

THE SOCIO-ECONOMIC GRADIENT IN CHILDREN'S TEST-SCORES - A  
COMPARISON BETWEEN THE U.S. AND DENMARK

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# The Socio-Economic Gradient in Children's Test-Scores

## - A Comparison Between the U.S. and Denmark

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### Abstract

This paper contributes to the debate on intergenerational mobility in the U.S. and Denmark by linking parental resources to differentials in cognitive development as they develop through primary and lower secondary school in each country. Using U.S. survey data and Danish register data, we observe a socio-economic gradient along the entire test score distribution in both countries, but the gradient is always largest in the U.S. The test-score difference between the above and below median household income groups at school entry is about 20 percent larger in the U.S. compared with Denmark. Our findings show that a substantial socio-economic test-score gradient is present even in a Scandinavian welfare state with universal child policies. However, in light of the recent debate on similarities in intergenerational mobility between Denmark and the U.S., it is important to note that the socio-economic gradient in test-scores is smaller in Denmark compared with the U.S.

## 1 Introduction

Despite considerable differences in the institutional setting between Denmark and the U.S., recent debates (Thompson, 2016; O'Brien, 2016) have questioned whether the re-

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relationship between parents' resources and children's outcomes differ substantially between the two countries. With comprehensive redistributive policies in place in Denmark, as well as social protection schemes and close to universal pre-school programs, it may seem counter-intuitive for social mobility to remain the same as in the U.S. Nonetheless, inter-generational mobility in gross wages, wealth, and educational attainment have of late been shown to be similar, with the latter possibly reflecting lower incentives to pursue higher education (Landersø and Heckman, 2016).

Whether social mobility in terms of educational attainment is in fact similar in the two countries is controversial. Tom Hertz and colleagues argue that studies of changes in the inter-generational transmission of educational inequality (IGTEI) are very sensitive to the measure used to capture this transmission (Hertz et al., 2007). In particular, they show that the past 50 years have seen a marked decrease in IGTEI globally if explored by comparing the magnitude of coefficients from a regression of children's educational attainment on parental educational attainment, but has been strikingly static if explored through correlation coefficients between parents' and children's educational attainment. Whether or not the relative variance of parents' and children's education is taken into account is equally important for comparing IGTEI between countries. In the case of the U.S. and Denmark, regression coefficients have the IGTEI to be slightly higher in Denmark compared with the U.S. while it is much lower in Denmark if gauged by correlation coefficients.

Educational attainment as an outcome summarizes a broad set of factors and processes that determine a young person's educational career. The socio-economic situation of the home environment may play a decisive role in determining which opportunities children will find open to them within the educational system and in shaping their educational choices. Within the Sociology of Education, a useful distinction is made between the *primary effects* of parents' economic and educational resources that translate into differentials in educational achievement and cognitive development for

the child, and the *secondary effects* which are expressed through differentials in choices (see Jackson et al., 2007). A rich literature has for many years explored the mechanics of these effects, highlighting the role of teacher's perceptions of pupils (Alexander et al., 1987; Papageorge et al., 2016), the efficacy of investments in children's cognitive development before and outside of the educational system (Heckman, 2006), the role of aspirations and expectations of children and their significant others (Eriksson and Jonsson, 1996), and the differing degrees of direct influence that parents exert on the day-to-day operations at the school level (Booth and Dunn, 1996), among other themes.

While arguing that the IGTEI is similar in Denmark and the U.S., Landersø and Heckman (2016) also note that there are notable differences in PISA test-score distributions across these two countries. The lowest proficiency level covers a considerably larger share of the population in the U.S. compared with Denmark. Esping-Andersen (2004) has shown a similar difference for the adult population using data from the International Adult Literacy Survey (IALS). Such results suggest that those children most at risk of falling out of the educational system stand a better chance in the institutional setup in Denmark. At the same time, differences in children's cognitive development and academic achievement remain to be linked to parental resources in each country such that a clearer picture of how the primary effects coincide or differ might be painted. As the justification of active social policies tends to build on a notion of fairness as equality of opportunity, the primary effects of parental resources stand out as a key aspect of IGTEI by which to judge their efficacy.

