

A Right not Granted<sup>1</sup>. A Wrong not Righted. Spending and performance in Texan Public Schools

## 1 Introduction

This paper estimates the educational return to spending in Texan public schools using two methods, which to my knowledge are previously unexplored. Arbitrary restrictions on tax rates due to the unconstitutionality of statewide taxes induced some cash-starved districts to max out their tax rates, presenting windows in which their revenue was completely dependent on property values and state aid. Thus changes in revenue may have been exogenous to changes in school performance. Further to this, random fluctuations in the oil price provided positive and negative revenue shocks which may constitute a viable instrument for district revenue, allowing for a more plausible estimate of the causal impact of spending on school performance. These combined with the time-series, campus-level nature of the data allows for estimates which plausibly address some endogeneity concerns which plague other educational production function estimates. Many remain, and are addressed in due course, as are the assumptions on which these estimates rest. The most salient elements of Texas' "byzantine" [10] school finance system are now described, followed by a brief literature review and then the formal results.

Texas is partitioned into 1026\* independent school districts (ISDs), each a kind of local government with the power to tax property and allocate funds between the schools within it. Some districts are vast, sprawling entities.

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<sup>1</sup>footnotes working fine

Dallas ISD for instance educated over 150,000 in 2018/19 with an operating budget of over 1.8b. [dallas wiki]. Others are more modest, like Cayuga ISD which is home to just three schools: an elementary, middle and high school, and under 600 students [cayuga wiki]. While some districts cater to non-public schools like charter, orphanage or prison schools, these are not the subject of this paper.

Districts are funded through a combination of local, state and federal revenue.

Almost twenty years would pass until Texans would successfully sue the Texan Commissioner of Education for discrimination against students in poor districts[3] in Edgewood Independent School District v. Kirby (Tex 1989). During the trial it was found that the "[the] wealthiest district [have] over 14,000,000*of property wealth per student, while the poorest [have] approximately* 20,000; this disparity reflects a 700 to 1 ratio"[4]. While as Americans the students in Edgewood ISD had no right to education, as Texans it was decided they did. The solution forged by the wrestle between parents, lawmakers and judges which followed was finance-equalisation legislation passed in 1993 and taken into effect in the 1993/94 school year. Though nicknamed 'Robin Hood' by the press, this belied the widespread ire the legislation would draw from economists[5], lawmakers[6] and parents[7] (rich and poor alike), and the two further rounds of lawsuits it would face. In January 2019 Republican Governor Greg Abbott tweeted: "We must put Robin Hood school funding on a path of extinction", later congratulating himself (more mutedly) for "reform" on the issue as the 86th Legislative Session ended [8]. Far from being a unique, arcane example, interesting only in its novelty,

Texas' school finance system mirrors dozens[9] of other states which rely on similar local funding models; as do its problems.

The "byzantine"[10] nature of the system presents two intriguing settings to the econometrician, which to my knowledge are previously unexplored. Arbitrary restrictions on tax rates due to the unconstitutionality of statewide taxes induced some cash-starved districts to max out their tax rates, presenting windows in which their revenue was completely dependent on property values and state aid. Further to this, random fluctuations in the oil price provided positive and negative revenue shocks which may constitute a viable instrument for district revenue, allowing for a more plausible estimate of the causal impact of spending on school performance. These combined with the time-series, campus-level nature of the data allows for estimates which plausibly address some endogeneity concerns which plague other educational production function estimates. Many remain, and are addressed in due course.

## 2 The Educational Landscape

## 3 Literature Review

Texas' education system has been the subject of several previous studies, most notably Hoxby '04, Hanushek and Rivkin '05 and

Our ultimate aim is to estimate a production function of the form:

$$Score = f(ability, resources, teacher, family, peers, community) + \epsilon$$

Once we have done this policy questions can be answered by investigating

the parameters obtained from this estimate. For example how does the effect of class size differ in different communities, what proportion of the variation in expenditure estimates can be attributed to district-level effects?

[Obviously I'll need to put the general background, data and theory here too. (Importantly I need to talk about data selection and assumptions about sampling process. That is, that the data I have dropped were dropped randomly).]

