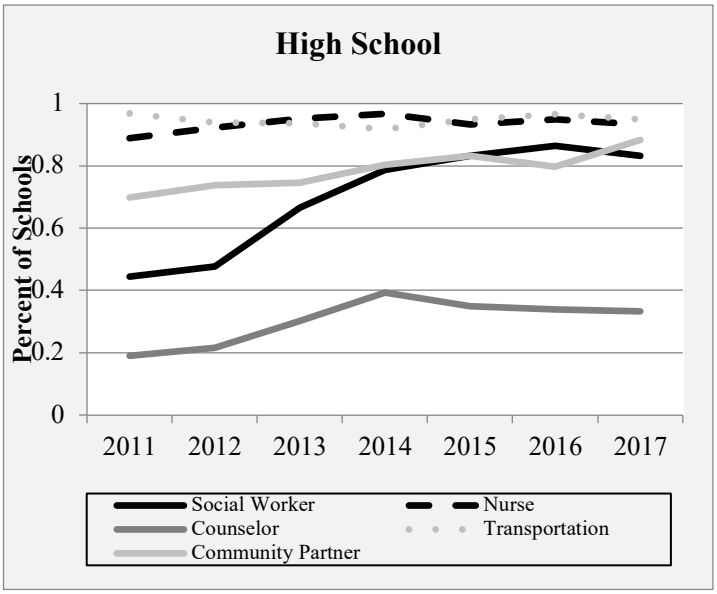




Appendix Figure 10 (cont.)

Advertised Support Services





Appendix Table 1: Inter-Rater Reliability for Parent's Guide Characteristics

Extracurricular Programming		Instructional Approach		Student Support Services	
Variable	**κ**	**Variable**	**κ**	**Variable**	**κ**
Before/after care	0.90	*Discipline Model*		*Transportation*	0.95
Extracurricular Activities		Discipline Code	1.00	*Support Staff*	
Academic	0.71	PBIS	1.00	Support Worker	0.95
Arts	0.62	Conflict Resolution	1.00	Nurse	0.98
Band	0.98	Restorative Approaches	1.00	Counselor	0.88
Sports	0.64	Suspension/Expulsion	1.00	*Community Partners*	
Other	0.88	Focus on Values	1.00	Sports	0.88
Team Sports		Zero Tolerance	1.00	Mentorship	0.64
Cross Country	1.00	Not specified	0.98	Health	1.00
Volleyball	1.00	*Special Education Model*		District	0.83
Track	1.00	Behavior Plan	1.00	College/University	0.95
Tennis	1.00	Community-Based Classroom	1.00	Arts Programming	1.00
Softball	1.00	Counseling/Intervention	1.00	Other	0.79
Soccer	1.00	Gifted/Talented	0.98		
Lacrosse	1.00	IEP	0.98		
Football	1.00	Inclusion	1.00		
Flag Football	1.00	Resource Room	0.98		
Dance Team	1.00	Not specified	0.95		
Cheer Squad	1.00	Other	0.93		
Basketball	1.00	*Curricular Model*			
Baseball	1.00	STEM	0.98		
Other	1.00	Progressive (i.e. Waldorf/Montessori)	1.00		
		Military	1.00		
		Literacy	0.95		
		Language Immersion	1.00		
		Career and Technical Education	0.98		
		College Prep	0.83		
		Arts Integration	1.00		
		AP	0.93		
		Alternative	1.00		
		Not specified	0.83		
		Extended Hours			
		Extended school hours	1.00		
		Extended instructional days	0.98		
		Weekend classes	1.00		
		Other Programs			
		Tutoring	1.00		
		Language Classes	0.90		
		Gardening	0.90		
		AP Classes	1.00		

