Trickle-Down Education? Effects of Elite Public Colleges on Primary and Secondary Schooling Markets in India*

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Abstract

We present some of the first estimates of the effects of public expenditure in higher education on primary and secondary schooling markets. Exploiting the rollout of elite public colleges in India, we find that public investment in college infrastructure increases years of education as well as educational attainment among school-age children. These gains in schooling are driven by a larger role played by private schools as more for-profit schools enter regions with new elite colleges, and students switch from public to private schools. We present suggestive evidence that new elite public colleges led to focal investments in roads, water and electricity services, reducing setup costs for private schools, and travel costs for school-going children.

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1 Introduction

The question of whether government spending on schooling infrastructure can cause an increase in educational attainment has been a central concern for policymakers and economists. While a large body of literature has evaluated the impact of public investment in primary and secondary schools on primary and secondary schooling (Birdsall, 1985; Duflo, 2001; Lavy, 1996; Lillard and Willis, 1994), little is known about the effects of public investment in higher education on primary and secondary schooling. Public investment in higher education, in the form of new colleges or universities, may affect both the demand and supply of lower levels of schooling. For instance, new public colleges may increase the demand for primary and secondary schooling by raising parental aspirations, or by providing better access to higher education. At the same time, public colleges may crowd-in investment in other public goods like power, roads, and water, in turn facilitating private investment in primary and secondary education. In this paper, we present the first estimates of the 'spillover' effects of public investment in college infrastructure on local markets for primary and secondary education, study the various channels that determine these consequences, and interpret our results through the lens of the literature on the determinants of private schools and school choice.

To measure the causal effect of public investment in higher education on local schooling markets we exploit the staggered rollout of elite public colleges in India between 2004 and 2014. In line with the larger trend of increased public spending on higher education, almost 50% of all elite public colleges have been established countrywide in the last decade. Two key features distinguish elite colleges from regular colleges or universities. First, the location of newer elite colleges has primarily been a function of addressing regional imbalance caused by the location of older such institutions. Second, student admissions into these colleges are determined by extremely competitive nation-wide entrance exams. Thus, it is plausible that elite college location and year of establishment are not driven by future changes in the local schooling market. Nevertheless, in our analysis, we restrict the sample to districts that eventually get an elite public college. Our identifying assumption is that the timing of establishment for a particular college is unrelated to the timing of unrelated shocks to the local schooling market. We present evidence in support of this assumption.

We find three key results. First, the establishment of a new elite public college increased years of education by 0.3 years among school-age children at the district level. Furthermore, new elite public colleges increased primary and middle school attainment by 5 percentage points, and secondary and higher secondary attainment increased by between 2 and 3 percentage points, respectively. Second, elite public colleges increase the probability of private school enrollment by over 5 percentage points, while significantly decreasing the probability of enrollment in public schools. Third, we examine the impacts on the entry and exit of schools. Elite public colleges increase the number of private schools by over 20% at the district level, but have no impact on the number of public schools. Overall, our simple calculations suggest that indirect benefits through primary and secondary education markets are at least 48% of the direct benefits of elite public colleges incurred through training undergraduate and graduate students.

We find compelling evidence that elite public colleges led to focal investments in infrastructure services, and may be one mechanism driving our results. We find that a decrease in distance to the closest elite college are significantly more likely to have access to electricity, tap water and paved roads at the village level. We corroborate these effects using satellite-measured nighttime lights as a proxy for electrification, we show that an increase in proximity of an elite colleges led to a large increase in the density of nighttime lights. Such investments in public infrastructure can reduce setup costs for private schools. Conditional on the availability of public schooling infrastructure, the entry of private schools could potentially solve a (travel) cost constraint for marginal students, enabling them to get additional years of education. Indeed, we find that private schools are more likely to exist in villages closest to the elite public college, and that distance to private schools decreases in districts that received an elite public college.

Besides contributing to the literature on the effects of public investment in schooling infrastructure on educational outcomes, in investigating the effects of elite public colleges on primary and secondary schooling markets, this paper also contributes to the literature on economic effects of place-based policies that target infrastructure development to an underdeveloped region (Kline and Moretti, 2014; Serrato and Wingender, 2016), within which a small number of papers have studied place-based programs in developing countries (Park, Wang and Wu, 2002; Ravallion and Jalan, 1999; Shenoy, 2018) Related also, is the literature evaluating the development impacts of specific infrastructure services like roads, water and electricity (Adukia, Asher and Novosad, 2017; Burlig and Preonas, 2016). We show that public expenditure on higher education can lead to infrastructure investments in roads, water and electricity services, and may have significant development impacts.

The rest of the paper is organized as follows. In Section 2 we provide a theoretical model of school choice and private school entry to understand the underlying possible mechanisms. Section 3 gives background information on elite public colleges in India, and Section 4 describes the data. In Section 5 we investigate the impacts of elite public colleges on educational attainment, enrollment in both state-run and private schools, and the number of primary and secondary schools. We discuss potential mechanisms behind these empirical patterns in Section 6, and Section 7 concludes.

2 A Model of School Choice & Private School Entry

2.1 The Supply of Schools

The supply of state-run or public schools N_0 in district d is determined exogenously by district administrators. The supply of private schools, on the other hand, is market determined; they enter if they can earn positive profits.[1]

Private schools are profit maximizers and have heterogeneous costs.[2] They are also price takers in a competitive market and charge a fee p. Muralidharan and Sundararaman, 2015, find that children enrolled in private schools do not perform better than their peers in public schools on subjects that are taught in both schools, although private schools are more cost-effective. In our model, private schools have the same output as public schools, although the operating costs might be different; and we have heterogeneity in efficiency across private schools (Kremer and Muralidharan, 2008).

We begin by looking at the profit function of school j in district d with inputs X_j. We

[1] For notational convenience we drop the district sub-script d from our equations, even though quantities vary across districts.

[2] Alternatively, they could have been modeled as having heterogeneous productivities, with the same result.

define total educational output (in student-years) as $Q_j = \overline{\theta} X_j$ and cost function $Z(X_j) = z_{1j} X_j + \frac{1}{2} z_2 X_j^2$ to be quadratic.[3] $\overline{\theta}$ is the average education level in the district and captures demand externalities driven by aspirations and peer effects (Birdsall, 1982; Bobonis and Finan, 2009). For instance, proximity to an elite public college may increase the demand for schooling. z_{1j} reflects the heterogeneity in costs across schools and districts, drawn from the distribution $G(z_{1j})$, where some schools use their inputs more effectively than others. This distribution varies across districts d as it may be cheaper to hire teachers in some districts, while others may have better public infrastructure like electricity or drinking water.

$$\pi_j = Q_j p - Z(X_j) = p\overline{\theta} X_j - Z(X_j)$$

Implying $X_j^* = \dfrac{p\overline{\theta} - z_{1j}}{z_2}$, output is $Q_j^* = \overline{\theta}\dfrac{p\overline{\theta} - z_{1j}}{z_2}$, and profit function $\pi_j^* = \frac{(p\overline{\theta} - z_{1j})^2}{2z_2}$.

The total number of potential private schools is N. School j would enter only if its profit is positive, and cost z_{1j} is drawn from $G(z_{1j})$. The fraction of schools in the district is $G(p\overline{\theta})$, and the number of private schools in the district that enter is

$$N_1 = N \int_0^{p\overline{\theta}} z_{1j} \, \mathrm{d}G(z_{1j}) = p\overline{\theta} N$$

Given this, the total supply of schooling in the district is

$$Q_{Sy} = \sum_{j=1}^{N_1} Q_j = \sum_{j=1}^{N_1} \overline{\theta} \frac{p\overline{\theta} - z_{1j}}{z_2} = \frac{p\overline{\theta}^2 N}{z_2}(p\overline{\theta} - \overline{z_1}) \tag{1}$$

2.2 Demand for Schooling and School Choice

Demand for schooling depends on the costs of going to school and the returns to schooling. Costs vary across individuals based on criteria like tuition, distance to the nearest school(s), ability and wealth. The cost for child i to attend school j is

$$c_{ij} = \alpha p_k + \beta T_{ij} - \gamma ln(W_i) - \Delta_i \tag{2}$$

[3] While easy to hire the first few teachers/administrators, it is more costly to hire the next as the pool of candidates dwindles.

where the costs depend on tuition p_k, travel costs T_{ij}, wealth W_i, and ability Δ_i. The tuition $p_k = 0$ for public schools, and $p_k = p$ for private schools, where $p > 0$. Increase in wealth makes schooling more affordable, also allowing us to capture any "consumption value" of education. Household wealth W_i, travel costs T_{ij} and abilities Δ_i are drawn from distributions such that their means ($ln(w)$, δ and T_k) vary across districts:

$$ln(W_i) = ln(w) + \zeta_i \quad \& \quad \Delta_i = \delta + \delta_i \quad \& \quad T_{ij} = T_k + \eta_{ij} \; for\{k = s, p\}$$

For ease of notation, we define an error term ε_{ij} based on these costs, and restate the cost function c_{ij}:

$$\varepsilon_{ij} \equiv \beta\eta_{ij} - \gamma\zeta_i - \delta_i \quad \& \quad c_{ij} = \alpha p_k + \beta T_k - \gamma ln(w) - \delta + \varepsilon_{ij} \quad for \;\; \{k = s, p\}$$

Children will only attend school if the returns to education, r, are greater than the cost of attending school. If a child decides to attend school, the choice of the school only depends on cost. School J is chosen if:

$$q_i = 1(r - min(c_{ij}) > 0) = 1(r - min(\alpha p_k + \beta T_k - \varepsilon_{ij}) + \gamma ln(w) + \delta > 0) \tag{3}$$

where the returns to education r for both public and private schools are equal.[4]

The probability of a student going to school k depends on whether school k is public or private. There are N_0 public schools and N_1 private schools. If the costs ε_{ij} is i.i.d. with distribution F(.), the aggregate demand for private school is

$$Q_p = MN_1F(\phi - \alpha p)[1 - F(\phi)]^{N_0}[1 - F(\phi - \alpha p)]^{N_1 - 1} \;, \tag{4}$$

where where $\phi \equiv r - \beta T_k + \gamma ln(w) + \delta$. Notice from the supply-side $N_1 = Np\bar{\theta}$.

In equilibrium the supply and demand of private schooling are equal, allowing us to

[4]Theoretically, the returns to schooling can be allowed to be different between private and public schools, without a change in our comparative statics. However, given that Muralidharan and Sundararaman, 2015, find similar returns for subjects commonly taught in both schools, we model them to be the same.

equate Equations (1) and (4).

$$MN_1F(\phi - \alpha p)[1 - F(\phi)]^{N_0}[1 - F(\phi - \alpha p)]^{N_1 - 1} = \frac{N_1\overline{\theta}}{z_2}\left(p\overline{\theta} - \overline{z_1}\right) \tag{5}$$

2.3 Comparative Statics

We analyze changes to the equilibrium by examining the effects of elite colleges on the supply Q_{Sy} and demand Q_d for private schooling at the district level.[5]

2.3.1 Effects of Infrastructure Upgrades:

An increase in the setup (or entry) costs for private school shifts the supply curve inwards, raising equilibrium market price ($dp/d\overline{z_1} > 0$; $dp/dz_2 > 0$). Conversely, if elite public colleges are bundled with investment in water, roads and electricity services, it may reduce these entry costs, and cause an outward shift in the supply of private schools ($dQ_{Sy}/d\overline{z_1}|_p < 0$; $dQ_{Sy}/dz_2|_p < 0$).

An increase in the supply of private schools lowers the equilibrium fees charged at a private school ($dp/d\overline{z_1} > 0$; $dp/dz_2 > 0$), and the distance to the nearest private school (lower T_p). We find that an increase in travel costs for private schools will decrease the demand for private schooling ($dQ_d/dT_p < 0$). So, if elite public colleges increase the number of private schools, it will lower travel costs T_p, resulting in greater demand for private schooling. If households are sensitive to travel costs and private school fees, an outward shift in the supply of private schools raises equilibrium educational attainment in the district.

2.3.2 Effects of Changes in Population, Incomes, Abilities and Aspirations:

If the establishment of public colleges increases incomes, migration, or an increase in the ability distribution of students, it may lead to private school entry. For instance, an increase in income increases the demand for all schooling (both public and private), raising the equilibrium fees as well as the number of private schools ($dp/dln(w) > 0$; $dN_1/dln(w) > 0$). Similarly, the demand for all schooling increases with population, raising equilibrium fee

[5] Detailed derivations are in Appendix A.

and the number of private schools ($dp/dM > 0$ and $dN_1/dM > 0$). Indeed, if the new population has more able students, as the children of faculty may be, this will have similar effects ($dp/d\delta > 0$; $dN_1/d\delta > 0$).

Demand externalities (either via peer effects, information or role model effects) will raise the demand for all schooling, raise tuitions and induce more private schools to enter the market ($dp/d\overline{\theta} > 0$; $dN_1/d\overline{\theta} > 0$). Public colleges may increase the actual returns to education by creating new employment opportunities; alternatively proximity to public colleges might affect perceived returns and student aspirations. Either scenario will encourage private school entry. To be specific, increases in the actual or perceived returns to education will raise schooling demand, raise tuitions and induce more private schools to enter the market ($dp/dr > 0$; $dN_1/dr > 0$).

3 Elite Public Colleges

Elite public colleges are federally funded, and specialize in offering undergraduate or postgraduate education in one of the following fields of study: medicine, information technology, sciences, engineering, architecture or business. Enshrined as 'Institutes of National Importance', elite public colleges receive special recognition and funding from the central government. Importantly, elite public colleges share certain features that are useful in investigating the causal effects on local schooling markets, as well as understand the underlying mechanisms.

First, student admissions into these institutions are determined by extremely competitive nation-wide entrance tests. Second, the location of newer elite colleges has been a function of addressing regional imbalance caused by location of older such institutions (Daily News and Analysis, 2015; The Hindu, 2014; The Hindu Business Line, 2003). A state is unlikely to get a new elite public college in medicine if it already has one.[6] This means that such colleges are not placed randomly. However, it is unlikely that the year of entry at a specific location are driven by anticipated changes in local schooling markets. Nevertheless, we restrict our analysis to districts that received a public college between 2004 and 2014, ensuring that

[6] We examine if states with an elite public college in a certain field of study, before 2004, received a new elite college in the same field of study, between 2004 and 2014. We find no such instance (Figure A.1)

we are not comparing dissimilar districts, and include district fixed effects to adjust for level differences across districts. Our identifying assumption is that the year of entry at a particular location is uncorrelated with the timing of other shocks to the local schooling market in that location.

Lastly, discussions between administrators, covered extensively by the popular press, help inform our analysis of the potential mechanisms through which elite public colleges impact schooling markets. There is a perception among local administrators, lobbying for economically backward districts, that these elite institutions can transform a district into an "educational hub" (The Telegraph India, 2014; The Times of India, 2015, 2016*a*). Indeed, newer elite public colleges have been established in economically backward districts, unlike their older counterparts. In such a context, it is plausible that these institutions lead to investments in infrastructure services like electricity and water.

Quotes from the foundation-stone laying ceremony of an elite business school in an economically backward state of India, Jharkhand are a case in point (The Pioneer, 2013; The Telegraph India, 2013). Some capture the sentiment of locals: *"A nondescript village devoid of proper electricity and drinking water supply, Cheri has one single kutcha (temporary) road that links it to Ring Road that leads to Ranchi (capital of Jharkhand). However, with today's high-profile installation, its residents hoped of good tidings in the future."* Others, capture the expectations of the Minister for Rural Development: *"Such institutions in backward region (state) like Jharkhand are beneficial."*.

Table A.1 provides year-on-year changes in the number of districts with elite public colleges between 2004-2014, and Figure A.2 shows districts where elite public colleges were set-up between 2004-2014, and used in our analysis.

4 Data

4.1 National Sample Survey

The National Sample Survey (NSS) is a nationally representative survey consisting of yearly small-sample rounds ("thin" rounds), and five-yearly large sample rounds ("thick" rounds).

These surveys ask detailed questions about thirteen different levels of education, and contain extensive information on schooling outcomes like years of education and educational attainment. The probability-weighted sample is constructed using a two-staged stratified sampling procedure with the first stage comprising of villages and block, and the second stage consisting of households. Households are selected systematically with equal probability, with a random start. We use four different rounds of the NSS data, between 2004 and 2012. The 2004 and 2010 "thick" rounds are the large-sample rounds. The 2007 and 2012 are small-sample "thin" rounds. Using these four NSS rounds, we evaluate the impact of elite public colleges on years of schooling and educational attainment. We present summary statistics on years of schooling and educational attainment in Table A.2.

4.2 Annual Status of Education Report

The Annual Status of Education Report (ASER) is an annual education survey for school-age children in India.[7] The sample is a representative repeated cross section at the district level.[8] The survey contains information on enrollment status, current grade, and school type for every child in the sampled household. Children are also tested in math and reading ability. The ASER is useful for our analysis for multiple reasons. First, ASER provides national coverage and a large sample size for each district. Second, unlike schools-based data, it is not administered in schools and therefore covers children both in and out of school. Third, it is administered each year on 2 to 3 weekends from the end of September to the end of November limiting considerations of spatially systematic seasonality in data collection, and endogenous sampling as in-school children are likely not available on weekdays. We use nine rounds of the ASER data between 2006 and 2014 to examine the effects of elite public colleges on private vs. public school enrollment. We present summary statistics on private and public enrollment in Tables A.3 and A.4.

[7]We thank Wilima Wadhwa for generously sharing the ASER data.

[8]In each district, 30 villages are sampled from the Census 2001 village list. In each village, 20 households are randomly sampled. This gives a total of 600 sampled households in each rural district, or about 300,000 households at the all India level.

4.3 District Information System for Education

District Information System for Education (DISE) is an administrative dataset on primary schools in India. Data collection involves a census of all schools in India, is coordinated at the district level, and then aggregated by each state government. Annual district level statistics across the country are made publicly available in the form of 'District Report Cards.' These data are designed to reflect statistics as of September 30th of the school year, which starts in the spring. We use eleven rounds of the DISE data between 2004 and 2014 to examine the effects of elite public colleges on number of private and public schools. Although, DISE data only provides statistics on primary schools, these include primary schools offering post-primary education. We present summary statistics on number of private and public schools in Tables A.5 and A.6.

5 Effects of Colleges on Lower Levels of Schooling

5.1 Gains in Years of Schooling and Attainment

Using NSS data for individuals between 6 and 20 years of age, we estimate Equation (6) to evaluate the impact of public colleges on years of schooling and educational attainment. Our empirical strategy exploits variation in the timing of establishment of elite public colleges in districts that received an elite public college between 2005 and 2011 in an event study framework. We estimate the following model:

$$y_{ijt} = \sum_{\tau=-p}^{-1} \beta_\tau 1(t - T_j^* = \tau) + \sum_{\tau=0}^{m} \beta_\tau 1(t - T_j^* = \tau) + \mu_j + \chi_t + \epsilon_{ijt} \tag{6}$$

where y_{ijt} is 1 if the child i is the outcome of interest in district j in round $t =$ 2004, 2007, 2010, or 2012. Estimates characterizing the effects of elite colleges are the coefficients on the event-year dummies, $1(t - T_j^* = \tau)$, which are equal to 1 when the year of observation is τ rounds away from T_j^*, the year when the elite college was established in district j ($\tau = -1$ is omitted). For instance, if a college was established in 2008 in a district j, the 2004 and 2007 rounds capture the pre-period $\tau < 0$, whereas the 2010 and 2012 rounds capture the post-treatment period $\tau > 0$. μ_j indicate district level fixed effects, while χ_t stands for survey-round indicators. We restrict our sample to districts that ever received an elite college so that we do not compare estimates to dissimilar districts. By adding district fixed effects μ_j, we control for time-invariant unobserved characteristics that affect local education markets and may also be correlated with the presence of public colleges. Round indicators control for round-specific unobservables common across all districts. Our identifying assumption is that, conditional on district and year fixed effects, the timing of the establishment of elite colleges is orthogonal to simultaneous location-specific shocks to the education market.