## 4 Model

Consider a simple linear model for academic performance over campuses  $i = 1, \dots, n$ ; school districts  $j = 1, \dots, 957$ ; and periods  $t = 2003, \dots, 2011$  (where 2003 represents the academic year '02-'03):

$$\begin{aligned} \text{Gr5.Score}_{ijt} = & \beta_0 + \beta_1 \text{Gr4.Score}_{ijt-1} + \beta_2 \text{Gr3.Score}_{ijt-2} \\ & + \beta_3 \text{Per.Pupil.Exp}_{ijt} + \beta_4 \text{Econ.Disadv.Per}_{ijt} \\ & + \beta_5 \text{T.Avg.Sal}_{ijt} + \beta_6 \text{T.Avg.Exp}_{ijt} \\ & + \beta_7 \text{Gr5.Class.Size}_{ijt} + \epsilon_{ijt} \end{aligned}$$

And another

Consider a simple linear model for academic performance over campuses  $i = 1, \dots, n$ ; school districts  $j = 1, \dots, 957$ ; and periods  $t = 2003, \dots, 2011$  (where 2003 represents the academic year '02-'03):

$$\begin{aligned} \text{Gr10.Score}_{ijt} = & \beta_0 + \beta_1 \text{Gr9.Score}_{ijt-1} + \beta_2 \text{Per.Pupil.Exp}_{ijt} \\ & + \beta_3 \text{Econ.Disadv.Perc}_{ijt} + \beta_4 \text{T.Avg.Sal}_{ijt} \\ & + \beta_5 \text{T.Avg.Exp}_{ijt} + \beta_6 \text{Gr10.Class.Size}_{ijt} + \epsilon_{ijt} \end{aligned}$$

Before estimating this model it is instructive to restrict it to more specialised cases and clearly step through the assumptions required for OLS to be an efficient, unbiased estimation strategy. This makes suggesting alternative estimation strategies much more intuitive.

#### 4.1 Within district, one time period

Let the first restriction be  $j = 1$  (WLOG let this represent DALLAS ISD) and  $t = 2006$ . These are arbitrary parameter values. The model then can be simplified to:

$$\begin{aligned}\text{Gr5.Avg}_i &= \beta_0 + \beta_1 \text{Gr4.Avg.Lag1}_i + \beta_2 \text{Gr3.Avg.Lag2}_i \\ &+ \beta_3 \text{Per.Pupil.Exp}_i + \beta_4 \text{Econ.Disadv.Perc}_i \\ &+ \beta_5 \text{T.Avg.Sal}_i + \beta_6 \text{T.Avg.Exp}_i \\ &+ \beta_7 \text{Gr5.Class.Size}_i + \epsilon_i\end{aligned}$$

In making these restrictions we can automatically rule out concerns due to time-trends and some spatial autocorrelation, however we must still be confident that the GM assumptions are satisfied.

##### 4.1.1 Multicollinearity

We require that the matrix  $\mathbf{X}'\mathbf{X}$  where

$$\mathbf{X} = \begin{pmatrix} 1 & x'_1 \\ 1 & x'_2 \\ \vdots & \vdots \\ 1 & x'_n \end{pmatrix}$$

,

$$x_i = \begin{pmatrix} \text{Gr4.Avg.Lag1}_i \\ \text{Gr3.Avg.Lag2}_i \\ \vdots \\ \text{Gr5.Class.Size}_i \end{pmatrix}$$

be invertible.

#### 4.1.2 Exogeneity

Measurement error, simultaneity.

#### 4.1.3 Homoskedasticity

Downward bias, local spatial autocorrelation.

#### 4.1.4 Normality

??

### 4.2 Within district, panel

A simple linear model for performance in Dallas ISD:

$$\begin{aligned} \text{Gr5.Avg}_{it} = & \beta_0 + \beta_1 \text{Gr4.Avg.Lag1}_{it} + \beta_2 \text{Gr3.Avg.Lag2}_{it} \\ & + \beta_3 \text{Per.Pupil.Exp}_{it} + \beta_4 \text{Econ.Disadv.Per}_{it} \\ & + \beta_5 \text{T.Avg.Sal}_{it} + \beta_6 \text{T.Avg.Exp}_{it} \\ & + \beta_7 \text{Gr5.Class.Size}_{it} + \epsilon_{it} \end{aligned}$$