Figure 1A: Product Differentiation Illustration

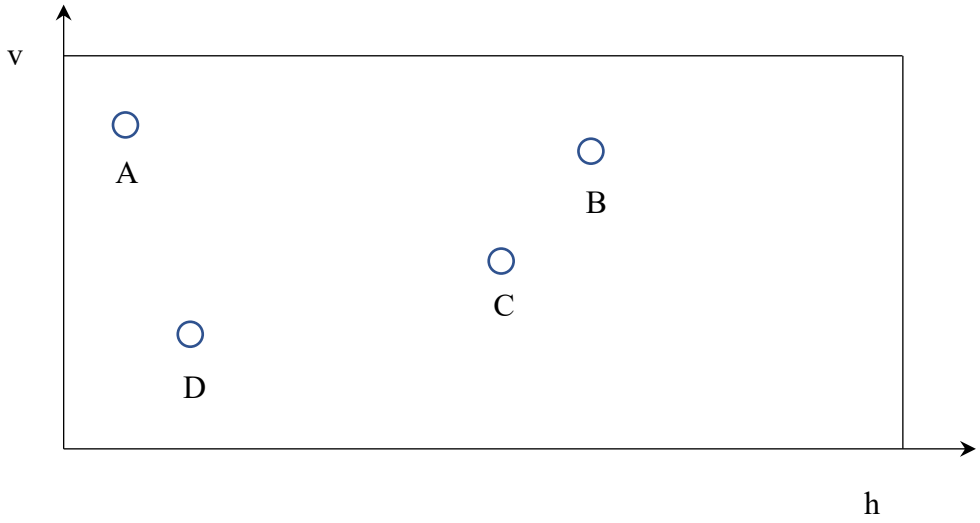


Figure 1B: Potential Evolution of Product Differentiation

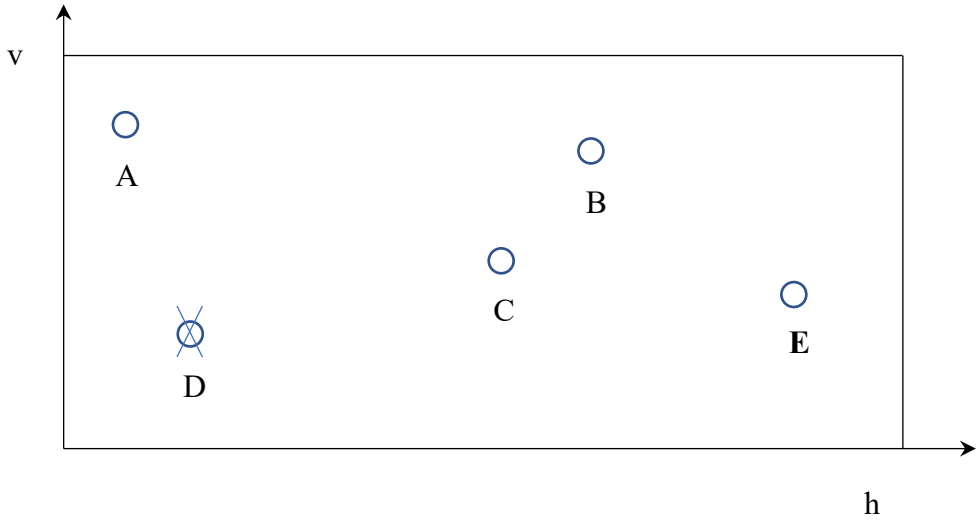
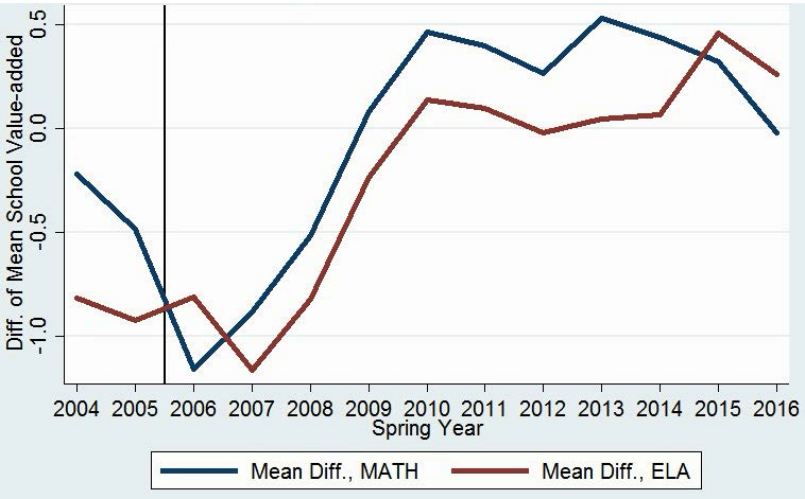
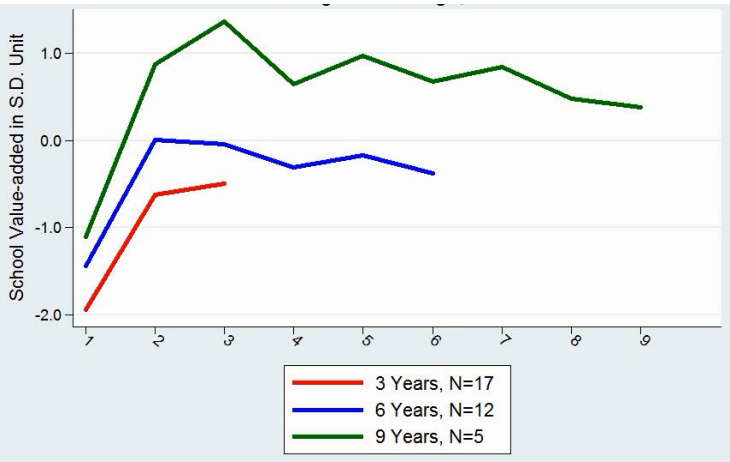