There exist two key challenges for our identification strategy. First, public investment in tertiary education (public colleges) may anticipate changes in local schooling markets rather than causing it. Second, the location of these elite colleges may be correlated with unobserved determinants of the primary, middle and secondary markets for education that are changing continuously, concurrently driving both the location of elite colleges as well as changes in the local education sector. Since student admissions are determined by nation-wide entrance exams, there is no reason to believe that the establishment of these colleges is driven by anticipated future changes in specific local schooling markets. With the inclusions of district and year fixed effects, the more relevant concern is whether location may be correlated with preexisting trends in education markets, if these colleges are introduced to areas which are changing more rapidly. For instance, rapid industrialization may drive both the location of these elite colleges as well as changes to education decisions. However, these variables are likely to change gradually over time rather than suddenly or all at once, therefore we might expect these effects to be evident in the form of preexisting trends in data.

Using Equation (6), we investigate impacts on years of schooling, as well as completing primary school (Grades 1-5), middle or upper-primary school (Grades 6-8), secondary school (Grades 9-10) and high school (Grades 10-12). Figure 1 presents the estimates for years of schooling. We find that the coefficients for the treatment rounds are positive and statistically significant. Elite public colleges increase schooling by over 0.3 years in the short-run ($\tau = 0$), and by 0.8 years in the medium-run ($\tau = 1$). Next, we examine the effects on educational attainment. We find that elite public colleges increases educational attainment at each schooling level (Figure 2). Elite public colleges increased primary and middle school attainment by 5 percentage points in the short run, and between 10 to 15 percentage points in the medium-run. Secondary and higher secondary attainment increased by between 2 and 3 percentage points in the short-run, and between 5 and 8 percentage points in the medium-run.

We find no evidence of preexisting trends, and moreover a statistically detectable change in the years of education that coincides with the first round following the establishment of the college $\tau = 0$. If elite public colleges were introduced in places where children are staying in school longer, or if rapid industrialization was driving both the location of public colleges and changes in schooling market, we may expect to see evidence of a positive pre-trend.

In other robustness checks, we estimate the effects on years of schooling and educational attainment on individuals that were too old to change their education decisions, between 21 and 35 years of age, as a falsification test (Figures A.3 and A.4). Next, we control for children's age, and find that our estimates remain unaffected (Figures A.5 and A.6). Since our sample consists of only districts that ever received a college, it is possible that a single outlier may drive our results. Therefore, we drop each district, one at a time, estimating Equation (6) each time (Figures A.8 and A.9). We also cluster-bootstrap our standard errors following Cameron, Gelbach and Miller, 2008 (Table A.7). Our estimates remain precisely estimated. Lastly, we show that the educational attainment results are robust to restricting estimation for each tier of education–primary, middle, secondary and higher secondary– to the corresponding age-appropriate sample (Figure A.7).

5.2 Private vs. Public Enrollment

Next, we investigate the effects of elite colleges on private vs. public enrollment for children in Grades 1-10 (5-16 year olds). We employ an event study framework, estimating Equation (6), but now use annual ASER data. Here too, we restrict our sample to districts that ever received an elite college so that we do not compare estimates to dissimilar districts.

In Figure 3 we report the impact of elite public colleges on private and public school enrollment. The coefficient in the year of treatment, the year when elite public colleges were established is -0.05, which means that, public colleges led to a 5 percentage point decrease in the probability of public school enrollment. These effects get larger in the medium term.

While, elite public colleges are associated with an increase of 5 percentage points in the probability of private school enrollment in the year of treatment, and over 10 percentage points by year 4. We find no evidence of a preexisting trend in any of our estimates. Indeed, the trend break in the left-hand side variable at $T = 0$ is apparent and economically and statistically significant for both public and private enrollment. The estimates of the pre-treatment periods are small in magnitude and statistically indistinguishable from zero.

As robustness checks, we add district-specific linear trends, age fixed effects, and control for gender; our estimates remain largely unaffected (Figure A.10). Next, we drop each of the 14 districts, one at a time, estimating Equation (6) each time (Figure A.11). Lastly, we conduct a placebo test where we run 200 iterations of Equation (6), each time randomly assigning year of treatment amongst treated districts. The magnitude of the effects presented in Figure 3, at $\tau = 0$, is observed in less than 5% iterations (Figures A.12 and A.13).

Are Children Staying in School Longer? The ASER data also helps us dig into the effects on schooling outcomes observed in the NSS data: the proportion of children who never attended school at the baseline ($T = -1$) was less than 2%. Gains in educational attainment may primarily be driven by children staying in school longer. Elite public colleges should increase dropout grade amongst children who dropped out of school. Indeed, we find that dropout grade increased by 0.5 at $\tau = 0$, and by almost 0.8 in the medium-run ($\tau = 4$). We also examine the effects of elite public colleges on dropouts in primary school (Grade 8). We find that elite public colleges decrease the probability of dropouts in primary school by 8 percentage points in the short-run ($\tau = 0$), and by over 20 percentage points in the medium-run, amongst children who dropped out of school (Figures A.14 and A.15). These results corroborate the increases in educational attainment observed in the NSS data.

5.3 Entry of Private Schools

Next, using annual district level data from DISE, we estimate the impact of elite public colleges on number of private schools using Equation (6). Here y_{jt} is log of number of private in district j in year $t \in [2004, 2014]$

In Figure 4 we report estimates for the effects of elite public colleges on number of private and public schools. Entry of elite public colleges led to a 20% increase in the number of private schools at $T = 0$, and a 30% increase by the fourth year ($T = 4$). Importantly, we find that elite public colleges have no impact on the number of government schools, suggesting that elite public colleges did not lead to broader increase in public expenditure on education in treatment districts. As robustness checks, we show that our results are robust to adding district-specific linear trends (Figure A.16). Again, we drop each treatment district, one at a time, estimating Equation (6) each time (Figures A.17). Lastly, we conduct a placebo test where we run 200 iterations of Equation (6), each time randomly assigning year of treatment amongst treated districts. The magnitude of the effect size presented in Figure 4, at $\tau = 0$, is observed in less than 5% iterations (Figure A.18).

6 Mechanisms

When examining different possible channels, we find evidence most consistent with infrastructure upgrades being an important mechanism. We find that elite public colleges increase access to paved roads, electricity and tap water, and that the intensity of these effects is largest among villages closest to the elite public college. While we find little evidence in support of alternative channels, we can't rule them out.

To fix ideas about the hypothesized chain of events, consider one simple explanation. The establishment of a public college leads to infrastructure investments that lower the set-up costs for private schools. Private schools enter and students that live closer to the private school transfer from public to private schools. Since the new (private) school is closer, instead of dropping out of school in later years students decide to stay enrolled for more years.

6.1 Infrastructure Upgrades

Comparative statistics from our model suggest that a decrease in entry or set-up costs for private schools shift the supply curve outwards ($dQ_{Sy}/d\overline{z_1}|_p < 0$; $dQ_{Sy}/dz_2|_p < 0$). If elite public colleges cause an increase in access to local public infrastructure, then this would cause an entry of new private schools.

To find evidence for this prediction, we match infrastructure indicators from Census

Village Directories with latitude-longitude coordinates of each village, as well as each elite public college.[9] Then, we calculate the distance of every village to the nearest elite college. If elite public colleges increase access to public infrastructure, we should observe larger effects for villages closest to the public college. Thus, we exploit the change in distance of each village to the closest public college, driven by the entry of new elite colleges, and estimate the following difference-in-difference model:

$$\begin{aligned} y_{ijt} = &\sum_{\tau=1}^{z} \alpha_\tau 1(DistancetoCollege \in [m, m+20])_{ij} + \beta\ Post_t \\ &+ \sum_{\tau=1}^{z} \gamma_\tau 1(DistancetoCollege \in [m, m+20])_{ij} \times Post_t \ \ + \mu_j + \epsilon_{ijt} \end{aligned} \tag{7}$$

where $m = 0, 20, ..., 60$ kms. y_{ijt} is the outcome of interest for village i in district j in year t. Estimates characterizing the effects of elite colleges are captured by the vector of coefficients γ_τ. The variable $1(DistancetoCollege \in [m, m+20])_{ij}$, equal to 1 if distance of village i in district j has *ever* been between 0-20 kms, 20-40 kms, 40-60 kms, or 60-80 kms away from the closest elite public college, 0 otherwise. Variable $Post_t$ is a post-treatment year for being in Census year 2011. $1(80 <= DistancetoCollege)_{ij}$ is the omitted distance category. μ_j capture district level fixed effects.

We present these results in Figure 5. We find that elite public colleges increase access to infrastructure, and the effects on electricity (6 percentage points), water (8 percentage points) and roads (4 percentage points) are larger for villages closer to elite colleges than for villages further away. As a placebo test, we examine the effects of future changes in distance to elite public college on present changes in infrastructure indicators, that is, we estimate Equation (7) to evaluate the effects of change in distance to elite public college between 2001 and 2011 on the change in access to roads, water and electricity between 1991 and 2001. It is clear from the figure that future changes in distance to the elite college do not predict current infrastructure investments.

Next, we estimate the effects of elite public colleges on village-level nighttime lights, as a proxy for rural electrification. Here too, we use latitude-longitude coordinates for each village

[9] We describe the data from Village Census Directories and Village Night Lights in Appendix A.

and elite public college in India, and calculate the distance of every village to the nearest elite college between 2004-2012. We estimate Equation (7) where y_{ijt} is log mean night-time lights in village i, district j, year t. Because we have 9 years of night lights data, we include village fixed effects (μ_i), and identify the effects of year-on-year changes in distance to public college on electrification at the village level. Furthermore, we estimate an even more flexible version of Equation (7), where we use 10km bins between 0 and 150kms, with $1(150 <= DistancetoCollege)_{ijt}$ being the omitted category. Our identifying assumption is that, conditional on village and year fixed effects, changes in distance of villages to the closest elite college are not correlated with unobservable village specific, time varying attributes that also affect changes in night time lights by distance bins.

Figure 6 presents the effects of elite public colleges on village night lights. The coefficient for $1(DistancetoCollege \in [0, 10]km)_{ijt}$ is 0.15, which means that villages within 10kms from the new college saw a 15 percent increase in mean night light intensity. Importantly, the effects of elite public colleges on changes in nighttime light intensity decreases with an increase in the changed distance to the nearest elite public college.

6.1.1 Public Infrastructure and Private Schooling

In Section 5.3, we showed that elite public colleges increase entry of private schools in at the district level. It is plausible that entry of private schools is driven by infrastructure upgrades. For instance, Kremer and Muralidharan, 2008, and Pal, 2010, find that private schools in India are more likely to be present in villages with access to public infrastructure. Public schools are less likely to respond to such investments as governments may prioritize under-served regions (Duflo, 2001; Kremer and Muralidharan, 2008). If infrastructure upgrades are driving the entry of private schools, effects on private school entry should be largest in villages closest to the elite public college, since the magnitude of the effects on public infrastructure are highest among villages closest to the elite public college. Using the 2011 Census Village Directory, we estimate Equation (7) to examine the effects of elite public colleges on the presence of private schools in a cross-section with district fixed effects. Indeed, we find suggestive evidence that private schools are more likely to be present in villages closest to elite public colleges (Figure 7).

Next, we examine the effects of elite public colleges on distance to private schools. Distance to school is a central determinant to school choice in low income countries (Carneiro et al., 2016; Carneiro, Das and Reis, 2015). In fact, Alderman, Orazem and Paterno, 2001, showed that lowering distance increase enrollment in private schools in Pakistan, partly by transfers from public schools. Using 2004-05 and 2011-12 rounds of Indian Human Development Survey (IHDS), we evaluate the effect of elite public colleges on distance to private schools for private school going children between 'treatment' and 'control' districts in a triple difference framework.[10] We find that elite public colleges decreased distance to private school amongst children attending private school in districts that received an elite college between 2006-2011 (Table 1). Thus, entry of private schools could potentially solve a (travel) cost constraint for marginal students, enabling them to get additional years of education as they transfer from public to private schools.

6.2 Alternative Explanations

In this section, we discuss some alternative channels that could potentially explain the observed relationship between public colleges and schooling outcomes. Specifically, we consider four alternative explanations: (1) an increase in population, (2) an income effect, (3) aspirations or parental perception of returns to education, (4) increases in returns due to access to higher education, and (5) a powerful politician hypothesis. We fail to find strong evidence for alternative mechanisms, but we can't completely rule them out.

6.2.1 Increase in Population: $dp/dM > 0$; $dN_1/dM > 0$

Demand for all schooling (both public and private) increases with population, raising equilibrium fee (tuition) and the number of private schools. If public colleges increase migration into the district, it may lead to entry of private schools. Elite public colleges can create jobs in the college itself, jobs working for college employees, or newly created jobs in existing or new firms that enjoy synergies with these academic institutions increasing the demand for schooling ($dN_1/dM > 0$), and entry of private schools.

[10] In Appendix A, we briefly describe the data set.

If elite public colleges increased demand for schooling through the population channel, we would also see an increase in enrollment in public schools. However, we find a significant decline in public school enrollment. Nevertheless, we directly examine the effects of elite public colleges on population. Using district level population data, we also evaluate effects on population by age group. We fail to find evidence for an increase in population of school-age children in districts that received an elite public college (Figure A.19).

Children of Faculty and Staff at Elite Public Colleges: $dp/d\delta > 0$ **;** $dN_1/d\delta > 0$ Next, we explore if children of faculty and staff alone can explain our results. An increase in the ability of the students will increase the demand for all schooling, raise market price (tuition) and induce more private schools to enter the market. If children of faculty from these public colleges are more 'able', then public colleges will lead to an increase in the number of private schools in the district. It is unlikely that the addition of these children alone can explain the magnitude of increase in number of private schools. We find an increase of almost 20 percentage points in the number of private schools in year of treatment; in 2004, the mean number of private schools in districts that received a public college between 2004-2014, was 350. So, a 20 percent increase means at least 70 new schools. From the DISE data, we know that each private school enrolls 200 students each, on average. So a substantial number of new faculty will have to migrate with the new public college to explain this result. Information obtained from these colleges indicate that on average these colleges have around 150 faculty members, so increases in the 'ability' of the local student population due to influx of faculty would at most explain 1% of the increase in number of private schools.

Supply of School Teachers: If students graduating from elite public colleges were opening-up new private schools in the district, and working as school teachers in these schools, it could also potentially explain our results. For instance, Andrabi, Das and Khwaja, 2013, show that private schools in Pakistan are three times more likely to emerge in villages with government girls' schools due to an increase in supply of teachers. We do not find evidence for such an explanation. First, since the first batch of students in these colleges would only graduate after 2-4 years, if an increase in the supply of teachers due to students graduating from elite public colleges was driving our results, we would not see an immediate increase in number of private schools, and the probability of enrollment in these schools. The mechanism presented in Andrabi, Das and Khwaja, 2013, is inherently long run: their paper looks at data 17 years apart. Second, it is important to note that students graduating from these highly-competitive elite public colleges are employed by technology or management firms in major Indian cities (Willis-Tower-Watson, 2016), making such supply-side channels less relevant to our context.

6.2.2 Income Effect: $dp/dln(w) > 0$; $dN_1/dln(w) > 0$

Previous studies have suggested that regional characteristics have a critical impact on the locational decisions made by new firms. In fact, the presence of a college or university can be one such a locational factor. There exist several linkages between academic institutions and the local economy (Adams, 2001; Basant and Chandra, 2007; Kantor and Whalley, 2014), and academic institutions can play a significant role in the local economic development (Aghion et al., 2009; Cantoni and Yuchtman, 2014). Thus, elite public colleges can increase incomes of existing local population by creating high-paying jobs, thus driving entry of private schools. An increase in income increases the demand for all schooling (both public and private), raising the equilibrium fees charged as well as the number of private schools.

Furthermore, if elite public colleges increase access to electrification, roads and tap water, these infrastructure upgrades could also increase expenditure or earnings. In addition to being useful as a proxy for electrification, night lights have been used by economists as an indicator for economic activity, especially in developing countries that have issues with disaggregated income data (Chen and Nordhaus, 2014; Henderson and Storeygard, 2009). However, Burlig and Preonas, 2016 find that a rural electrification program in India had insignificant effects on annual incomes, despite causing a substantial shift in nighttime lights.

We believe that it is unlikely that our results are only driven by increase in local incomes. First, we fail to find evidence for an increase in population. It is plausible that if elite colleges increased incomes by creating new jobs there would an increase in local population driven by migration from neighboring districts. Second, we find a significant decrease in enrollment at public schools; an increase in local incomes would increase demand for *all* schooling. We also estimate Equation (6) using NSS data to examine the effects of public colleges on wages. We fail to find evidence for an increase in wages (Figure A.20).

6.2.3 Aspirations: $dp/d\bar{\theta} > 0$; $dN_1/d\bar{\theta} > 0$ or Returns to Education: $dp/dr > 0$; $dN_1/dr > 0$

Close proximity to elite public colleges may increase salience of higher education, raising parents educational aspirations for their children. Entry of public colleges might also alter local perceptions about returns to education due to information spillovers, and since human capital investment decisions are linked to perceived economic returns to education (e.g., Jensen, 2010; Manski, 1993; Nguyen, 2008), it could increase demand for all schooling.

If elite public colleges raised parental aspirations or altered their perceptions about returns to education, we would expect an increase in both public and private school enrollment. However, we observe a significant decrease in public school enrollment. It is unlikely that elite public colleges only affected parents perception of returns to private schooling, or that parents who now have higher aspirations for their children perceive that private schools alone offer an easier pathway to tertiary education. We are unable to test these hypotheses directly, since we do not have an indicator for perceived returns to education or aspirations. But, insofar as increase in perceived returns or aspirations translated into an increase in human capital investment, we may find an increase in children's test scores. The ASER data includes test scores on math and reading for all school-age children. Surveyors ask each child four potential questions in math and reading (in their native language). In each subject, they begin with the hardest of four questions. If a child is unable to answer that question, they move on to the next easiest question and so on and so forth. We estimate Equation (6) to examine the effects of elite public colleges in both math and reading scores. We fail to find evidence for an increase in test scores (Figure A.21).