### 4.3 Across districts, one time period

A simple linear model for performance in 2006:

$$\begin{aligned}\text{Gr5.Avg}_{ij} = & \beta_0 + \beta_1 \text{Gr4.Avg.Lag1}_{ij} + \beta_2 \text{Gr3.Avg.Lag2}_{ij} \\ & + \beta_3 \text{Per.Pupil.Exp}_{ij} + \beta_4 \text{Econ.Disadv.Per}_{ij} \\ & + \beta_5 \text{T.Avg.Sal}_{ij} + \beta_6 \text{T.Avg.Exp}_{ij} \\ & + \beta_7 \text{Gr5.Class.Size}_{ij} + \epsilon_{ij}\end{aligned}$$

### 4.4 Across districts, panel

This linear model utilises all our data.

$$\begin{aligned}\text{Gr5.Avg}_{ijt} = & \beta_0 + \beta_1 \text{Gr4.Avg}_{ijt-1} + \beta_2 \text{Gr3.Avg}_{ijt-2} \\ & + \beta_3 \text{Per.Pupil.Exp}_{ijt} + \beta_4 \text{Econ.Disadv.Per}_{ijt} \\ & + \beta_5 \text{T.Avg.Sal}_{ijt} + \beta_6 \text{T.Avg.Exp}_{ijt} \\ & + \beta_7 \text{Gr5.Class.Size}_{ijt} + \epsilon_{ijt}\end{aligned}$$

where  $\epsilon_{ijt} = \alpha_i + \mu_j + v_{ijt}$  and

$$v_{ijt} \sim \mathcal{N}(0, \sigma^2) \text{ for all } i, j, t.$$

That is our errors are composed of time-invariant, campus-level and district-level heterogeneity and an idiosyncratic error.

## 5 Data

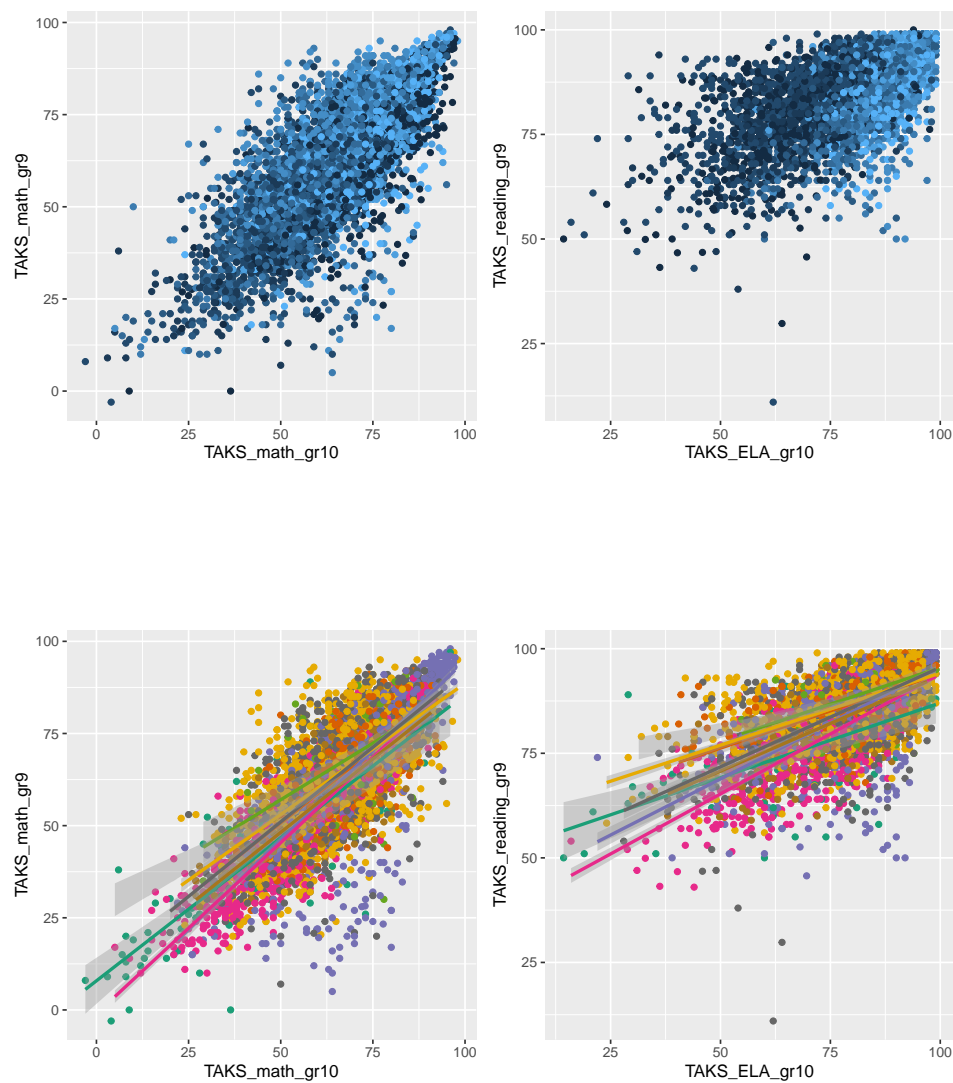
Fixed effects is likely not to be appropriate in the presence of time trends.