Figure 2
Average School Value-Added Trend in New Orleans Relative to the Rest of LA



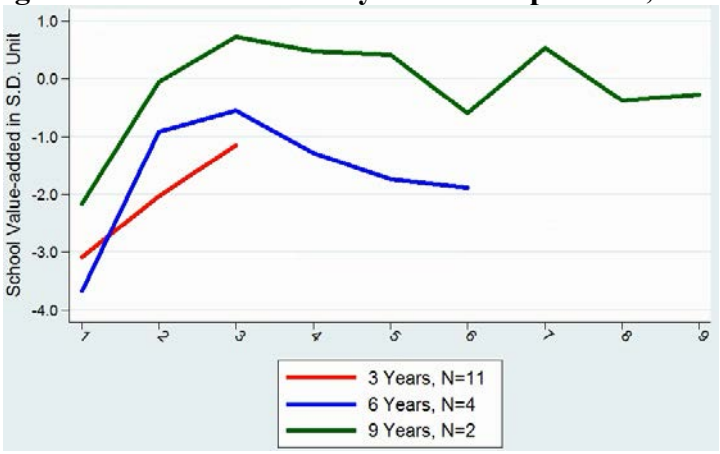
Notes: Trend lines are differences of average school value-added between NOLA and the rest of LA. The vertical (black) line indicates 2015 August, the start of the reforms. School value-added measures are obtained from equation (1). We apply a post-estimation shrinkage adjustment similar to Herrmann, Walsh and Isenberg (2016). See additional details on the value-added estimation in the main text.

Figure 3A
Trends in Value-Added by Years of Operation, *All Schools*



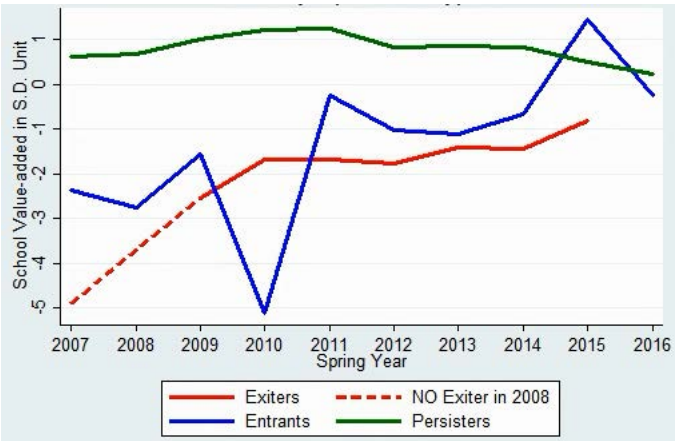
Notes: We grouped schools based on the number of years we can observe their value-added and the figure reports the weighted mean value-added by years opened. This means we include that are closed/taken over and those where we simply run of data in 2016. Year 1 on the x-axis indicates the first year a school is opened and so on. This figure includes