6.2.4 Access to Higher Education

Returns to education are convex, higher at the secondary and post-secondary levels than at primary level (e.g., Colclough, Kingdon and Patrinos, 2010; Schultz, 2004) Correspondingly, studies have also shown that parents believe that the first few years of schooling have lower returns than in the later years (e.g., Banerjee and Duflo, 2011, 2005). Thus, better access to post-secondary institutions or colleges could represent a reduction in the cost of future schooling, increasing the possibility of continuation into higher levels of schooling.

Admission into elite public colleges in India is determined by an extremely competitive nation-wide entrance exams. For instance, elite colleges such as the Indian Institutes of Technology (IITs) have an acceptance rate of 2 percent from a pool of roughly 500,000 students who qualify to take the entrance exam. Thus, access to elite public colleges is not a likely explanation for our results. However, if elite public colleges, like private schools, also incentivize entry of private colleges due to infrastructure upgrades, it could increase a demand for all schooling, and explain observed gains in years of schooling.

Using village level indicators for private and public college presence for the 2011 Census Village Directory, we estimate Equation (7) to examine effects of elite public colleges on presence of private colleges. We find that private colleges are more likely to exist in villages nearest to elite public colleges (Figure A.22). The entry of private colleges could increase demand for all schooling, but given that we find a significant decrease in public school enrollment, the entry of private colleges could only explain our results if parent's perceive that private schools offer an easier pathway to private colleges. It's unlikely that infrastructure upgrades increase access to private colleges but not private schools, and that private schools enter exclusively because of an increase in demand for private schooling, driven by better access to these private colleges.

6.2.5 Powerful Politicians

In a developing country like India, it is possible that powerful local politicians successfully lobby the federal government for both elite public colleges, and public expenditure on infrastructure in their constituency or district. This would mean that changes to infrastructure and colleges are driven by powerful politicians, and not directly by elite public colleges. Although, such an explanation is compatible with supply-side factors discussed earlier, we do not find evidence for such an hypothesis. First, unless these 'powerful politicians' precisely align the timing of infrastructure upgrades with the entry of elite public colleges, we would find evidence for it in the form of preexisting trends in our outcome variables. Second, we do not find evidence for an increase in public spending in school infrastructure: we fail to find an increase in the number of public schools or 'regular' public colleges. Third, out of the 42 districts that received an elite college between the period 2004-2014, almost 50% were represented by members from the opposition and not the ruling national coalition. Moreover, out of the districts represented by members from the ruling coalition, more than 40% were first time Members of Parliament (MPs). It is reasonable to assume that experienced MPs from the ruling coalition enjoy the most 'influence'; however, since only 14 districts had MPs from the ruling coalition serving a second term or higher, political clout doesn't seems to play a significant role in the location of these elite colleges. Fourth, and most importantly, the effects of elite colleges on infrastructure are not only robust to dropping all districts governed by MPs from the ruling coalition, but slightly larger (Figure A.23).

7 Conclusion

This paper establishes an important fact: public investment in higher education can have spillover effects on primary and secondary education markets in India. Elite public colleges encourage the entry of private schools, and increase enrollment in cost-effective private schools at the expense of public schools. Overall, our results translate into gains in educational attainment as children stay enrolled in school longer. Simple calculations indicate that the indirect benefits due to gains in efficiency and educational attainment for school-going children are almost half the size of the direct benefits accrued through training of undergraduate and graduate students (Appendix A). Lastly, we find that elite public colleges led to localized investments in electricity, water and road services, plausibly reducing setup costs for private school and travel costs for school-going children, and could be one mechanism driving our results.

Our paper provides two important takeaways for economic policies in developing countries. First, our results enter the debate between education policymakers who believe that public resources for education in developing countries should be reallocated from higher to lower levels of education. For instance, in India, the budget for higher education budget has been steadily increasing. In fact, in 2016-17, India allocated almost two-thirds of the budget for school education and literacy to higher education (IndiaSpend, 2017). And, although international donors like the World Bank have revaluated the social returns of investment in higher education by emphasizing the long run public benefits said to flow from higher education, including a wider appreciation of democratic values, and greater innovation (The World Bank, 2000), some observers in India have criticized such public investment in higher education as inordinate, and expenditures on college infrastructure is perceived to come at the expense of schooling infrastructure.[11] In this paper, we show that investments in higher education crowd-in private investment in primary and secondary schooling, and may increase educational attainment for low income children in developing countries. Stakeholders in India's education policy should account for these benefits to lower levels of schooling and reevaluate their perceptions of the social returns of public spending in higher education.

Second, our results suggest that place-based policies that involve construction of elite public colleges in India may have a large effect on local infrastructure in contrast to certain last-mile programs that target specific infrastructure services. For instance, we find that elite public colleges increased nighttime brightness by 0.5 units (18%) compared to a rural electrification program in India that increased nighttime brightness by 0.15 units (Burlig and Preonas, 2016). In fact, our estimates are comparable to a policy that targeted massive improvements in infrastructure, a generous investment subsidy, and a complete exemption from corporate and excise taxes for a newly formed state in India in 2002.[12] In India, access to public goods like power, roads, water and education is a matter of who can extract them from the political system (Banerjee and Somanathan, 2007). In such a context, not only do elite public colleges effectively crowd-in public investment on power, roads and water services, but also private investment in provision of education.

[11] See for instance: NDTV, 2017; The Hindu, 2011; The Times of India, 2016*b*; The Wire, 2017

[12] Shenoy, 2018, shows that nighttime brightness increased by 22% due to such a policy.

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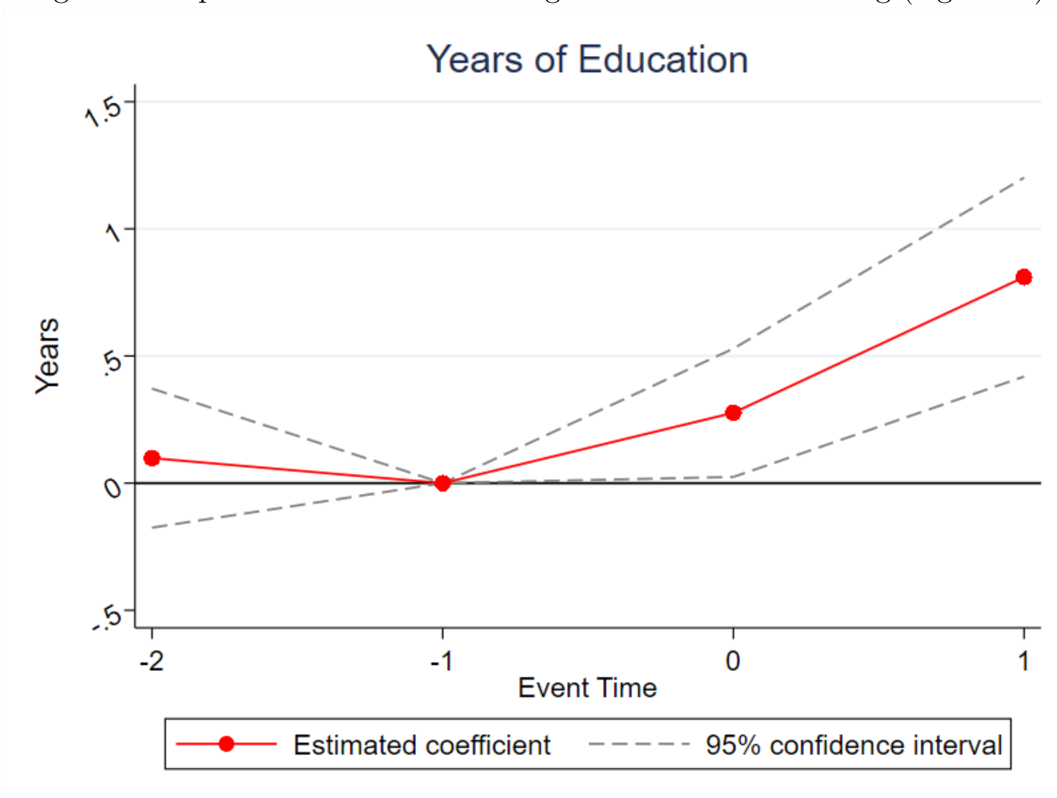
Tables and Figures

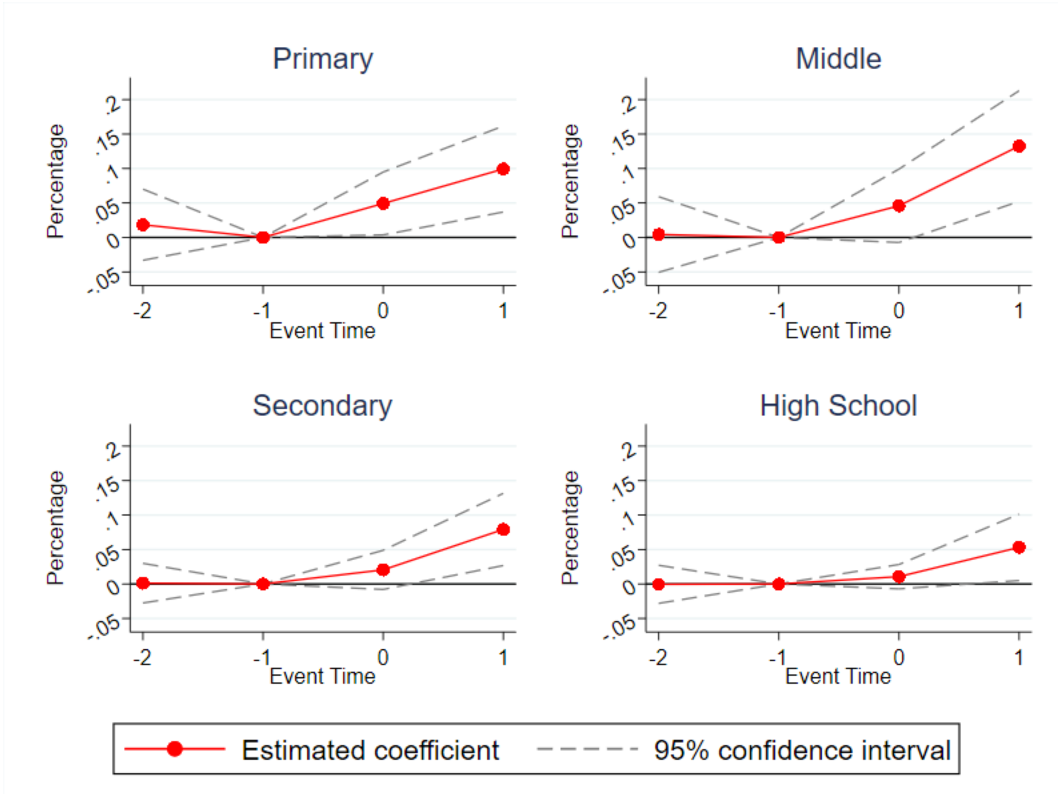
Figures

Figure 1: Impact of Elite Public Colleges on Years of Schooling (Age 6-20)



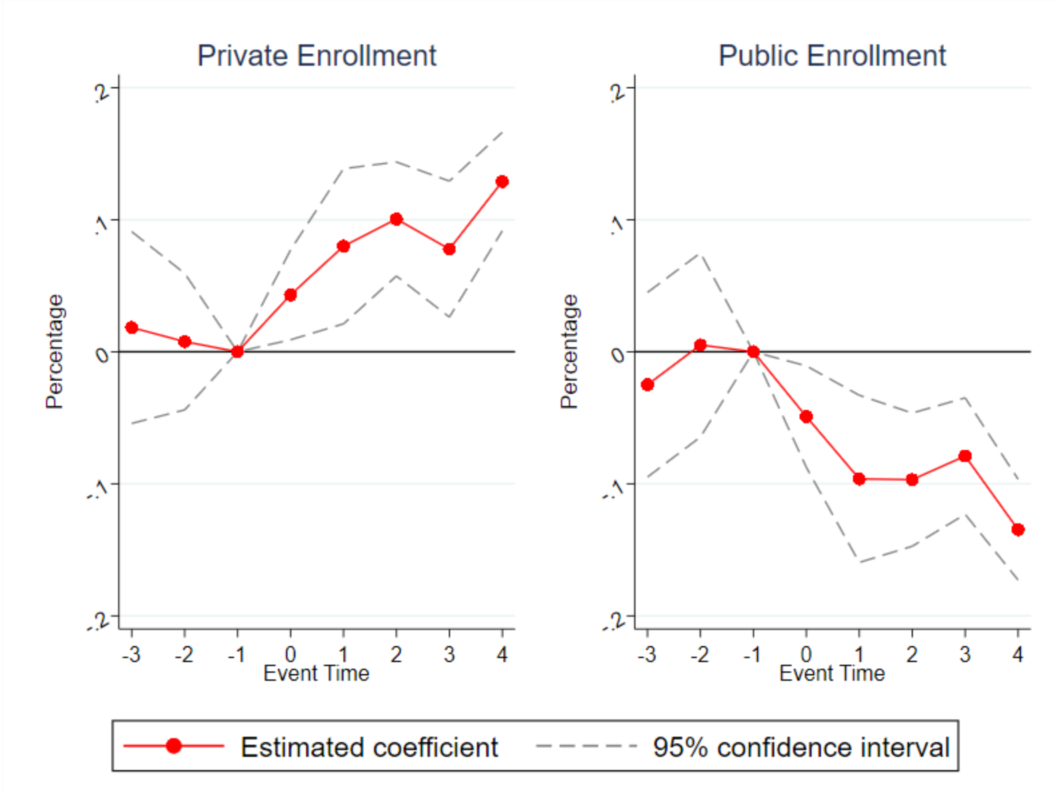
Notes: Sample includes individuals between 6 and 20 years of age across 4 NSS survey rounds (2004, 2007, 2010 and 2012). The figure presents the effects of elite public colleges on years of schooling. $\tau = 0$ is the treatment round. Standard errors are in parentheses, clustered by district.

Figure 2: Impact of Elite Public Colleges on Educational Attainment (Age 6-20)



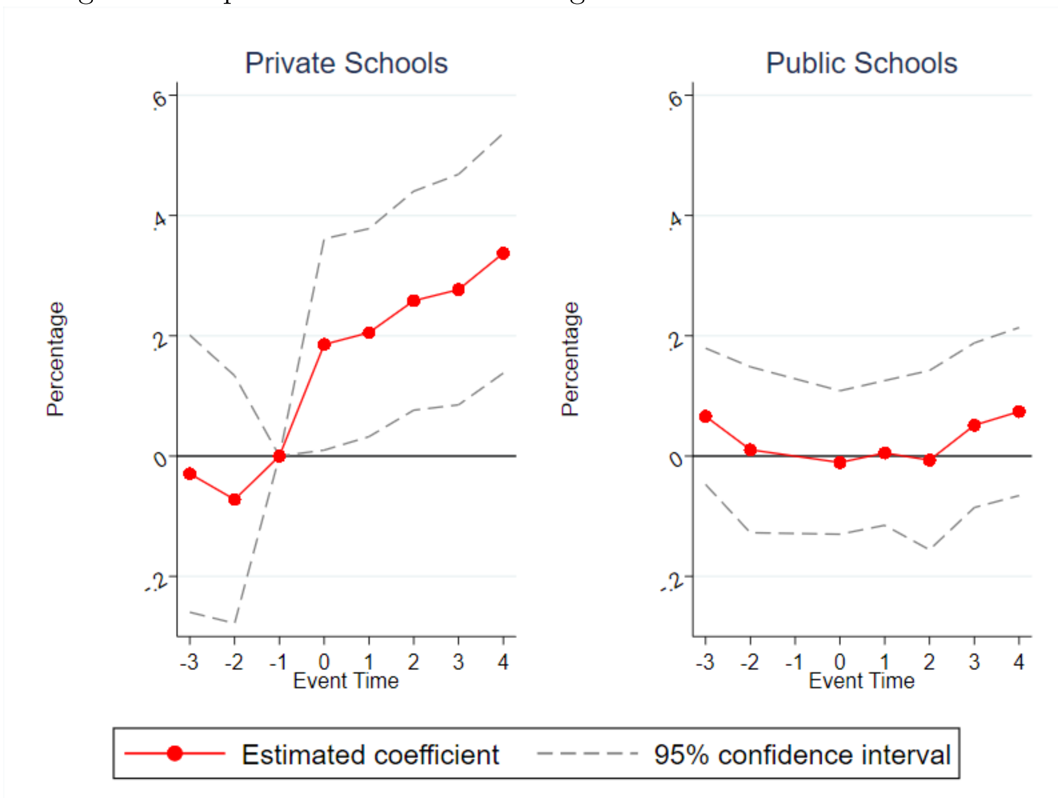
Notes: Sample includes individuals between 6 and 20 years of age across 4 NSS survey rounds (2004, 2007, 2010 and 2012). The figure presents the effects of elite public colleges on educational attainment. $\tau = 0$ is the treatment round. Standard errors are in parentheses, clustered by district.

Figure 3: Impact of Elite Public Colleges on Private vs. Public Enrollment (Age 5-16)



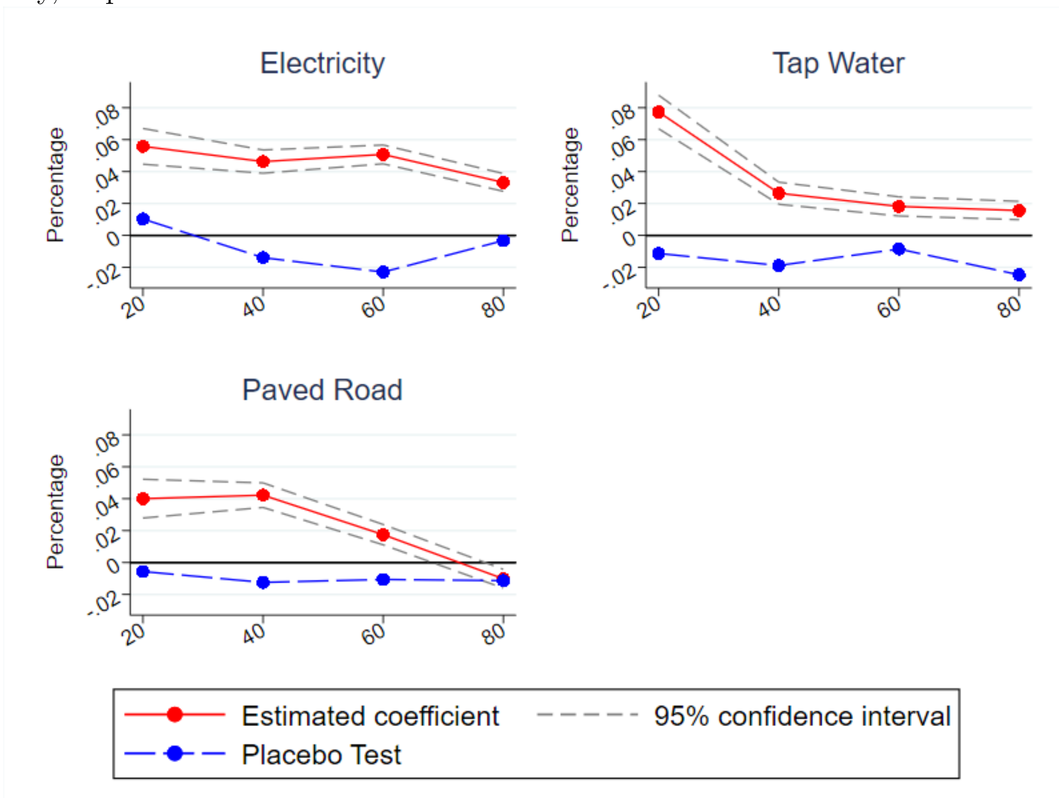
Notes: Sample includes individuals between 5 and 16 years of age across 9 ASER rounds (2006-2014). The figure presents the effects of elite public colleges on private vs. public enrollment status. $\tau = 0$ is the treatment year. Standard errors are in parentheses, clustered by district.