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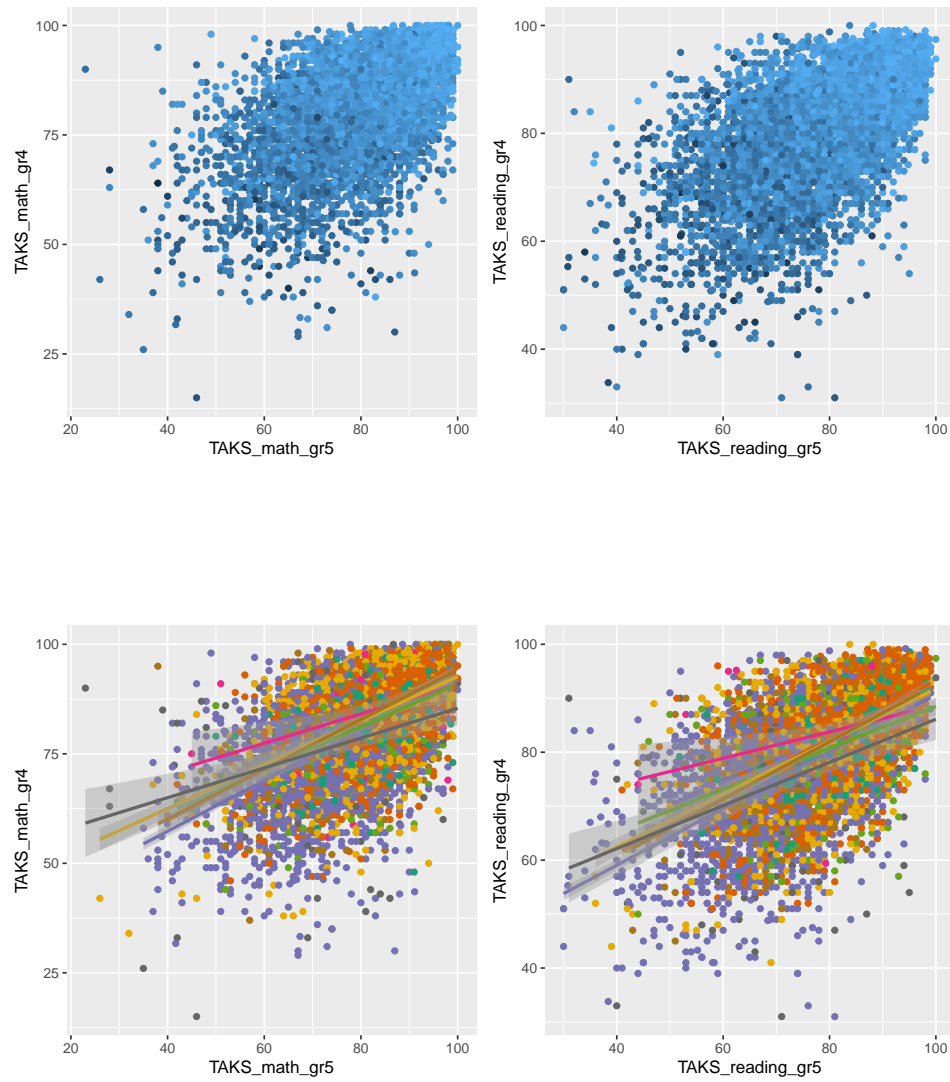
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## **6 Results**