Figure 3B
Trends in Average School Value-Added by Years of Operation, *Closed Schools Only*



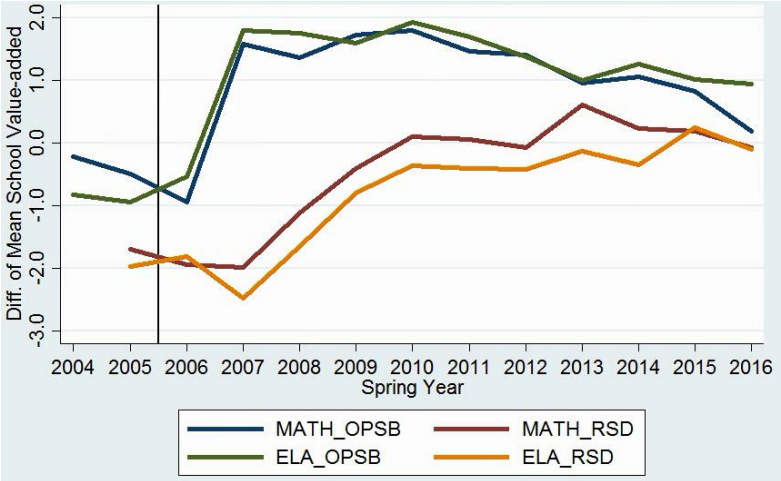
Notes: This figure is the same as 3A except that we restricted the same to those schools that were closed/taken over.

Figure 4
Trends in Average First-Year School Value-Added by School Opertional Status



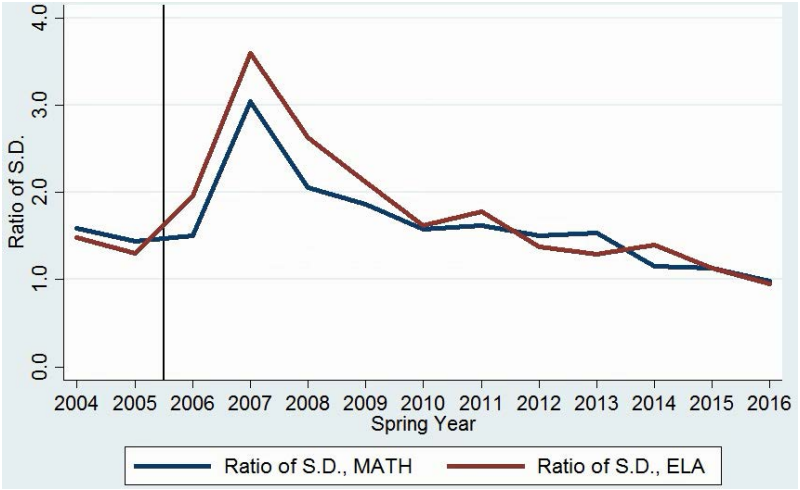
Notes: The "entrants" line reports the weighted mean value-added of new schools in the first year. For example, for 2005, we keep all schools which are open in that year and report their weighted mean of school value-added. The "exiters" line reports the weighted mean value-added of exiting schools in their last year. The dash line between 2007 and 2009 represents there is no exiter in 2008, so the line connects 2007 and 2009. The "perisiters" line reports the weighted mean value-added of schools persist from 2007 through 2016 by year.