Figure 4: Impact of Elite Public Colleges on Private vs. Public Schools



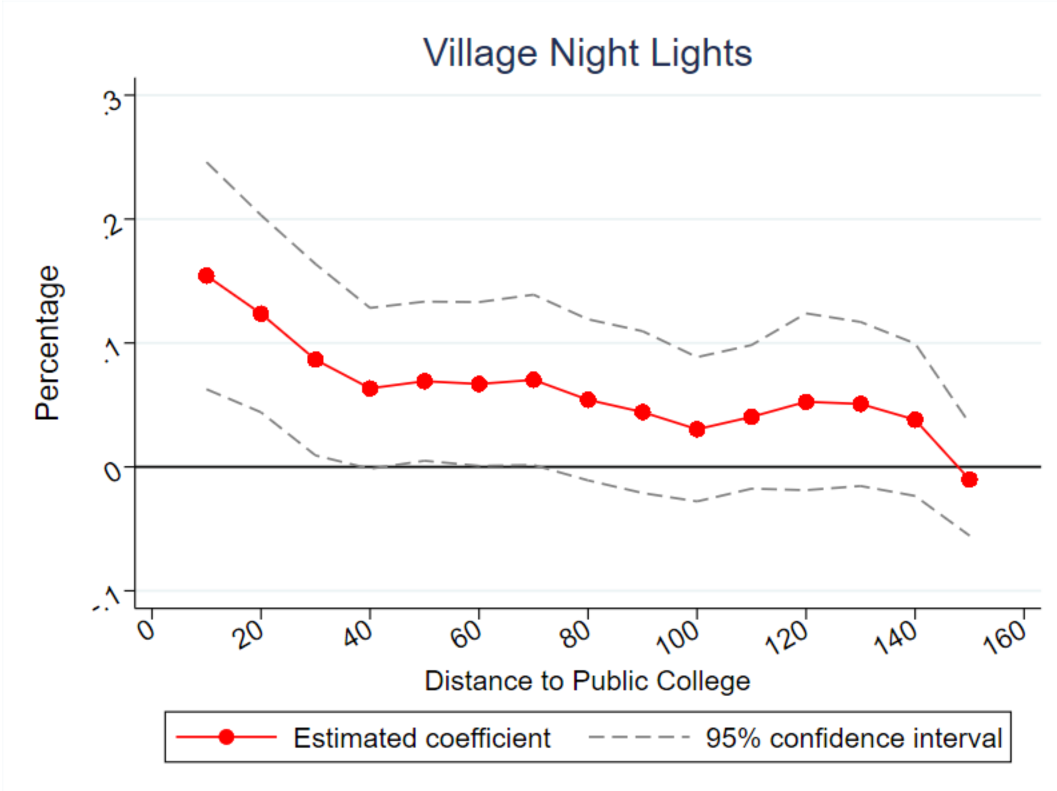
Notes: Sample includes treatment districts across 11 years of DISE data (2004-2014). The figure presents the effects of elite public colleges on number of private and public schools. $\tau = 0$ is the treatment year. Standard errors are in parentheses, clustered by district.

Figure 5: Village Distance to Public College: Impact of Elite Public Colleges on Access to Electricity, Tap Water and Roads



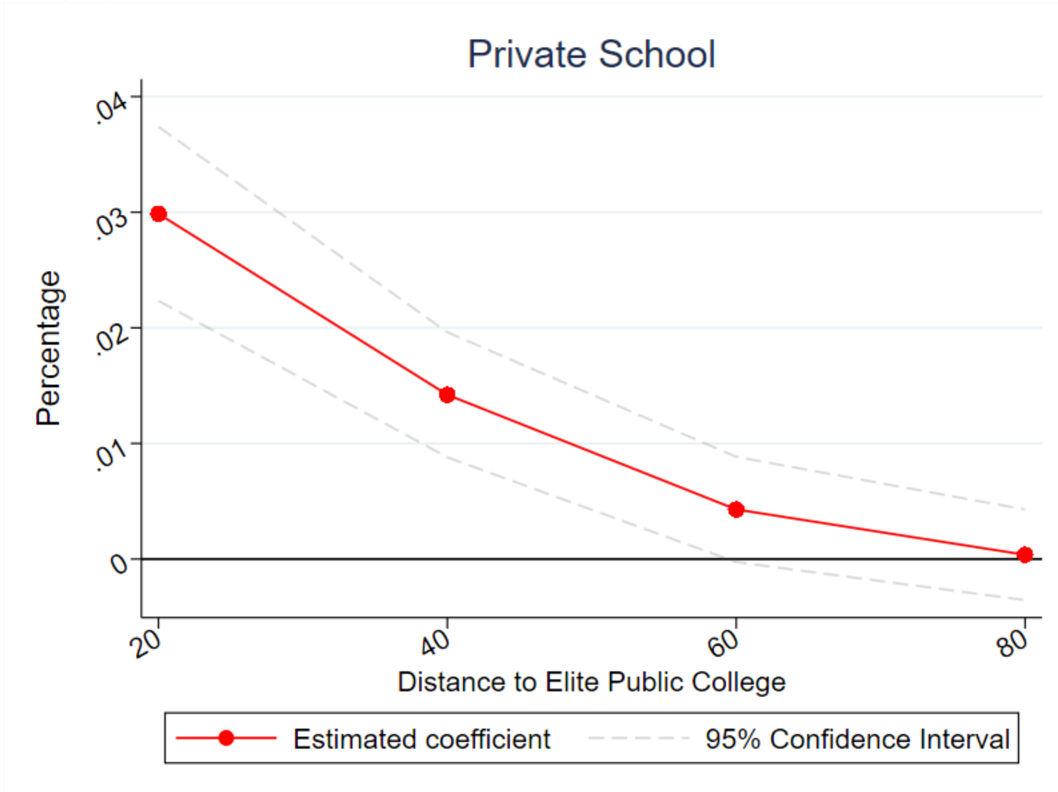
Notes: Sample includes around 500,000 villages across 2 Census Village Directories (2001 and 2011). The figure presents the effects of elite public colleges on village level infrastructure upgrades. Standard errors are heteroskedasticity-robust.

Figure 6: Village Distance to Public College: Impact of Elite Public Colleges on Night Light Intensity



Notes: Sample includes over 450,000 villages across 9 years (2004-2012). Standard errors are in parentheses, clustered by district. The figure presents the effects of elite public colleges on village level night lights, a proxy for rural electrification. Standard errors are clustered by district.

Figure 7: Village Distance to Elite Public College: Impact of Elite Public Colleges on Private School Presence



Notes: Sample includes around 500,000 villages in the 2011 Census Village Directory. The figure presents the effects of elite public colleges on presence of private schools. Standard errors are hetereoskedasticity-robust.

Tables

Table 1: Impact of Elite Public Colleges on Distance to Private School for Private School-Going Children

	(1) Distance <=1 km (0/1) Full Sample β / SE	(2) Distance <=1 km (0/1) Rural Sample β / SE
Private*2011*Public_College	0.128**	0.126**
	(0.055)	(0.061)
Mean	0.74	0.74
Observations	73479	52384
R^2	0.121	0.147

Notes: Sample includes over 50,000 children across 2 rounds of Indian Human Development Survey (2004-05 and 2011-12). The figure presents the effects of elite public colleges on distance to private school for private school going children in treatment vs. control districts. $Private * 2011 * PublicCollege$ presents triple difference estimates. Standard errors are in parentheses, clustered by district.

A Appendix

Comparative Statics

From Equation (5) we derive the equilibrium condition for the market for education.

In order to solve for a closed form solution and do comparative statics we specify the error term distribution $F(.)$ to be child and school specific of Type I Extreme Value. The probability with which a student chooses a private school from the menu of J schools is

$$= \frac{exp(r - \alpha p - \beta T_p + \gamma ln(w) + \delta)}{\sum^{J} exp(r - \alpha p - \beta T_k + \gamma ln(w) + \delta)}$$

$$= \frac{exp(r - \alpha p - \beta T_p + \gamma ln(w) + \delta)}{Np\overline{\theta} exp(r - \alpha p - \beta T_p + \gamma ln(w) + \delta) + N_0 exp(r - \beta T_s + \gamma ln(w) + \delta) + 1} \tag{8}$$

$$Q_d = \frac{MNp\overline{\theta} exp(r - \alpha p - \beta T_p + \gamma ln(w) + \delta)}{Np\overline{\theta} exp(r - \alpha p - \beta T_p + \gamma ln(w) + \delta) + N_0 exp(r - \beta T_s + \gamma ln(w) + \delta) + 1} \tag{9}$$

This equation can be simplified to:

$$Q_d = \frac{MNp\overline{\theta}}{Np\overline{\theta} + N_0 exp(\alpha p + \beta(T_p - T_s)) + exp(\alpha p + \beta T_p - \gamma ln(w) - \delta - r)} \tag{10}$$

Plugging in this value of Q_d in (5) we get With M students, summed over all $Np\overline{\theta}$ private schools, from Equation (5) we get

$$\frac{M}{Np\overline{\theta} + N_0 exp(\alpha p + \beta(T_p - T_s)) + exp(\alpha p + \beta T_p - \gamma ln(w) - \delta - r)} = \frac{\overline{\theta}}{z_2}\left(p\overline{\theta} - \overline{z_1}\right) \tag{11}$$

After equating private school supply with demand, we derive the following equation in the paper:

$$\frac{M}{\Lambda} - \frac{\overline{\theta}}{z_2}\left(p\overline{\theta} - \overline{z_1}\right) = 0 \tag{12}$$

For convenience, we define Λ as:

$$\Lambda \equiv Np\overline{\theta} + N_0 exp(\alpha p + \beta(T_p - T_s)) + \lambda,$$

where we also define λ as:

$$\lambda \equiv exp(\alpha p + \beta T_p - \gamma ln(w) - \delta - r)$$

Using this, we can derive the following relationships using the implicit function theorem:

1. $\frac{dp}{dln(w)} = -\frac{-\left(N\overline{\theta} + N_0 exp(\alpha p + \beta(T_p - T_s))\alpha + \lambda\alpha + \Lambda^2 \overline{\theta}^2 z_2^{-1}\right)}{\lambda\gamma} > 0$ and $\frac{dN_1}{dln(w)} = N\overline{\theta}\frac{dp}{dln(w)} > 0$

2. $\frac{dQ_d}{dT_p} = -\frac{MNp\overline{\theta}\lambda\beta}{\Lambda^2} < 0$

3. $\frac{dQ_d}{dT_p} = -\frac{MNp\overline{\theta}\lambda(-\beta)}{\Lambda^2} < 0$

4. $\frac{dp}{d\delta} = -\frac{-\left(N\overline{\theta}+N_0 exp(\alpha p+\beta(T_p-T_s))\alpha+\lambda\alpha+\Lambda^2\overline{\theta}^2 z_2^{-1}\right)}{\lambda} > 0$ and $\frac{dN_1}{d\delta} = N\overline{\theta}\frac{dp}{d\delta} > 0$

5. $\frac{dp}{dr} = -\frac{-\left(N\overline{\theta}+N_0 exp(\alpha p+\beta(T_p-T_s))\alpha+\lambda\alpha+\Lambda^2\overline{\theta}^2 z_2^{-1}\right)}{\lambda} > 0$ and $\frac{dN_1}{dr} = N\overline{\theta}\frac{dp}{d\delta} > 0$

6. $\frac{dp}{d\overline{\theta}} = -\frac{-\left(N\overline{\theta}+N_0 exp(\alpha p+\beta(T_p-T_s))\alpha+\lambda\alpha+\Lambda^2\overline{\theta}^2 z_2^{-1}\right)}{Np-2p\Lambda^2\overline{\theta}M^{-1}z_2^{-1}} > 0$ and $\frac{dN_1}{d\overline{\theta}} = N\overline{\theta}\frac{dp}{d\delta} > 0$

7. $\frac{dp}{dM} = -\frac{-M\left(N\overline{\theta}+N_0 exp(\alpha p+\beta(T_p-T_s))\alpha+\lambda\alpha+\Lambda^2\overline{\theta}^2 z_2^{-1}\right)}{\Lambda} > 0$ and $\frac{dN_1}{dM} = N\overline{\theta}\frac{dp}{dM} > 0$

8. $\frac{dp}{dT_s} = -\frac{-\left(N\overline{\theta}+N_0 exp(\alpha p+\beta(T_p-T_s))\alpha+\lambda\alpha+\Lambda^2\overline{\theta}^2 z_2^{-1}\right)}{-(-\beta N_0 exp(\alpha p+\beta(T_p-T_s))} > 0$ and $\frac{dN_1}{dT_s} = N\overline{\theta}\frac{dp}{dT_s} > 0$

9. $\frac{dp}{d\overline{z_1}} = -\frac{-M\left(N\overline{\theta}+N_0 exp(\alpha p+\beta(T_p-T_s))\alpha+\lambda\alpha+\Lambda^2\overline{\theta}^2 z_2^{-1}\right)}{\Lambda^2\overline{\theta}z_2^{-1}} > 0$ and $\frac{dQ_{sy}}{d\overline{z_1}}\big|_p = -\frac{p\overline{\theta}^2 N}{z_2} < 0$

$\frac{d\frac{dQ_{sy}}{d\overline{z_1}}|_p}{dT_s} = -\frac{\overline{\theta}^2 N}{z_2}\frac{dp}{dT_s} < 0$

10. $\frac{dp}{dz_2} = -\frac{-M\left(N\overline{\theta}+N_0 exp(\alpha p+\beta(T_p-T_s))\alpha+\lambda\alpha+\Lambda^2\overline{\theta}^2 z_2^{-1}\right)}{\Lambda^2\left(p\overline{\theta}^2-\overline{z_1}\right)z_2^{-2}} > 0$ & $\frac{dQ_{sy}}{dz_2}\big|_p = -\frac{p\overline{\theta}^2 N(p\overline{\theta}-\overline{z_1})}{z_2^2} < 0$

Benefit Analysis

We use our results to get an estimate of the unintended benefits of elite public colleges. We focus only on benefits through the education market, in the form of private gains, and ignore other potential benefits like infrastructure upgrades. Furthermore, we are not interested in a cost-benefit analysis, rather we want to quantify unintended benefits as a proportion of total benefits accrued through the impacts of elite public colleges on markets for primary, secondary or higher education. Indeed, the estimates obtained through this exercise involve tremendous uncertainty (Manski, 2013). Nonetheless, we believe that these estimates will provide some insight into, hitherto, unaccounted benefits of these elite public colleges.

We begin by estimating the direct or intended benefits of an elite public college imparting higher education. We obtain the enrollment numbers from websites of elite colleges set-up between 2004-2014. We find that the average enrollment is around 800 students. This figure includes undergraduates, masters and PhD students. To get an estimate of the benefit accrued through training these students, we rely on median starting-salaries of students obtained through a survey of 70 companies.[13] Average starting-salaries were summarized by college tiers, with students from Tier 1 students averaging INR 1,305,625; Tier 2, INR 641,812.5; Tier 3, INR 407,375. We estimate direct benefits as the value added through attending an elite public college. We come up with two annual estimates:

$$LowerBound/College : 800 * (1,305,625 - 641,812.5) = INR\ \ 531,050,000$$

$$UpperBound/College : 800 * (1,305,625 - 407,375) = INR\ \ 718,600,000$$

Next, we estimate indirect, or unintended benefits accrued through the primary and secondary education markets. First, we estimate the benefits accrued to the social planner due to transfers from public to private schools. Muralidharan and Sundararaman (2015), find that although there exists little difference in output, private schools are more costs effective than public schools. They also provide us with estimates for 'Annual Cost/Child for both public and private schools in the state of Andhra Pradesh, in India; the per child difference in cost is INR 6,541.12.[14] We calculate the number of rural children, aged 5-16, in private schools in treatment districts. Using population numbers from the 2011 census (310,816) and proportion of children in private schools at $T = -1$, or 'pre-treatment (27%), we come up with an estimate of 83,920 children. Because the magnitude of decrease in public school enrollment is close to the magnitude of increase in private school enrollment, and since, initially, we find no increase in overall enrollment, to estimate annual benefits accrued through transfers, we use coefficients estimating the impact of elite public colleges on private enrollment, at $T = 0$ (25%) and $T = 2$ (40%):

$$LowerBound : 310,816 * 0.27 * 0.25 * 6,541.12$$

[13]Willis Tower Watson, a global advisory company, in Willis-Tower-Watson (2016), polled 70 of Indias top organizations and HR leaders across sectors to gauge campus hiring trends and differentiation of compensation philosophy across college tiers for the following degrees BTech, MTech, MBA and Other Graduates (BA, BCom, BSc and BBA).

[14]It is important to note that these figures pertain to the cost incurred by schools, and not household costs. We are not concerned about household costs, since, as per our model children switch from public to private schools only if the cost of attending private schools < cost of attending public schools.

$$UpperBound: 310,816 * 0.27 * 0.40 * 6,541.12$$

We estimate benefits due to increase in educational attainment amongst primary and secondary students. Our NSS estimates suggest that elite public colleges increased educational attainment by 0.33 years, amongst students aged 7-20 in rural areas. The literature on returns to education suggests that an extra year of schooling in India leads to gains ranging from INR 2,000 to 4,000.[15] Thus, we use the 2011 Census to get the number of rural children between ages 7-20 in treatment districts 307,726, and provide two annual estimates for private gains due to increase in educational attainment:

$$LowerBound: 307,726 * 0.33 * 2,038.40$$

$$UpperBound: 307,726 * 0.33 * 3,902.08$$

Finally, we present total annual indirect benefits per college:

$$LowerBound: INR \;\; 344,231,884.8$$

$$UpperBound: INR \;\; 615,827,738.5$$

Therefore, annual unintended or indirect benefits are anywhere between 48 to 115 percent of the intended or direct benefits of elite public colleges.[16]

[15] Authors' calculations based on Kingdom, 1998, INR 3086.72; Khanna, 2015, INR 3902.08; Patrinos and Montenegro, 2014, INR 2038.4

[16] We also do year-by-year calculations, for 25 years, where direct benefits, and private gains due to increase in educational attainment only accrue from the fourth year. Furthermore, we estimate cost-savings from transfers using the coefficient at $T = 0$, 25%, initially, and the coefficient at $T = 2$, 40% from the third year of elite public colleges. Finally, we discount all future estimates at 5%, increase future returns to education, and starting-salaries at elite colleges by 7% (growth rate in India). The annual estimates reached through this exercise are very close to the estimates presented above.