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Table 1: Dependent Variable - Gr10 English Score

	(1)	(2)	(3)	(4)	(5)	(6)
Gr9 Eng Lag	0.684*** (37.29)	0.319*** (14.25)	0.229*** (13.26)	0.119*** (3.84)	0.173*** (4.47)	0.308*** (5.58)
Per Pupil Exp	0.000445*** (3.68)	0.00229*** (11.82)	0.000780*** (5.57)	0.000844** (2.69)	0.000423 (1.10)	0.00161*** (3.46)
Perc Econ Disadv	-0.0319*** (-4.31)	0.476*** (22.72)	-0.0543** (-3.23)	0.00666 (0.28)	-0.164*** (-4.01)	-0.108 (-1.85)
T Avg Sal	0.000320*** (7.46)	0.000280*** (3.36)	0.000273*** (4.38)	0.000853*** (5.35)	0.000861*** (3.79)	0.000460 (1.67)
T Exp	-0.224*** (-3.63)	-0.868*** (-7.78)	-0.391*** (-5.12)	-0.900*** (-5.07)	-1.014*** (-4.47)	-0.554 (-1.89)
Class Size	-0.173*** (-4.57)	-0.428*** (-8.67)	-0.135*** (-3.86)	-0.0709 (-1.13)	-0.124* (-2.17)	-0.173 (-1.68)
Constant	15.35*** (6.03)	25.64*** (6.80)	44.84*** (14.83)	37.67*** (5.52)	34.10*** (3.48)	32.41** (2.85)
year fe	No	No	Yes	Yes	Yes	Yes
N	6641	6641	6641	1251	981	639
fe	No	Yes	Yes	Yes	Yes	Yes
(1),(2),(3) - Whole Sample						
(4) - Suburban Areas, Major Cities						
(5) - Urban Areas, Major Cities						
(6) - Rural Areas						

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	(1)	(2)	(3)	(4)	(5)	(6)
Gr9 Math Lag	0.628*** (72.52)	0.460*** (45.41)	0.321*** (30.81)	0.242*** (12.79)	0.330*** (11.99)	0.357*** (11.30)
Per Pupil Exp	0.000352*** (3.42)	0.00207*** (13.17)	0.00112*** (7.28)	0.000593 (1.69)	0.00264*** (6.33)	0.00151** (2.92)
Perc Econ Disadv	-0.102*** (-15.88)	0.0581*** (3.46)	-0.105*** (-5.69)	-0.118*** (-4.33)	-0.262*** (-5.84)	-0.224*** (-3.48)
T Avg Sal	0.000416*** (11.08)	0.000754*** (11.12)	0.0000932 (1.36)	0.00105*** (5.87)	0.000891*** (3.61)	0.000804** (2.64)
T Exp	-0.137** (-2.58)	-0.629*** (-6.94)	-0.160 (-1.91)	-0.799*** (-4.01)	-0.758** (-3.05)	-1.131*** (-3.48)
Math Class Size	0.0111 (0.35)	-0.275*** (-7.01)	-0.128*** (-3.56)	-0.0692 (-1.07)	-0.125* (-2.12)	-0.0805 (-0.90)
Constant	14.04*** (8.62)	4.529 (1.61)	47.98*** (16.21)	28.13*** (3.96)	17.51 (1.76)	34.66** (3.04)
year fe	No	No	Yes	Yes	Yes	Yes
N	6641	6641	6641	1251	981	639
fe	No	Yes	Yes	Yes	Yes	Yes
(1),(2),(3) - Whole Sample						
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Table 1: Dependent Variable - Gr5 English Score