Figure 5
Average School Value-added in New Orleans OPSB/RSD Relative to the Rest of LA by School Governance Type



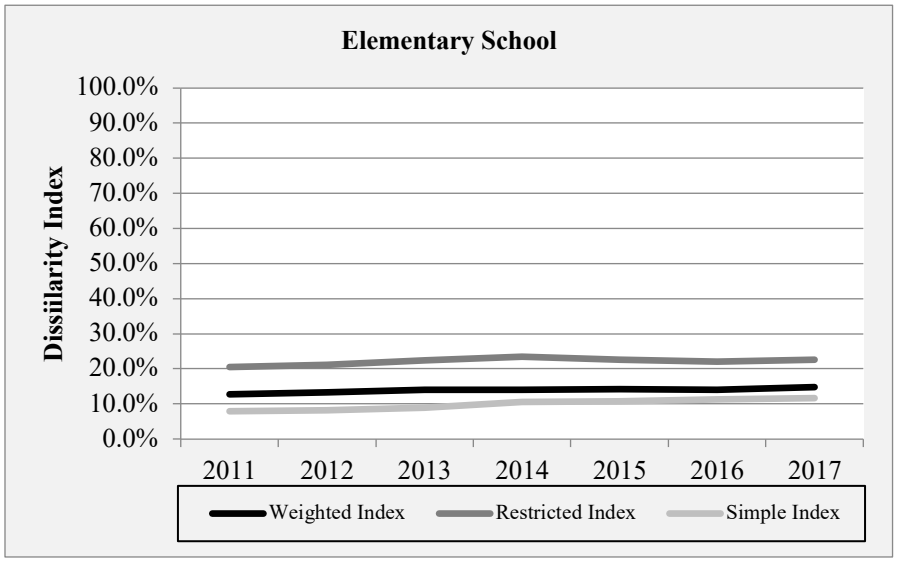
Notes: School value-added calculations are the same as in earlier figure but re-gouped by governance (weighted by enrollment size). OPSB = Orleans Parish School Board (the local district. RSD = Recovery School District (a state agency).

Figure 6
Variation in NOLA School Value-Added Relative to the Rest of LA



Notes: Trend lines are ratio of school value-added standard deviation in New Orleans divided by that of the average district-level s.d. in the rest of LA.

Figure 7A: Gower Dissimilarity Index for All New Orleans Schools



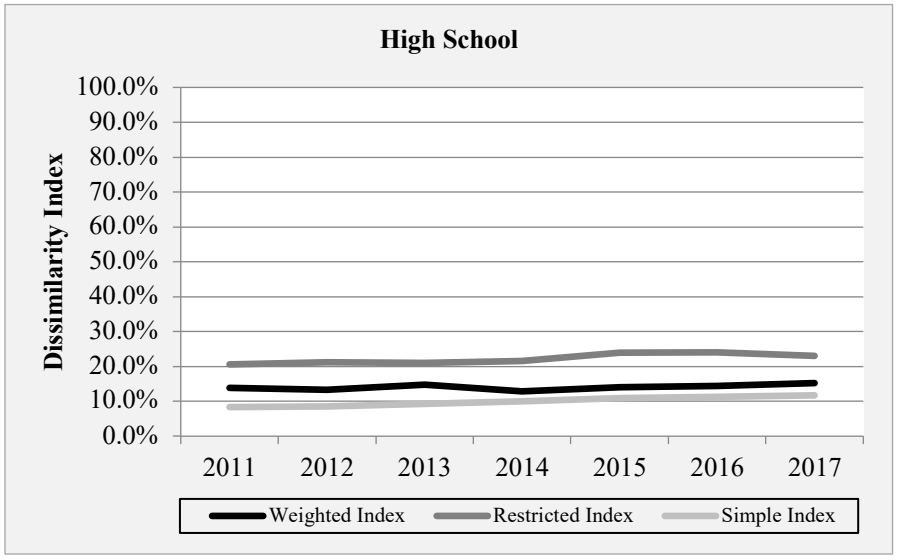
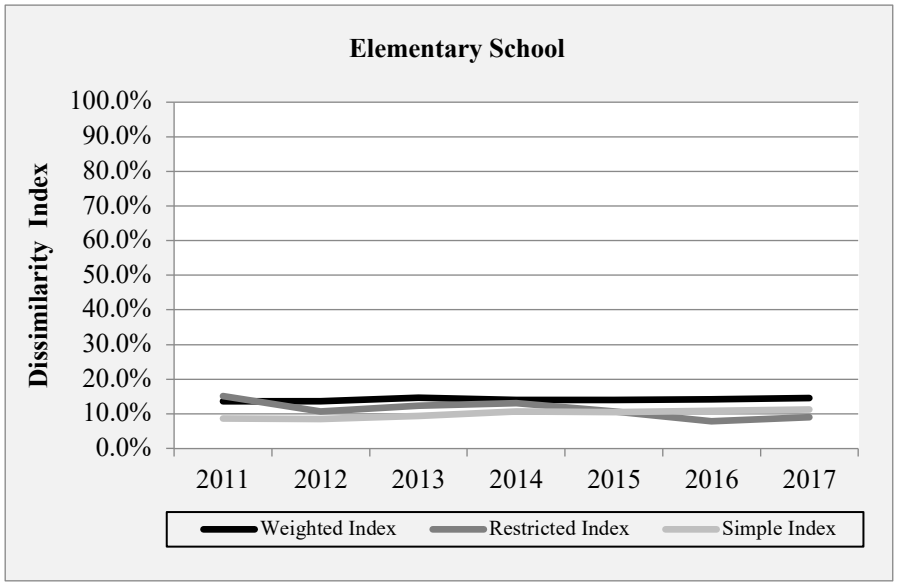