Additional Data Sets

Census Village Directories

We use data from the village census directories in 1991, 2001, and 2011 to procure information on village level infrastructure indicators like access to electricity, roads and tap water.[17] We code electricity access as "1" if electric power was available for all users in the village,"0" otherwise. We code road access as "1" if the village can be accessed through a permanent or paved road, "0" otherwise. Finally, we code tap water as "1" if untreated or treated tap water is available within the village, "0" otherwise. In the 2011 wave, these directories also contain information on presence of private schools and colleges.

Village Night Lights

We use nighttime lights as measured by satellite imagery to capture intensity of changes in electrification within a village. Existing work on India has shown that nighttime lights can be used to detect electrification (Min, 2011; Min and Gaba, 2014; Min et al., 2012). In fact, Chand et al. (2009) finds a direct relationship between nighttime lights and electric power consumption in India, and most recently, Burlig and Preonas (2016) have used changes in nighttime brightness as an indicator of electrification in India to evaluate the effects of a rural electrification program on electricity access at the village level.

Researchers at the National Oceanic and Atmospheric Administration's (NOAA) National Geophysical Data Center (NGDC) process data from weather satellites that circle the Earth 14 times a day and take pictures between 2030 and 2200 hours at night. They use algorithms to filter out other sources of natural light using information about the lunar cycles, sunset times and the northern lights, and other occurrences like forest fires and cloud cover. The data is calculated at approximately every one square kilometer, but we aggregate up to the village level.

India Human Development Survey

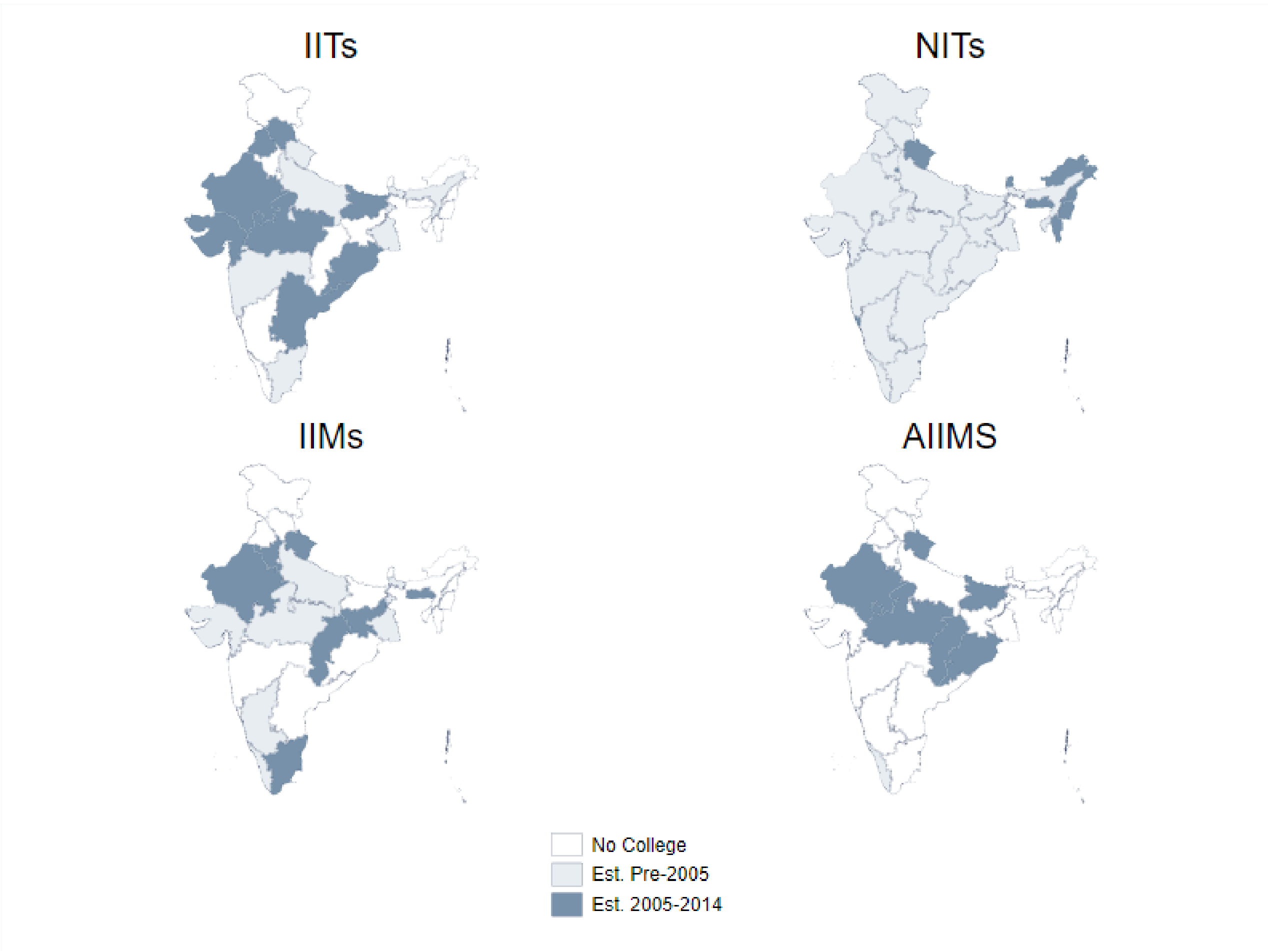
In addition to the data sets mentioned in the main paper, we also make use of the India Human Development Survey (IHDS), which is a nationally representative, multi-topic survey conducted across urban and rural areas. There are currently two waves of IHDS (2004-05 and 2011-12), both of which we obtained from the survey's public portal. We use IHDS to examine the effects of elite public colleges on distance to private schools.

[17]We thank Sam Asher for generously sharing the 1991 village census directory.

Tables and Figures

Figures

Figure A.1: Elite Public College Districts: Old vs. New



Notes: 'IITs': Indian Institute of Technology; 'NITs': National Institute of Technology; 'IIMs': Indian Institute of Mangement; 'AIIMS': All India Institute of Medical Sciences. These four types of elite public colleges constitute around 75% of all elite public colleges. Similar maps for colleges in other fields of study are available on request.

Figure A.2: Treatment (Elite Public College) Districts

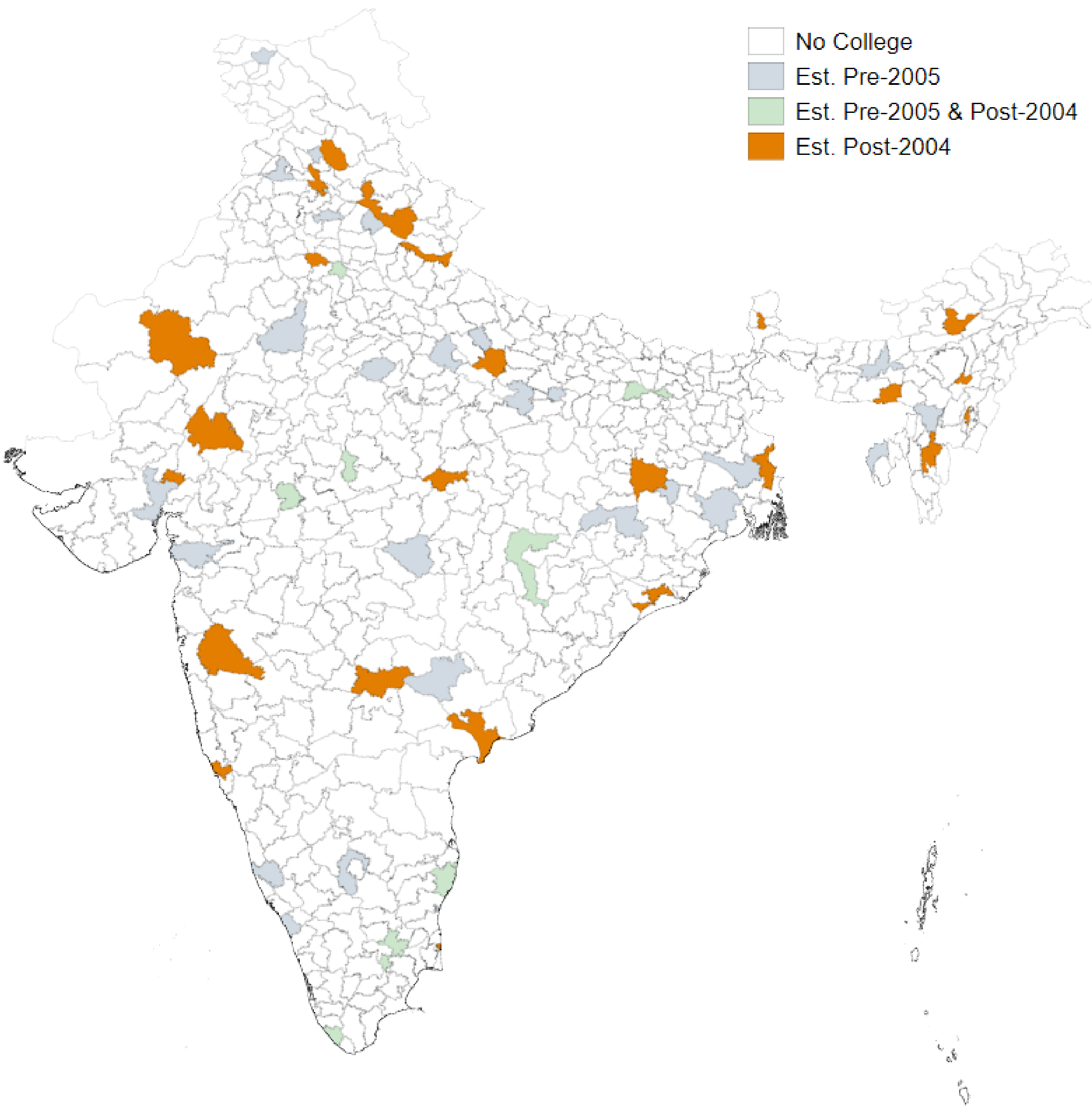
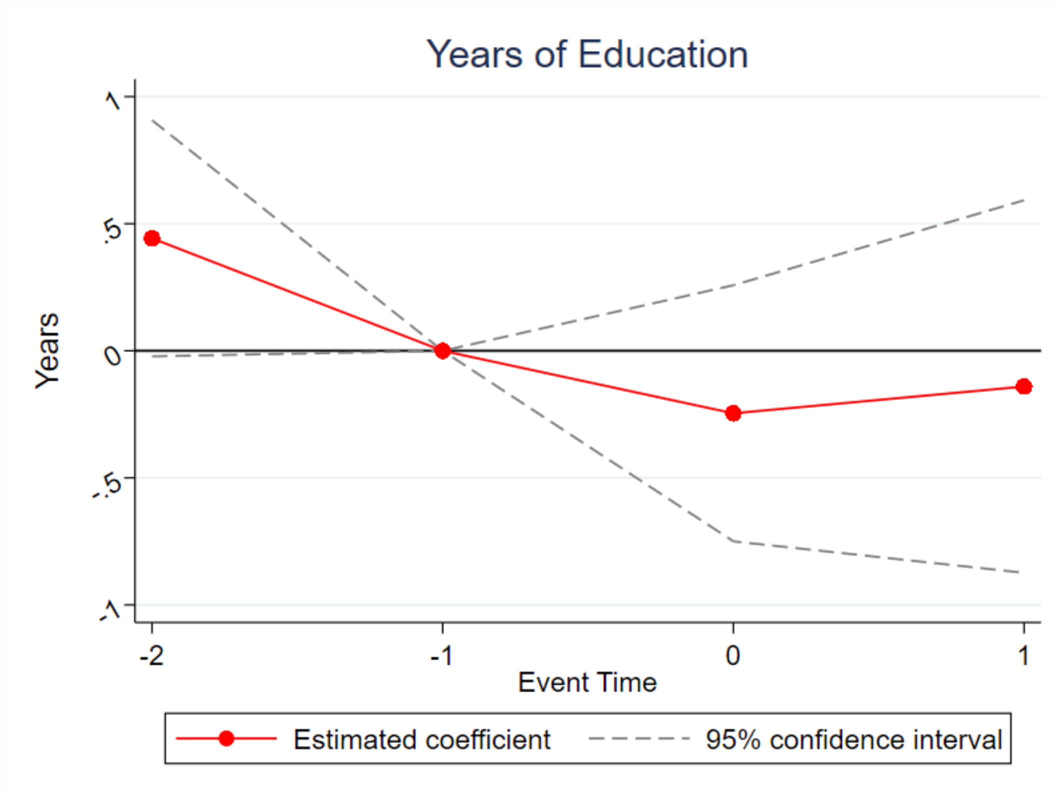
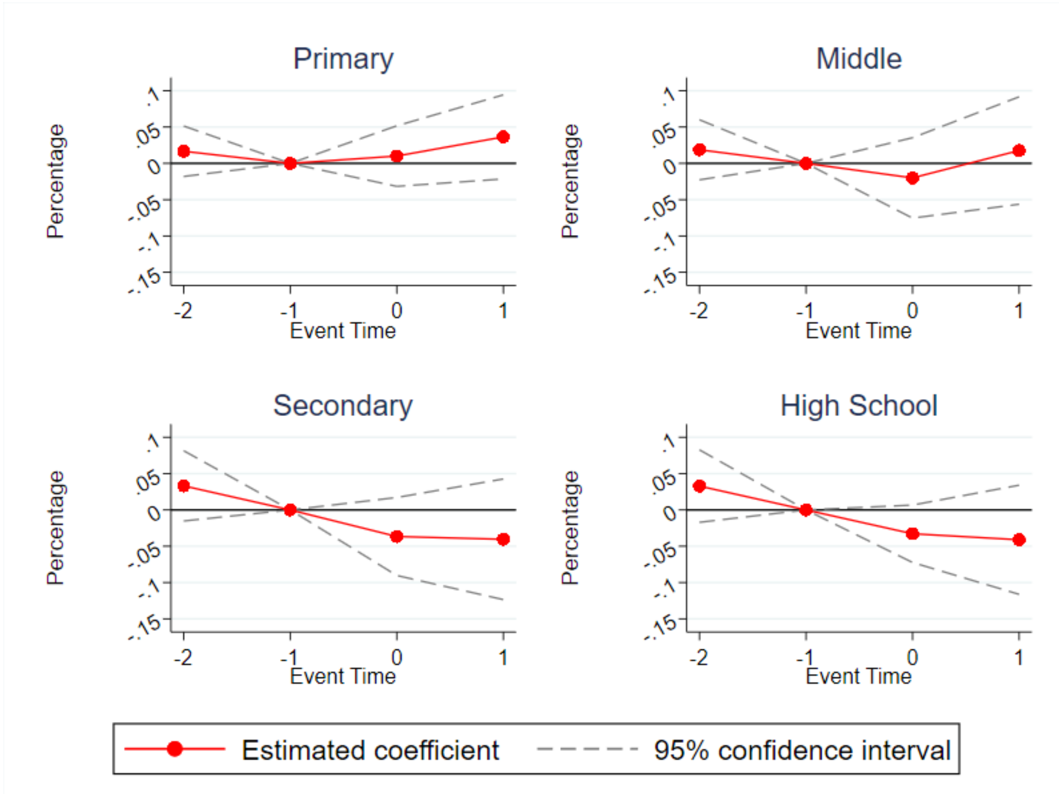


Figure A.3: Falsification Test: Impact of Elite Public Colleges on Years of Schooling (Age 21-35)



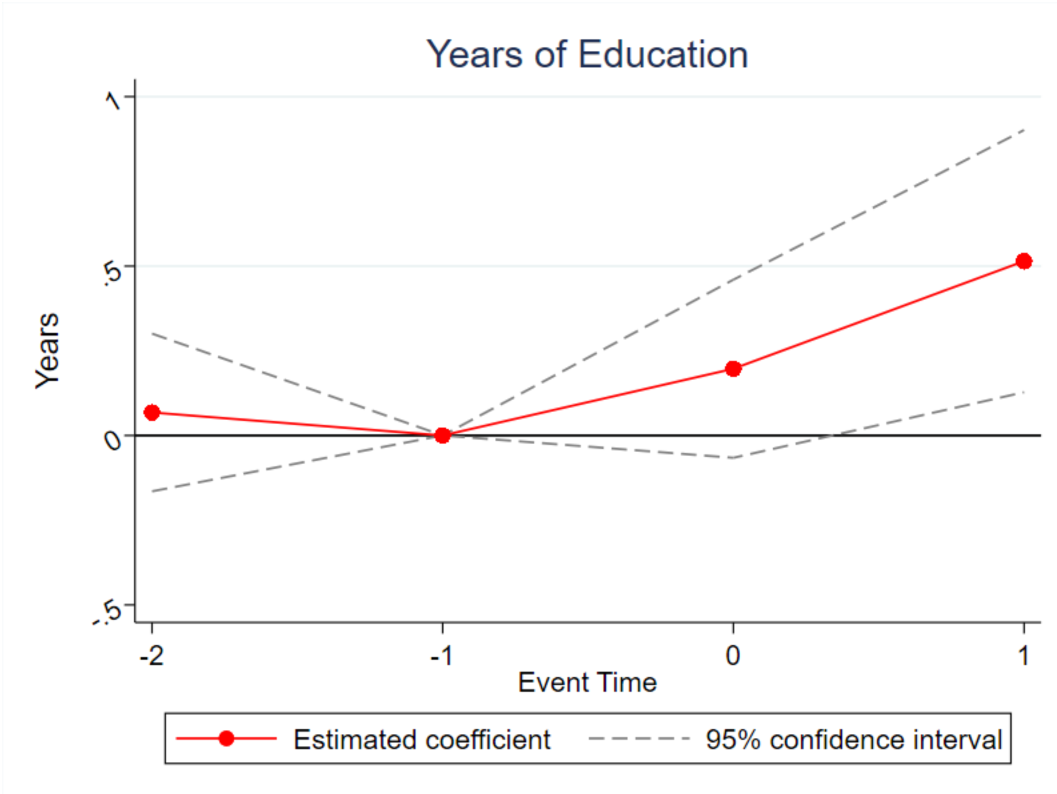
Notes: Sample includes individuals between 6 and 20 years of age across 4 NSS survey rounds (2004, 2007, 2010 and 2012). The figure presents the effects of elite public colleges on years of schooling. $\tau = 0$ is the treatment round. Standard errors are in parentheses, clustered by district.