	(1)	(2)	(3)	(4)	(5)	(6)
Gr4 Eng Lag	0.376*** (34.74)	0.222*** (20.93)	0.259*** (24.38)	0.253*** (13.61)	0.231 (1.75)	0.268*** (7.13)
Gr3 Eng Lag2	0.177*** (13.85)	0.0660*** (5.32)	0.0294* (2.43)	0.0318 (1.56)	0.107 (0.70)	0.0458 (1.16)
Per Pupil Exp	0.00101*** (8.98)	0.000318* (2.02)	0.000458** (2.75)	0.000712* (2.21)	0.00311 (1.46)	0.000209 (0.39)
Perc Econ Disadv	-0.183*** (-38.29)	-0.177*** (-11.07)	-0.173*** (-11.01)	-0.279*** (-7.06)	0.227 (1.07)	-0.157** (-2.79)
T Avg Sal	0.000471*** (21.01)	0.000991*** (28.46)	0.0000275 (0.34)	0.0000891 (0.56)	-0.00337** (-2.85)	-0.000167 (-0.58)
T Exp	0.0170 (0.50)	-0.580*** (-8.71)	-0.0203 (-0.25)	-0.106 (-0.63)	0.394 (0.34)	0.230 (0.94)
Class Size	-0.100*** (-5.50)	-0.0601** (-3.26)	-0.0544** (-3.10)	-0.0816* (-2.07)	0.123 (0.60)	-0.189** (-3.07)
Constant	21.14*** (13.06)	29.37*** (15.44)	62.72*** (19.45)	65.87*** (9.89)	149.1*** (3.67)	68.45*** (5.96)
year fe	No	No	Yes	Yes	Yes	Yes
N	8566	8566	8566	2772	81	720
fe	No	Yes	Yes	Yes	Yes	Yes
(1),(2),(3) - Whole Sample						
(4) - Suburban Areas, Major Cities						
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Table 1: Dependent Variable - Gr5 Math Score

	(1)	(2)	(3)	(4)	(5)	(6)
Gr9 Math Lag	0.420*** (40.69)	0.270*** (25.92)	0.258*** (24.01)	0.248*** (13.29)	0.344* (2.46)	0.247*** (6.54)
Gr3 Math Lag2	0.0477*** (4.93)	-0.0370*** (-3.79)	0.00725 (0.71)	-0.0153 (-0.87)	0.0999 (0.65)	0.0182 (0.51)
Per Pupil Exp	0.0000859 (0.72)	-0.000733*** (-4.27)	0.000396* (2.14)	0.0000787 (0.22)	0.00163 (0.67)	0.00127* (2.10)
Perc Econ Disadv	-0.129*** (-26.79)	-0.140*** (-7.94)	-0.108*** (-6.16)	-0.245*** (-5.59)	-0.122 (-0.52)	-0.120 (-1.88)
T Avg Sal	0.000279*** (11.58)	0.000580*** (14.76)	0.000200* (2.23)	0.000345 (1.96)	-0.00198 (-1.48)	0.000104 (0.32)
T Exp	-0.0510 (-1.41)	-0.284*** (-3.90)	-0.125 (-1.40)	-0.334 (-1.79)	-0.00574 (-0.00)	-0.0616 (-0.22)
Class Size	-0.110*** (-5.66)	-0.116*** (-5.77)	-0.108*** (-5.52)	-0.174*** (-3.99)	-0.0684 (-0.29)	-0.150* (-2.16)
Constant	41.98*** (28.26)	56.10*** (29.23)	62.53*** (18.08)	71.69*** (9.97)	123.8** (2.96)	65.64*** (5.14)
year fe	No	No	Yes	Yes	Yes	Yes
N	8566	8566	8566	2772	81	720
fe	No	Yes	Yes	Yes	Yes	Yes

(1),(2),(3) - Whole Sample

(4) - Suburban Areas, Major Cities

(5) - Urban Areas, Major Cities

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## 7 Estimation Strategy

Fixed effects is likely not to be appropriate in the presence of time trends.

### 7.1 Non-Linear Models

GMM estimation.

### 7.2 Dynamic Panel Model

Small T (9), large N (957).

## References

- [1] Michel Goossens, Frank Mittelbach, and Alexander Samarin. *The L<sup>A</sup>T<sub>E</sub>X Companion*. Addison-Wesley, Reading, Massachusetts, 1993.
- [2] Albert Einstein. *Zur Elektrodynamik bewegter Körper*. (German) [*On the electrodynamics of moving bodies*]. Annalen der Physik, 322(10):891–921, 1905.
- [3] Knuth: Computers and Typesetting,  
<http://www-cs-faculty.stanford.edu/~uno/abcde.html>