Figure 7B: Dissimilarity Index for Persisting New Orleans Schools



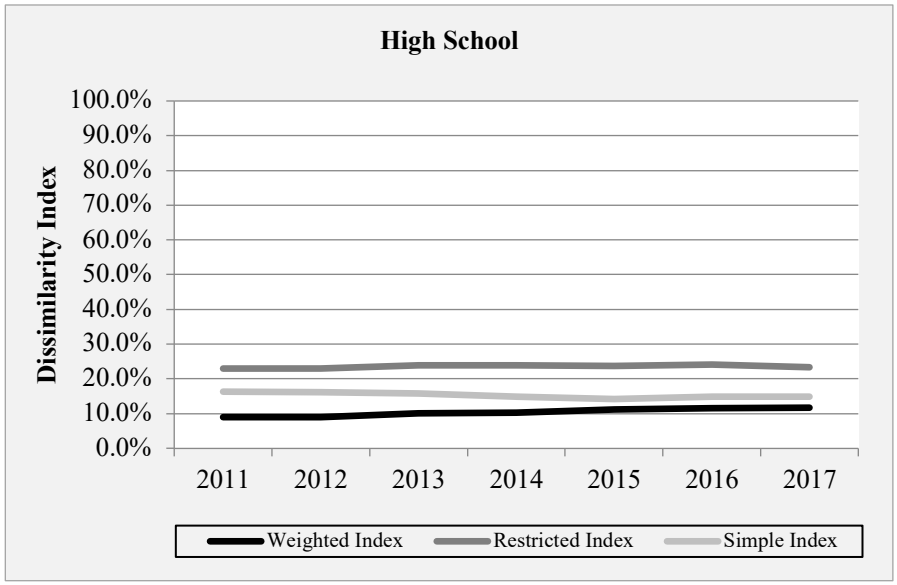


Table 1: NOLA School Market Structure Changes and Decomposition Results

Panel A: NOLA School Market Structure Changes

Years	Num. of Schools Exiters/ Persisters/ Entrants	Share of Students In Beginning Year Exiters/Persisters	Share of Students In Ending Year Persisters/Entrants
2007-2016	20/24/37	41% /59%	47%/53%
2007-2010	4/40/26	3%/97%	70%/30%
2010-2013	25/41/29	32%/68%	65%/35%
2013-2016	22/48/13	24%/76%	83%/17%

Panel B: Decomposition Results

Years	Total Growth	Development - value added change	Development - student share change	Takeover and opening - value added change	Takeover and opening - student share change
2007-2016	1.30	-0.23	-0.03	1.56	0.00
2007-2010	1.32	1.45	-0.11	0.10	-0.12
2010-2013	0.13	-0.23	-0.02	0.39	-0.01
2013-2016	-0.15	-0.38	0.01	0.21	0.01