Figure A.4: Falsification Test: Impact of Elite Public Colleges on Educational Attainment (Age 21-35)



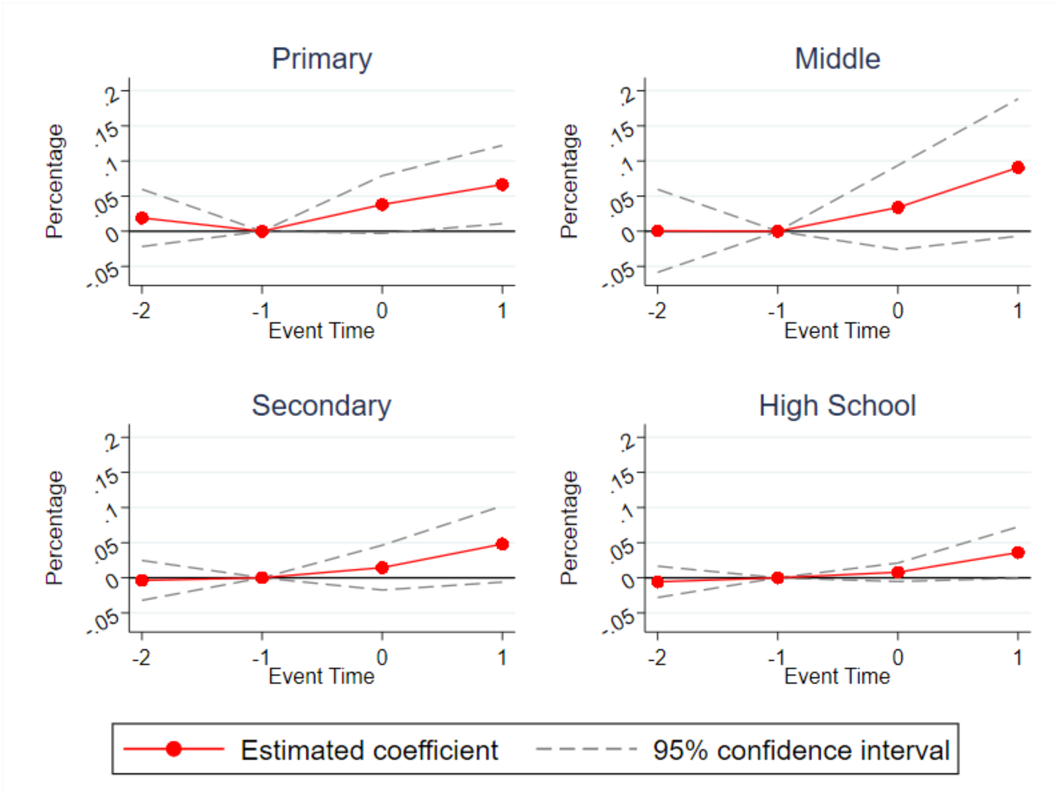
Notes: Sample includes individuals between 6 and 20 years of age across 4 NSS survey rounds (2004, 2007, 2010 and 2012). The figure presents the effects of elite public colleges on educational attainment. $\tau = 0$ is the treatment round. Standard errors are in parentheses, clustered by district.

Figure A.5: Control for Age: Impact of Elite Public Colleges on Years of Schooling (Age 6-20)



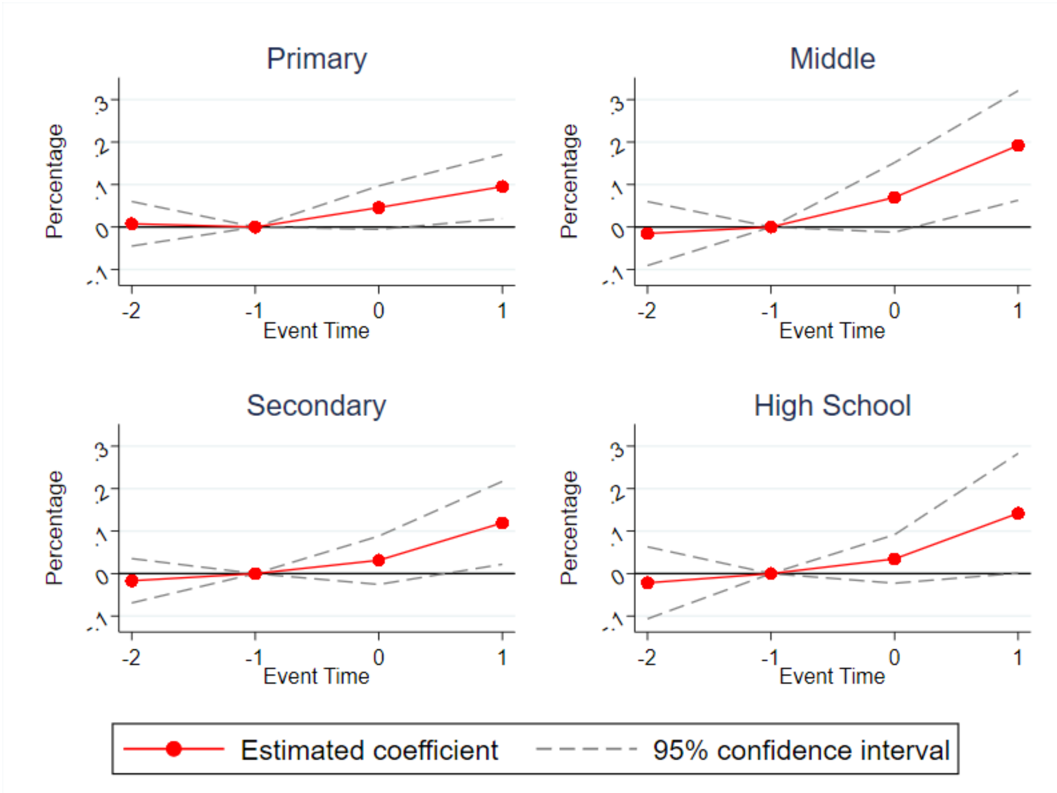
Notes: Sample includes individuals between 6 and 20 years of age across 4 NSS survey rounds (2004, 2007, 2010 and 2012). The figure presents the effects of elite public colleges on years of schooling. $\tau = 0$ is the treatment round. Standard errors are in parentheses, clustered by district.

Figure A.6: Control for Age: Impact of Elite Public Colleges on Educational Attainment (Age 6-20)



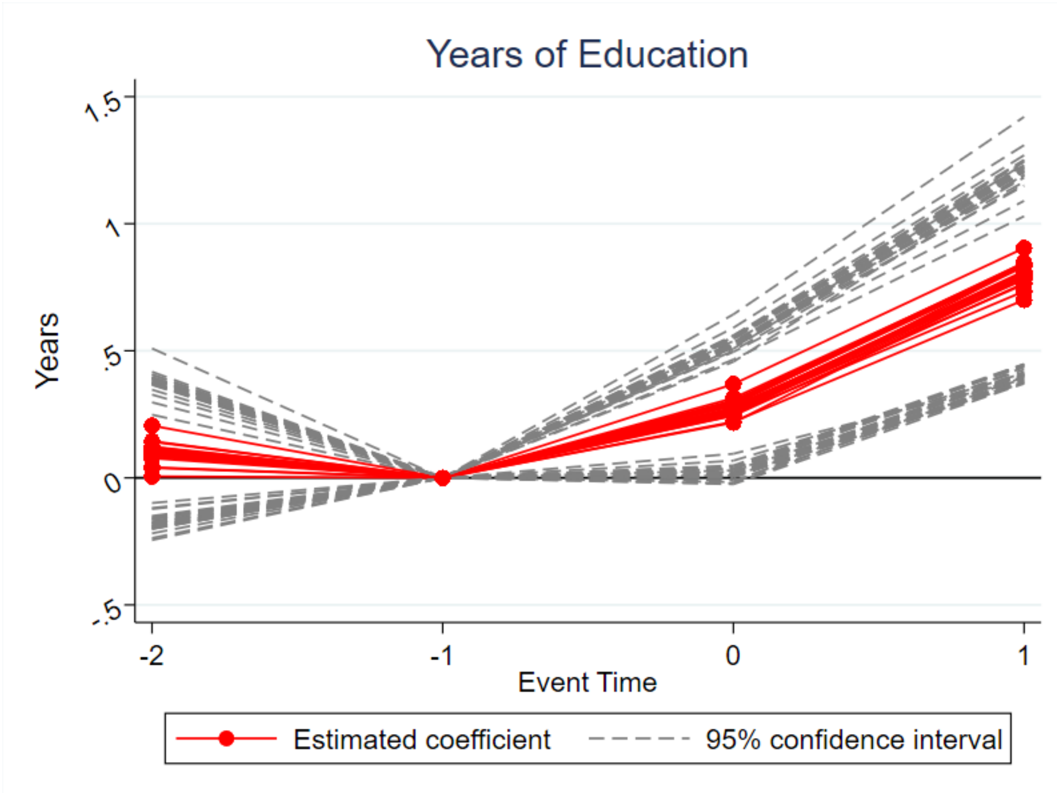
Notes: Sample includes individuals between 6 and 20 years of age across 4 NSS survey rounds (2004, 2007, 2010 and 2012). The figure presents the effects of elite public colleges on educational attainment. $\tau = 0$ is the treatment round. Standard errors are in parentheses, clustered by district.

Figure A.7: Age-Appropriate Sample: Impact of Elite Public Colleges on Educational Attainment (Primary: 9-20; Middle: 12-20; Secondary: 14-20; Higher Secondary: 17-20)



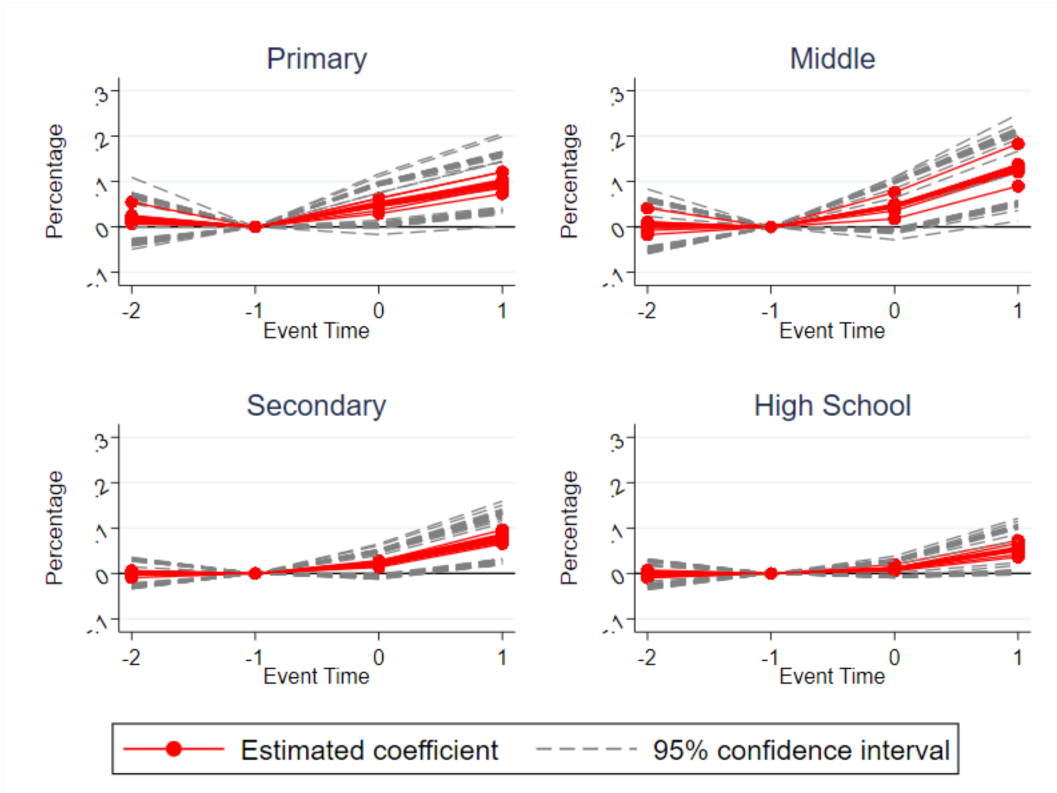
Notes: Sample includes individuals between 10 and 20 years of age across 4 NSS survey rounds (2004, 2007, 2010 and 2012). The figure presents the effects of elite public colleges on educational attainment. $\tau = 0$ is the treatment round. Standard errors are in parentheses, clustered by district.

Figure A.8: Dropping Each District: Impact of Elite Public Colleges on Years of Schooling (Age 6-20)



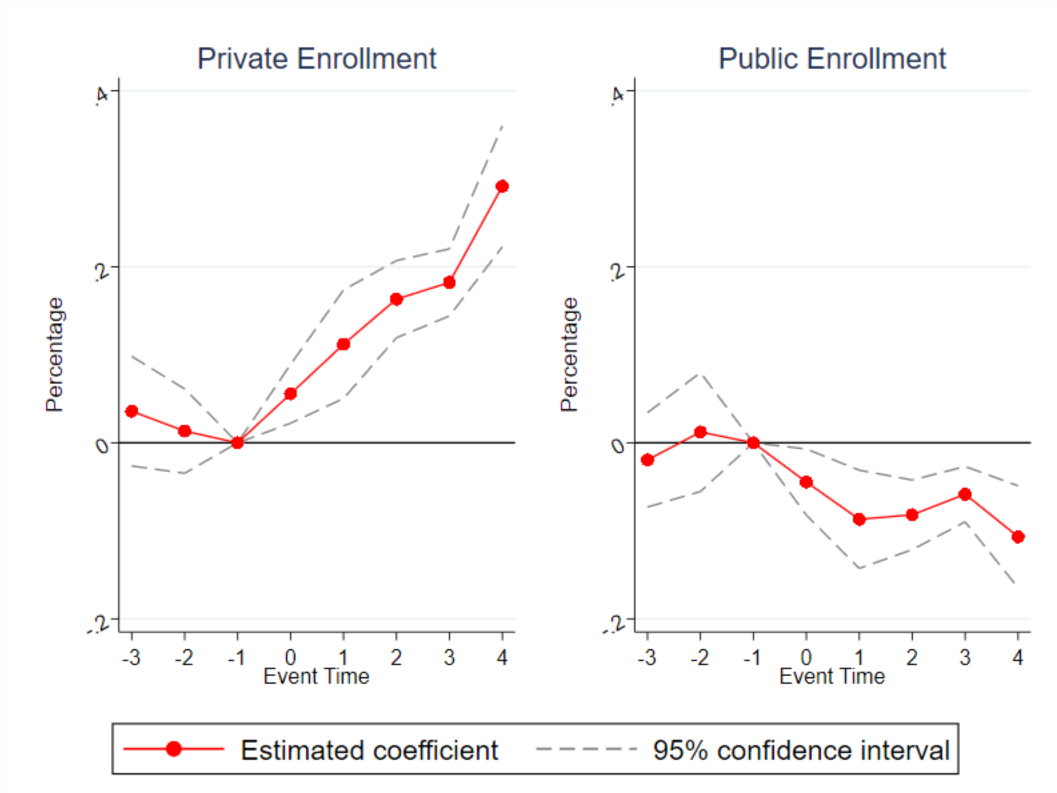
Notes: Sample includes individuals between 6 and 20 years of age across 4 NSS survey rounds (2004, 2007, 2010 and 2012). The figure presents the effects of elite public colleges on years of schooling. $\tau = 0$ is the treatment round. Standard errors are in parentheses, clustered by district.

Figure A.9: Dropping Each District: Impact of Elite Public Colleges on Educational Attainment (Age 6-20)



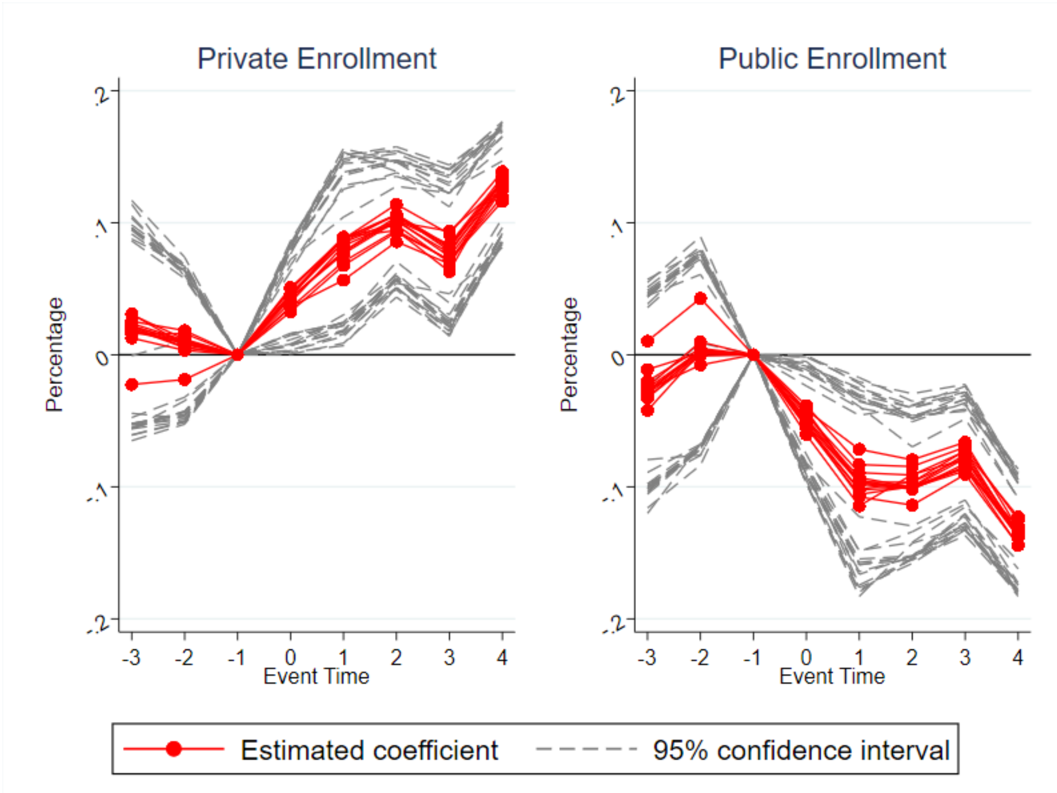
Notes: Sample includes individuals between 6 and 20 years of age across 4 NSS survey rounds (2004, 2007, 2010 and 2012). The figure presents the effects of elite public colleges on educational attainment. $\tau = 0$ is the treatment round. Standard errors are in parentheses, clustered by district.

Figure A.10: Other Controls: Impact of Elite Public Colleges on Private vs. Public Enrollment (Age 5-16)



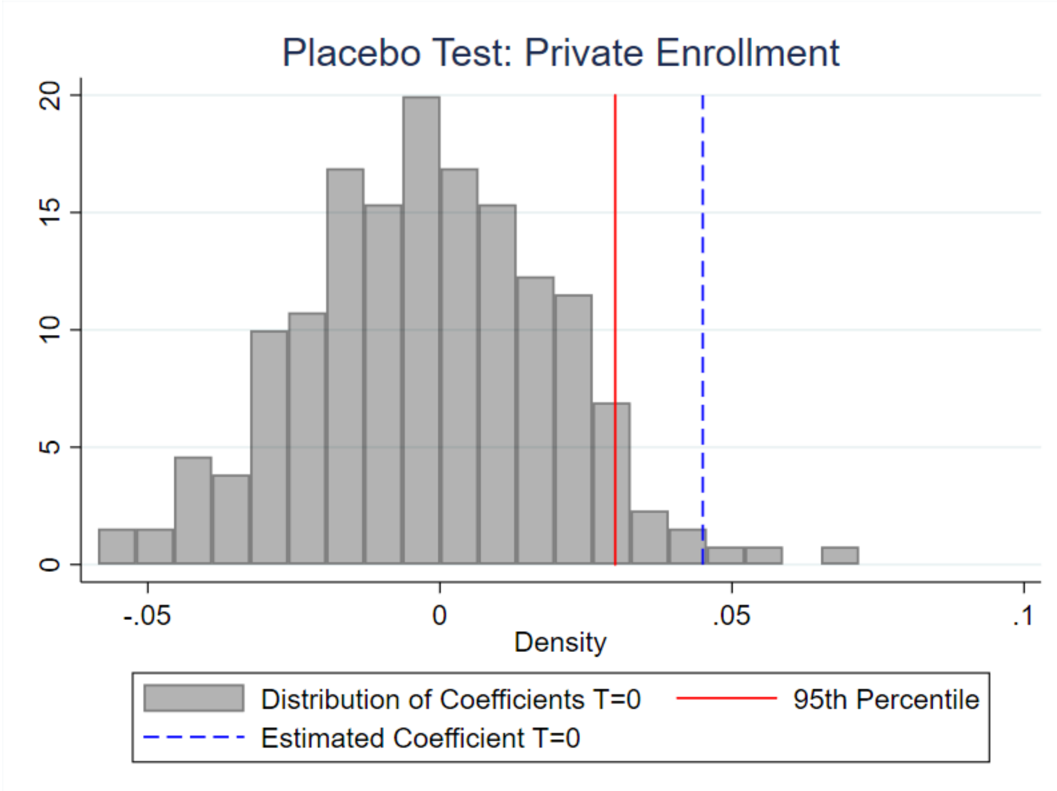
Notes: Sample includes individuals between 5 and 16 years of age across 9 ASER rounds (2006-2014). The figure presents the effects of elite public colleges on private vs. public enrollment status. $\tau = 0$ is the treatment round. Standard errors are in parentheses, clustered by district.