Panel C: Further Decomposition

Years	θ_{t+k}^{Pers}	θ_{t}^{Pers}	$\theta_{t+k}^{Pers} - \theta_{t}^{Pers}$	$\theta_{t+k}^{Entrants}$	$\theta_{t}^{Exiters}$	$\theta_{t+k}^{Entrants} - \theta_{t}^{Exiters}$
2007-2016	0.24	0.63	-0.39	0.02	-3.79	3.81
2007-2010	0.41	-1.10	1.51	-0.46	-3.54	3.08
2010-2013	0.59	0.92	-0.33	-0.30	-1.52	1.22
2013-2016	0.16	0.68	-0.52	-0.08	-0.97	0.89

Notes: Taking 2007-2010 as an example, school types are defined as followings. Persisters: Schools in operation in 2007 and in 2010. Exiters: Schools in operation in 2007 but not in 2010. Entrants: Schools in operation in 2010 but not in 2007. Decomposition is conducted following equation (4).

Table 2: Effects of New Orleans School Reforms on Average and Variation in School Value-Added

	1	2	3	4
Pre years	2003-2005	2003-2005	2003-2005	2006-2008
Post years	2014-2016	2014-2016	2006-2008	2014-2016
Dependent variable	Average SVA	SVA S.D.	SVA S.D.	SVA S.D.
Post	-0.12	0.06	-0.06	0.12***
	(0.08)	(0.06)	(0.05)	(0.04)
Nola*post	1.17***	-0.23***	1.22***	-1.45***
	(0.08)	(0.06)	(0.05)	(0.04)
Constant	0.02	0.87***	0.87***	0.86***
	(0.03)	(0.03)	(0.02)	(0.02)
Parallel trend coefficients	-0.14***	0.08**	-0.12***	-0.82***
	(0.03)	(0.03)	(0.02)	(0.02)
Num. of Districts	68	68	68	68

Notes: Table 2 lists regression results following equation (7). The dependent variables are the mean or s.d. of school value-added within districts. Column 1 and 2 focuses on the entire period 2003-16, with two pre-reform years (2003-05) and two post-reform years (2014-16) averaged together in the DD. We also re-run regression 1 and 2 using three pre-years and three post-years instead and get similar results. Column 3 and 4 split the entire period further into two sub-periods to capture the spike in the s.d. of SVA in 2007. At the bottom of the table, we report parallel trend coefficients. When there are two pre-periods, the parallel trend coefficient shows the change in difference between NOLA and the rest of LA. A zero means difference between the two groups is constant prior to hurricane Katrina (parallel trend). When there are three periods, the parallel trend coefficient shows the change in difference between the two groups in the first pre-year and the last pre-year. No other district-level control variables are included in above regressions.

Table 3: Coding of the Parents Guide

Extracurricular Programming	
Before/after care	Programs to care for children before and after school hours, primarily in schools serving grades K-6.
Extracurricular activities	Opportunities provided for students to participate in activities outside of the required curriculum. Includes arts, sports, music, etc.
Team sports	Organized team sports for students to participate in.
Instructional Approach	
Discipline model	Discipline model(s) specified by the school (i.e. Zero Tolerance, Restorative Approaches, etc.).
SPED model	Special Education model(s) specified by the school (i.e. Inclusion, Gifted/Talented, etc.).
Curricular model	Curricular focus, if there is one, specified by the school (i.e. College Prep, Language Immersion, etc.)
Extended hours	School provides an extended day, year, or weekend hours beyond what is typically required for instructional time. This does not include before/afterschool childcare.
Other programs	School has a range of other opportunities for students such as a school garden, or language and AP courses offered.
Student Support Services	
Transportation	Includes both yellow school bus and RTA. Indicates whether one, both, or none are offered.
On-site support staff	Providing staff to support the emotional and behavioral wellbeing of students, including nurses, social workers, and counselors.
Community partnerships	Opportunities provide to students through partnerships with external organizations (i.e. health and emotional well-being, mentorship, college coursework, etc.)

Notes: Table 1 includes all of the 66 school characteristics we used in the analysis of product differentiation, organized into 13 specific categories and three broad categories. These categories are, to some degree, arbitrary and could be organized differently. The categories are mainly relevant to the calculation of the weighted Gower indices where we calculate a separate Gower index for each of the 13 categories and then equally weight these within each of the three broad categories.