Figure A.11: Dropping Each District: Impact of Elite Public Colleges on Private vs. Public Enrollment (Age 5-16)



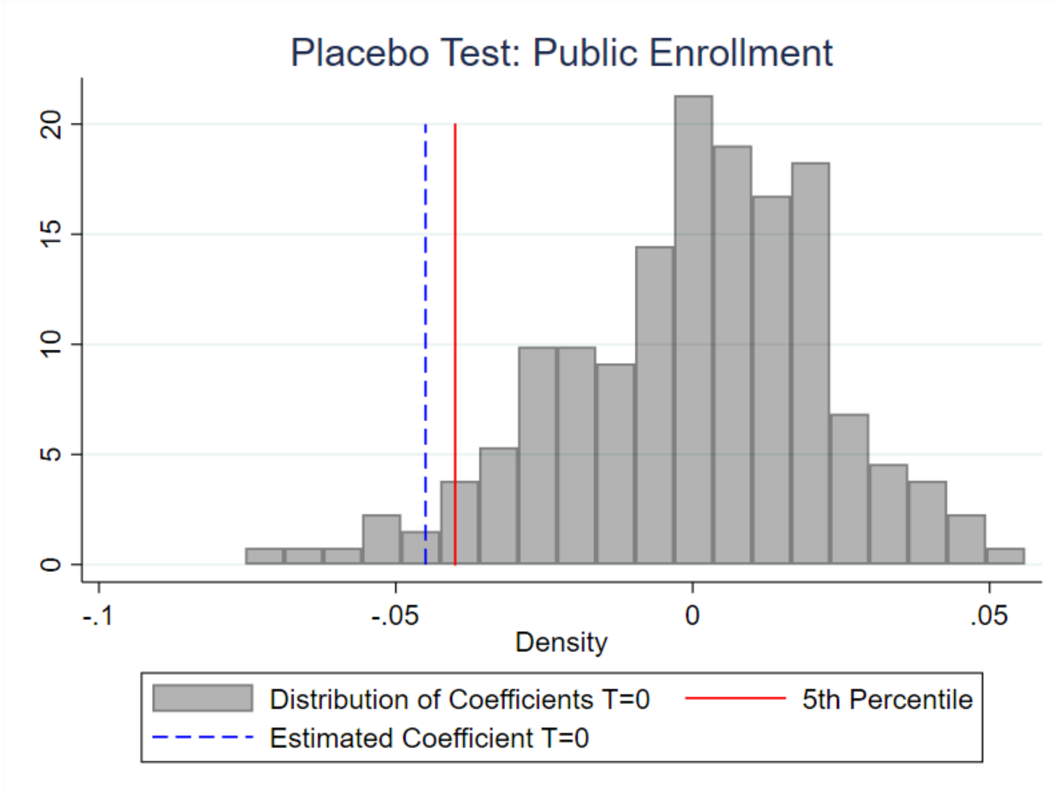
Notes: Sample includes individuals between 5 and 16 years of age across 9 ASER rounds (2006-2014). The figure presents the effects of elite public colleges on private vs. public enrollment status. $\tau = 0$ is the treatment round. Standard errors are in parentheses, clustered by district.

Figure A.12: Placebo Test: Impact of Elite Public Colleges on Private Enrollment at $T = 0$



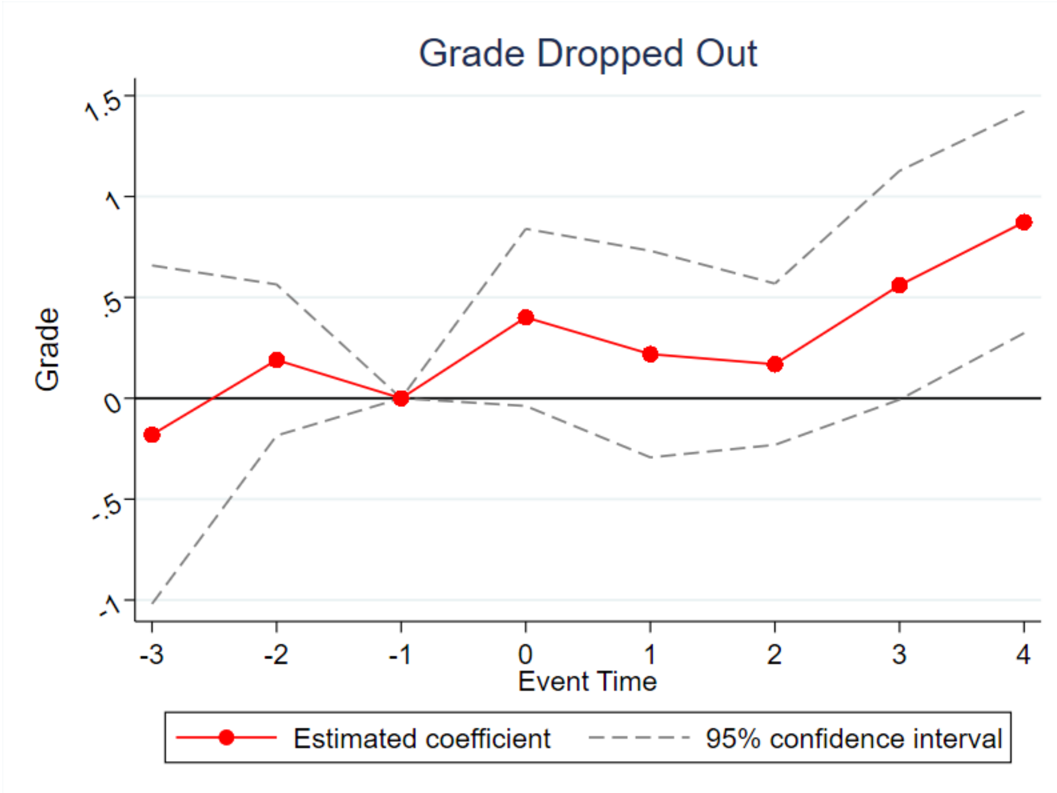
Notes: Sample includes individuals between 5 and 16 years of age across 9 ASER rounds (2006-2014). The figure presents the distribution of the effects of elite public colleges on private enrollment status at $\tau = 0$, when treatment year is randomly assigned amongst treated districts.

Figure A.13: Placebo Test: Impact of Elite Public Colleges on Public Enrollment at $T = 0$



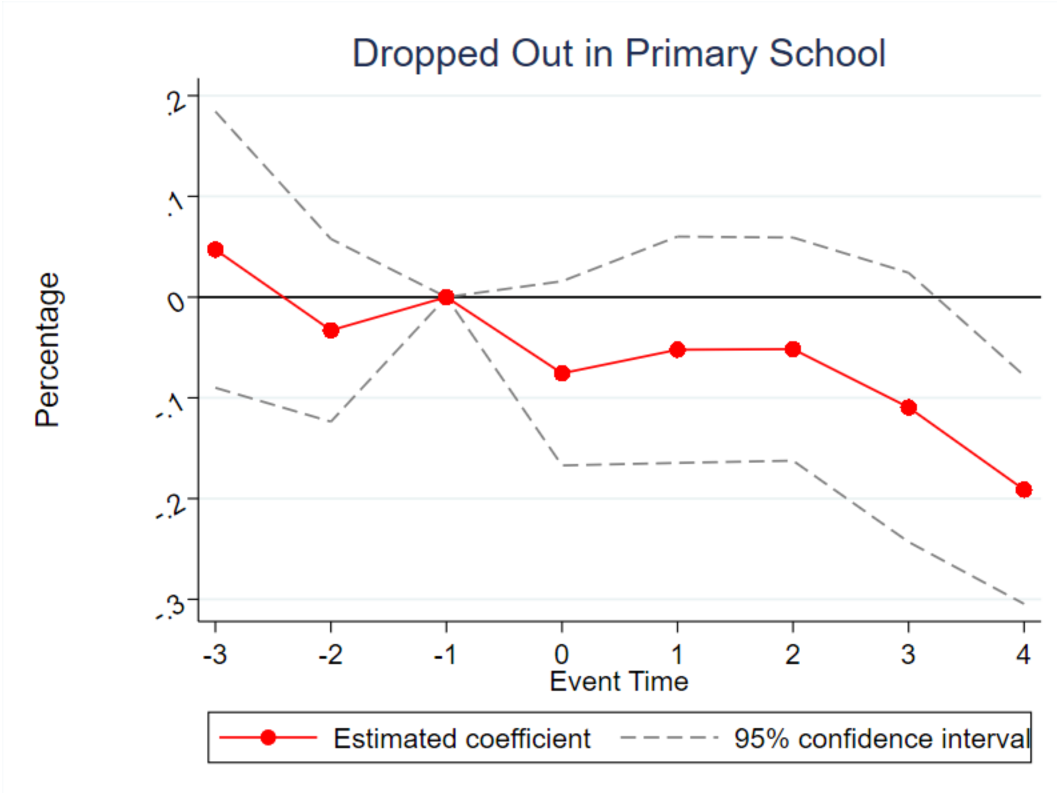
Notes: Sample includes individuals between 5 and 16 years of age across 9 ASER rounds (2006-2014). The figure presents the distribution of the effects of elite public colleges on public enrollment status at $\tau = 0$, when treatment year is randomly assigned amongst treated districts.

Figure A.14: Impact of Elite Public Colleges on Dropout Grade (Age 5-16)



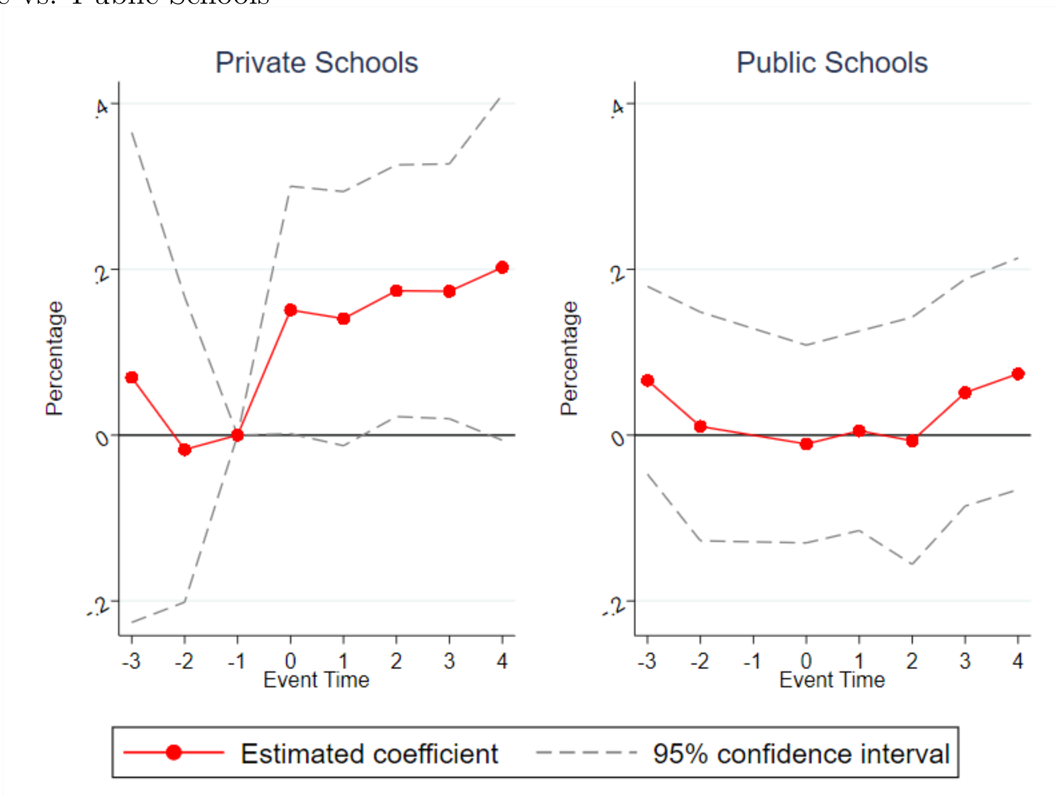
Notes: Sample includes individuals between 5 and 16 years of age across 9 ASER rounds (2006-2014). The figure presents the effects of elite public colleges on dropout grade. $\tau = 0$ is the treatment round. Standard errors are in parentheses, clustered by district.

Figure A.15: Impact of Elite Public Colleges on Dropouts in Primary School (Age 5-16)



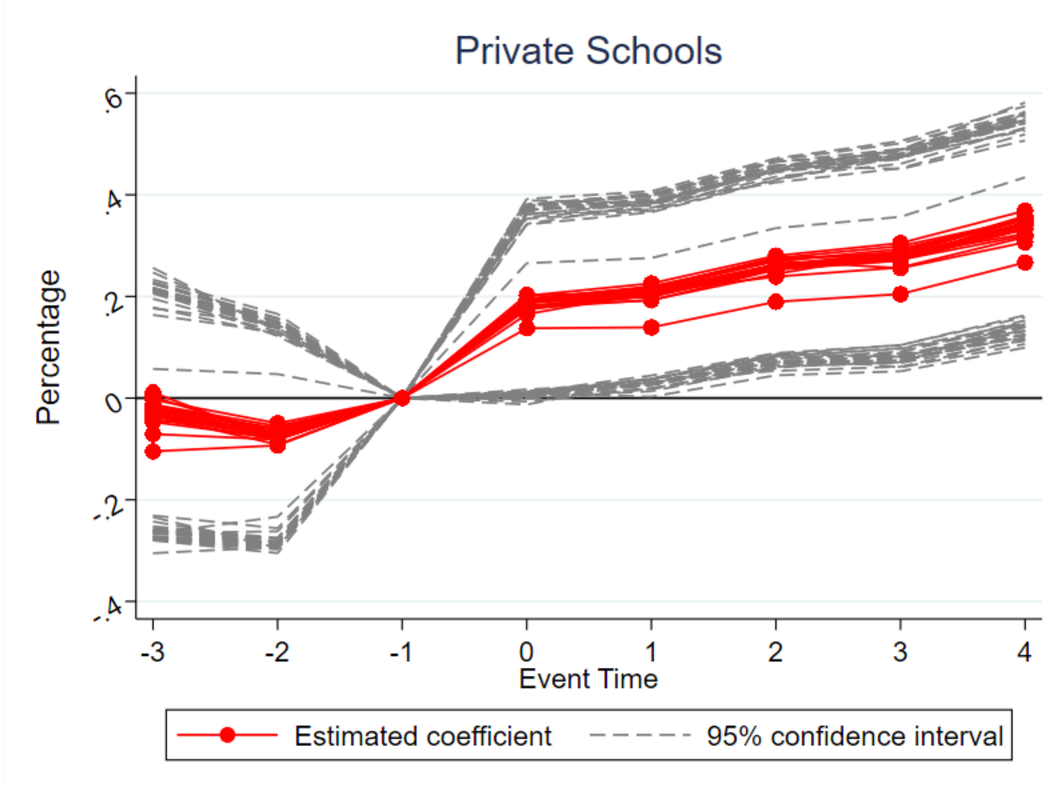
Notes: Sample includes individuals between 5 and 16 years of age across 9 ASER rounds (2006-2014). The figure presents the effects of elite public colleges on the probability of dropping out in primary school. $\tau = 0$ is the treatment round. Standard errors are in parentheses, clustered by district.

Figure A.16: Adding District-Specific Linear Trends: Impact of Elite Public Colleges on Private vs. Public Schools



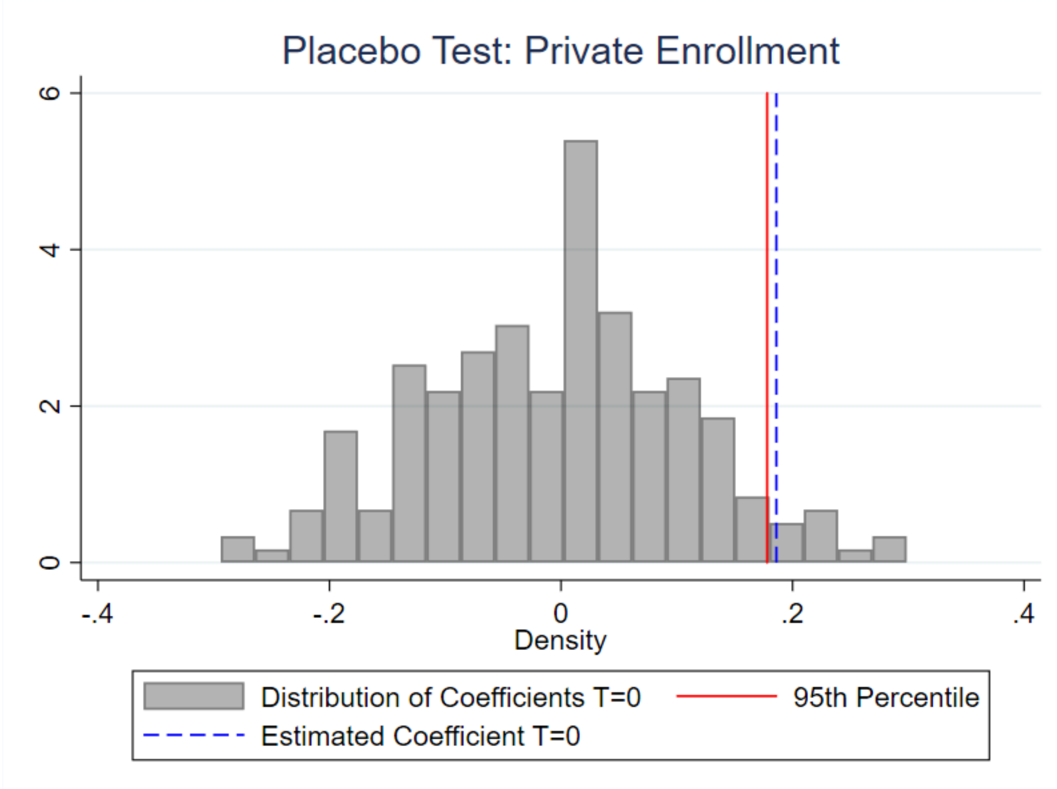
Notes: Sample includes treatment districts across 11 years of DISE data (2004-2014). The figure presents the effects of elite public colleges on number of private and public schools. $\tau = 0$ is the treatment year. Standard errors are in parentheses, clustered by district.

Figure A.17: Dropping Each District: Impact of Elite Public Colleges on Private Schools



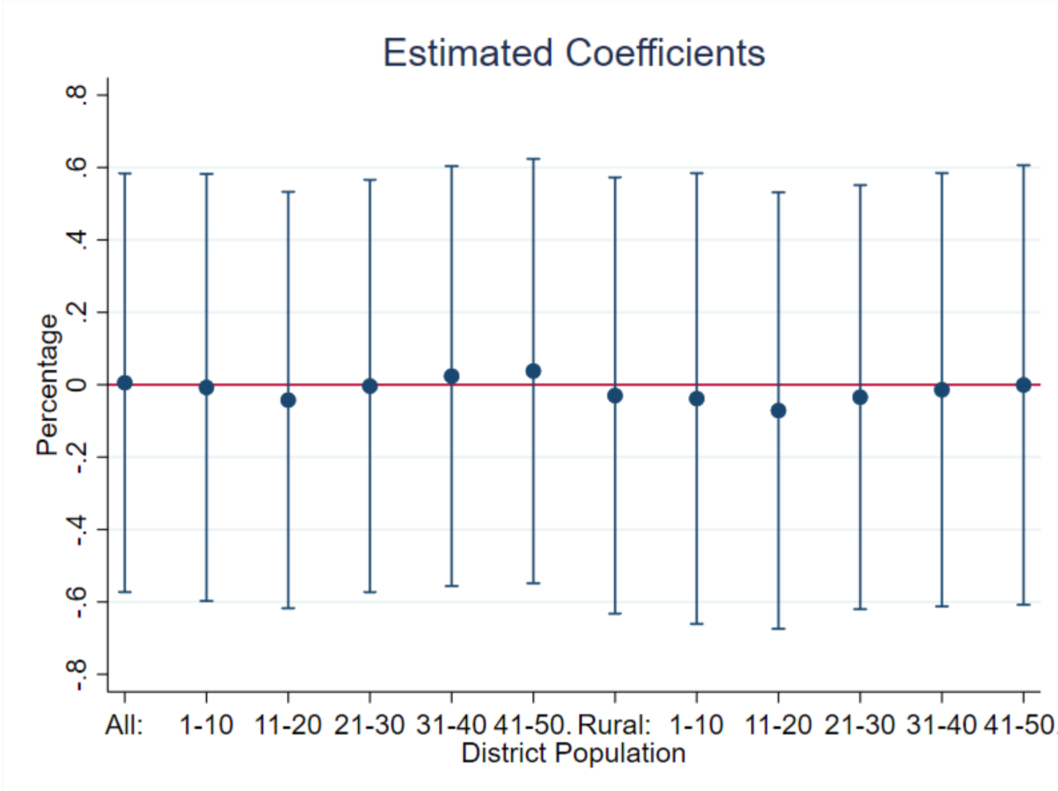
Notes: Sample includes treatment districts across 11 years of DISE data (2004-2014). The figure presents the effects of elite public colleges on number of private and public schools. $\tau = 0$ is the treatment year. Standard errors are in parentheses, clustered by district.

Figure A.18: Placebo Test: Impact of Elite Public Colleges on Private Schools at $T = 0$



Notes: Sample includes treatment districts across 11 years of DISE data (2004-2014). The figure presents the distribution of the effects of elite public colleges on number of public schools at $\tau = 0$, when treatment year is randomly assigned amongst treated districts.

Figure A.19: Impact of Elite Public Colleges on Population by Age Group

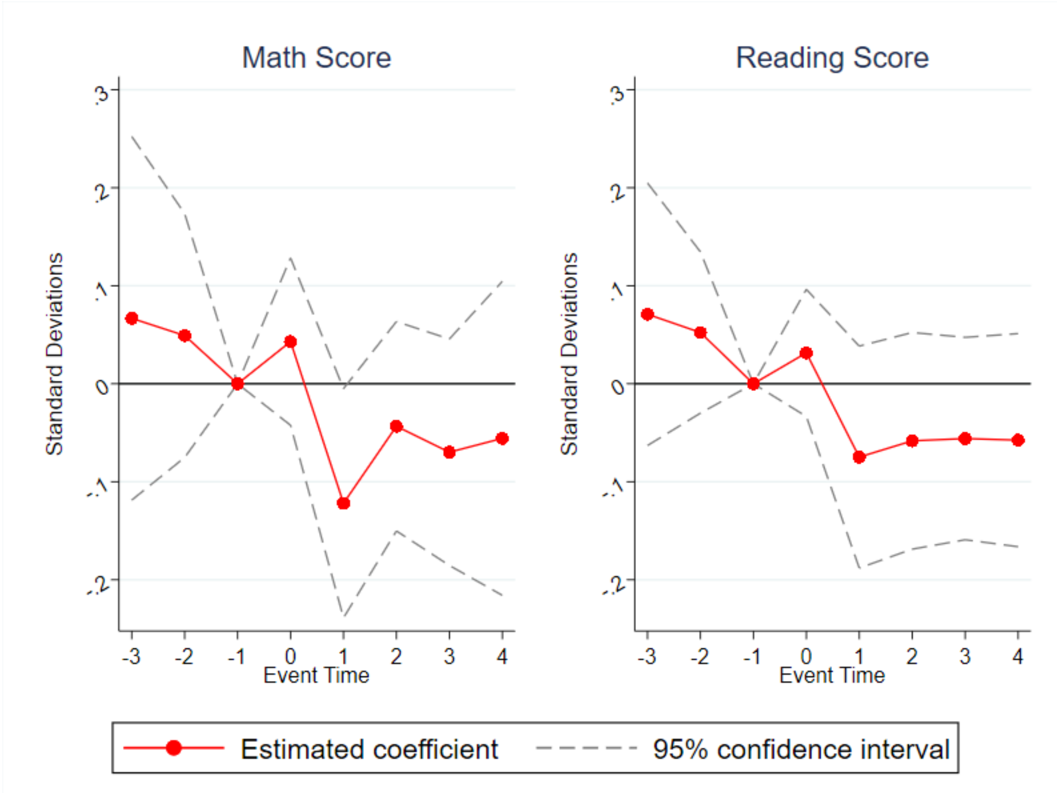


Notes: Sample includes over all districts in India villages across 2 Census rounds (2001 and 2011). The figure presents the effects of elite public colleges on district population. 95% confidence interval (homoskedastic standard errors) presented.

Figure A.20: Impact of Elite Public Colleges on Wages

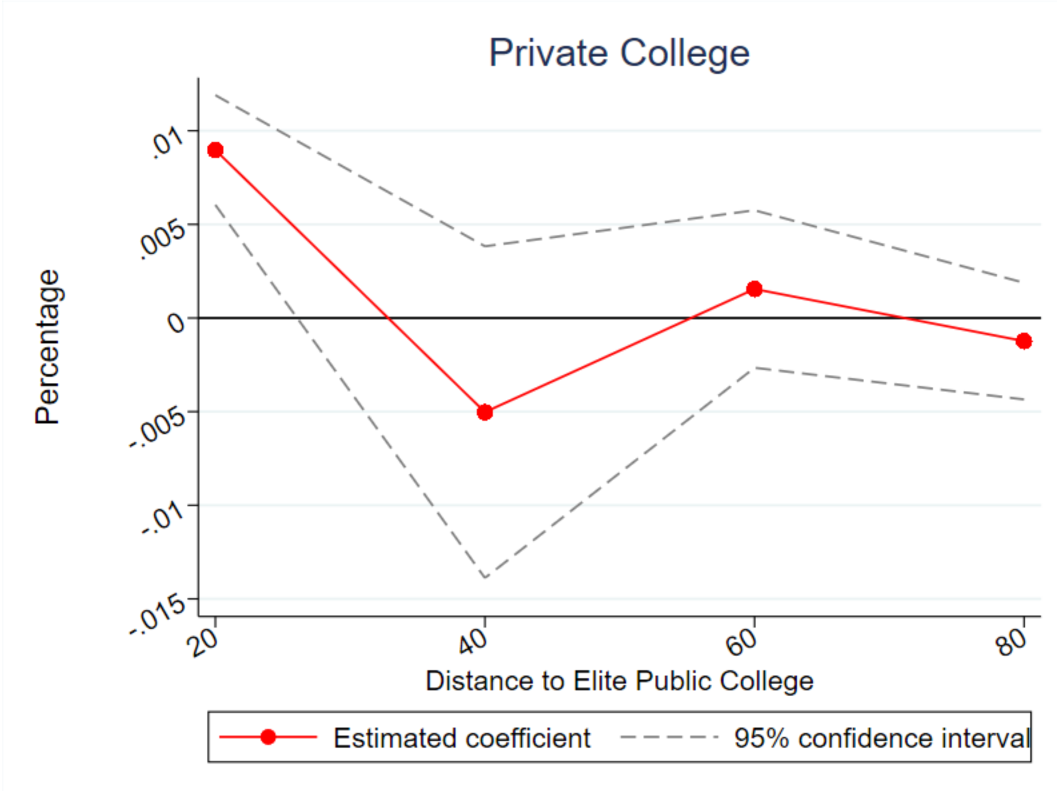
Notes: Sample includes households across 4 NSS survey rounds (2004, 2007, 2010 and 2012) in all treatment districts. The figure presents the effects of elite public colleges on wages. $\tau = 0$ is the treatment round. Standard errors are in parentheses, clustered by district.

Figure A.21: Impact of Elite Public Colleges on Test Scores (Age 5-16)



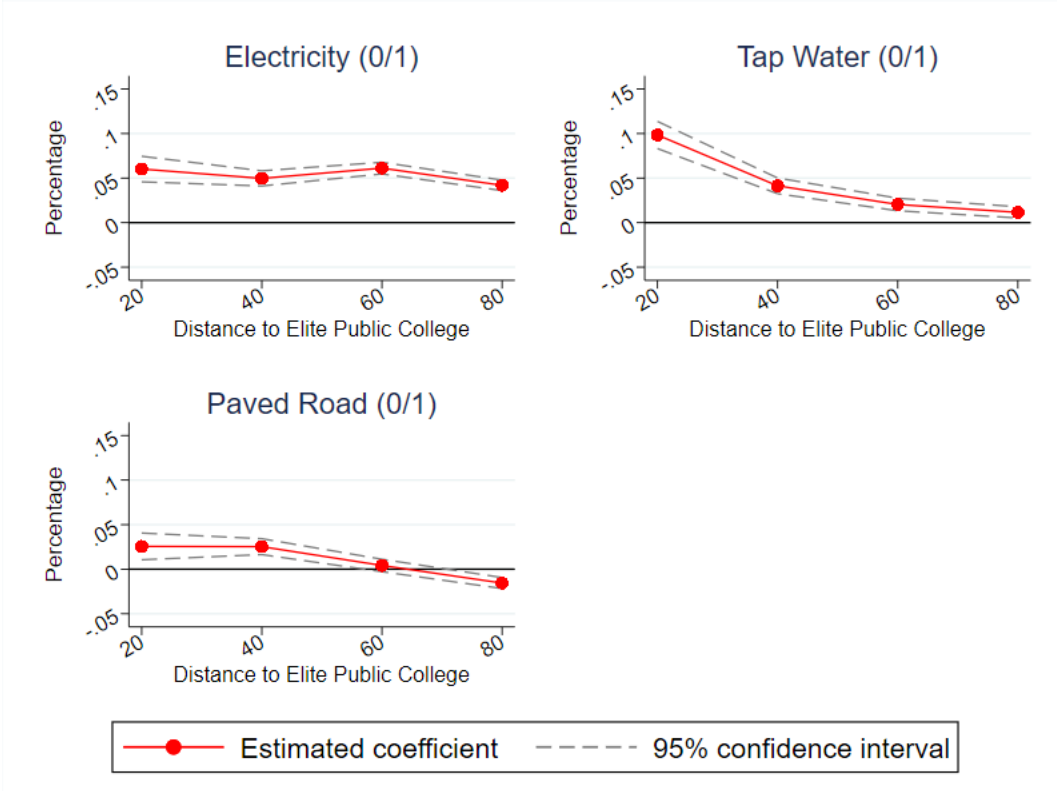
Notes: Sample includes individuals between 5 and 16 years of age across 9 ASER rounds (2006-2014). The figure presents the effects of elite public colleges on math and reading test scores. $\tau = 0$ is the treatment round. Standard errors are in parentheses, clustered by district.

Figure A.22: Village Distance to Public College: Impact of Elite Public Colleges on Presence of Private College



Notes: Sample includes over 500,000 villages in the 2011 Census Village Directory. The figure presents the effects of elite public colleges on presence of private college at the village level. Standard errors are clustered by district.

Figure A.23: Dropping Districts Governed by Powerful Politicians: Impact of Elite Public Colleges on Access to Electricity, Tap Water and Roads



Notes: Sample includes around 500,000 villages across 2 Census Village Directories (2001 and 2011). The figure presents the effects of elite public colleges on village level infrastructure upgrades.

Tables

Table A.1: Summary Statistics on Districts with Elite Colleges (EC)

	Period	**# of Districts with Elite College**
	Pre-2004	40
	2004-2014	35
Balanced Panel		
Year	**# of Districts with new Elite College**	**# of new Districts with Elite College**
2004	0	0
2005	1	1
2006	2	2
2007	4	2
2008	9	6
2009	2	1
2010	13	11
2011	3	2
2012	1	1
2013	0	0
2014	0	0
Total	**35**	**26**

Notes: This table lists all elite colleges established between 2004-2014. A total of 42 elite public universities were established in this period. Out of 42, 13 were established in 6 districts. Therefore, 35 districts got new elite colleges during this period. Out of these 35 districts, 9 districts already had an elite college in 2003. Thus, identification is derived from 26 districts who received an elite college for the first time between 2004-2014. We only use a balanced sample in our analysis, therefore, in DISE we use 23; ASER, 14; Population Census, 25; Village Census Directories, 13; and NSS, 25 districts.

Table A.2: National Sample Survey (NSS): Summary Statistics on Years of Education and Educational Attainment (Age 6-20)

	Pooled	2004	2007	2010	2012
Years of Education	5.83	5.34	5.87	6.08	6.16
	(3.32)	(3.24)	(3.40)	(3.22)	(3.34)
Primary (0/1)	0.63	0.58	0.63	0.67	0.65
	(0.48)	(0.49)	(0.48)	(0.47)	(0.48)
Middle (0/1)	0.39	0.34	0.40	0.42	0.42
	(0.49)	(0.47)	(0.49)	(0.49)	(0.49)
Secondary (0/1)	0.19	0.15	0.20	0.21	0.23
	(0.40)	(0.35)	(0.40)	(0.41)	(0.42)
High School (0/1)	0.08	0.05	0.09	0.08	0.09
	(0.27)	(0.23)	(0.28)	(0.27)	(0.29)
Observations	41151	11363	11305	9330	9153

Notes: Sample includes individuals between 6 and 20 years of age across 4 NSS survey rounds (2004, 2007, 2010 and 2012). The table presents summary statistics on years of schooling and educational attainment in treatment districts.

Table A.3: Annual Survey of Education Report (ASER): Summary Statistics on Years of Education and Educational Attainment (Age 6-20)

	Pooled	2006	2007	2008	2009
Public Enrollment (0/1)	0.57	0.61	0.61	0.60	0.61
	(0.49)	(0.49)	(0.49)	(0.49)	(0.49)
Private Enrollment (0/1)	0.32	0.25	0.29	0.30	0.27
	(0.47)	(0.43)	(0.45)	(0.46)	(0.45)
Observations	120915	15774	15705	14371	13750

Notes: Sample includes individuals between 5 and 16 years of age across 9 ASER rounds (2006-2014). The table presents summary statistics on private vs. public enrollment status in treatment districts.

Table A.4: Annual Survey of Education Report (ASER): Summary Statistics on Years of Education and Educational Attainment (Age 6-20)

	2010	2011	2012	2013	2014
Public Enrollment (0/1)	0.57	0.55	0.53	0.51	0.50
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Private Enrollment (0/1)	0.33	0.35	0.36	0.39	0.40
	(0.47)	(0.48)	(0.48)	(0.49)	(0.49)
Observations	13955	13145	12161	11346	10708

Notes: Sample includes individuals between 5 and 16 years of age across 9 ASER rounds (2006-2014). The table presents summary statistics on private vs. public enrollment status in treatment districts.

Table A.5: District Information System for Education (DISE): Summary Statistics on # of Private and Public Schools

	All	2004	2005	2006	2007	2008
# Private Schools (00s)	5.41	3.49	3.84	4.48	5.04	5.36
	(4.95)	(3.55)	(4.06)	(4.47)	(4.78)	(5.11)
# Public Schools (00s)	16.91	15.55	16.52	16.82	17.06	16.77
	(13.30)	(12.72)	(13.61)	(14.47)	(14.11)	(13.56)
Observations	253	23	23	23	23	23

Notes: Sample includes treatment districts across 11 years of DISE data (2004-2014). The table presents summary statistics on number of private and public schools in treatment districts.

Table A.6: District Information System for Education (DISE): Summary Statistics on # of Private and Public Schools

	2009	2010	2011	2012	2013	2014
# Private Schools (00s)	5.69	5.72	5.97	6.33	6.67	6.93
	(5.41)	(4.90)	(4.93)	(5.24)	(5.62)	(5.78)
# Public Schools (00s)	16.86	17.16	17.16	17.47	17.54	17.12
	(13.63)	(13.37)	(13.25)	(13.38)	(13.94)	(13.10)
Observations	23	23	23	23	23	23

Notes: Sample includes treatment districts across 11 years of DISE data (2004-2014). The table presents summary statistics on number of private and public schools in treatment districts.

Table A.7: Cluster-Bootstrap Standard Errors: Impact of Elite Public Colleges on Years of Schooling and Educational Attainment

	(1) Years of Education β / SE	(2) Primary β / SE	(3) Middle β / SE	(4) Secondary β / SE	(5) High School β / SE
t== -2.0000	0.098	0.018	0.004	0.001	-0.000
	(0.58)	(0.58)	(0.86)	(1.00)	(1.00)
t== 0.0000	0.277	0.049	0.046	0.021	0.011
	(0.02)	(0.00)	(0.24)	(0.18)	(0.30)
t== 1.0000	0.810	0.099	0.133	0.079	0.053
	(0.00)	(0.00)	(0.00)	(0.00)	(0.14)
Observations	41124	41151	41151	41151	41151

Notes: Sample includes individuals between 6 and 20 years of age across 4 NSS survey rounds (2004, 2007, 2010 and 2012). The table presents the effects of elite public colleges on years of schooling and educational attainment. $\tau = 0$ is the treatment round. P-values are in parentheses.