The objective of this paper is to explore the link between academic achievement<sup>1</sup> and parental resources more carefully in the U.S. and Denmark. Using data from the Early Childhood Longitudinal Study (ECLS-K) for the U.S. and administrative register data from Denmark we provide three sets of comparative findings: First, we find that

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<sup>1</sup>Throughout this paper we treat cognitive skills as interchangeable with academic achievement as expressed in standardized test scores

the above-below median household income difference in reading test scores is 17 (14) percentile rank scores in the U.S. (Denmark) at school entry, and 22 (15) in grade eight. The pattern for the test score gap with respect to college/no-college educated parents is very similar. Second, we provide percentile-percentile plots that show a socio-economic gradient along the entire test score distribution. The gradient is always largest in the U.S. The median test score among the low income children corresponds to the 18th percentile among the high income children in the U.S. and the 25th percentile in Denmark. Third, we show that the parental-income and child test score relationship is considerably steeper in the US than in Denmark. The test score difference between the highest and lowest income groups at school entry is about 50 percent larger in the U.S. than in Denmark. To evaluate whether our findings are driven by differences in the tests used in the two countries, we use data from the PISA 2012 that provides assessments that are designed to be directly comparable across countries and replicate some of our main findings.

This paper contributes to the literature on international comparisons of socio-economic gradients in test-scores (see e.g., Bradbury et al., 2015) by focusing on differences along both the test-score and parental income distributions, from school entry to around age 14. Moreover, we are, to the best of our knowledge, the first to provide a comparison between the U.S. and Denmark; two countries that have been used as contrasting examples and caused the debate on the "Scandinavian Fantasy" (Landersø and Heckman, 2016; Thompson, 2016; O'Brien, 2016). The studies most similar to ours are Jerrim (2012), Beuchert and Nandrup (2014), and Bradbury et al. (2015).<sup>2</sup> Jerrim (2012) assesses the socio-economic gradient along the test score distribution for six countries (including the U.S. but not including Denmark) using PISA data. Bradbury et al. (2015) use the same data for the U.S. as we do, the ECLS-K survey, to show the mean test score gap

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<sup>2</sup>There is a rich literature both within sociology and economic about intergenerational mobility. For a review of this literature see e.g. Black and Devereux (2011)

by parental background for the U.S. and Beuchert and Nandrup (2014) use the same data for Denmark, as we do, data from the National Tests, to show the mean test score gap in Denmark. While both Beuchert and Nandrup (2014) and Bradbury et al. (2015) also consider the socio-economic test score gap from school entry to age 14, they both focus on mean comparisons. Jerrim (2012) on the other hand looks at the gap along the test score distribution, but using only outcomes at age 15 (and not including Denmark). In contrast, the objective of this paper is to assess the socio-economic gradient throughout grade school along both the income and test score distributions in a comparison between Denmark and the U.S.

In the next section we briefly describe the data sources and empirical strategy. In section three we show the three sets of results: The mean test-score gap in Denmark and the U.S.; the test-score gap along the test distribution; and the test-score gradient along the parental income distribution. In section four we conclude this paper with a brief discussion.

## **2 Data and Empirical Strategy**

### **2.1 Data**

As the objective of this paper is to assess how the development of cognitive skills in primary school relate to parental background in the U.S. and Denmark, we need data from both countries that satisfy two conditions: One, the datasets should include assessments of children's cognitive abilities at several points in childhood. Two, the datasets should contain information on parental background. For the U.S. we use data from the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K). For Denmark we use test score data from the Danish Ministry of Education linked to administrative registers on parental background from Statistics Denmark. We briefly describe

these two datasets in the following two sections.<sup>3</sup>

### **2.1.1 US: ECLS-K**

The ECLS-K is a longitudinal survey by the U.S. National Center for Education Statistics (NCES). The gross survey consists of almost 20,000 children who began kindergarten in the fall of 1998. The children were surveyed in kindergarten, grade one, three, five, and eight. While the survey consists of a wide range of detailed information about the children, their families and the schools, we here focus on the children's reading test scores and the parents educational background and the household income. Both parental education and household income is measured when the children are in grade one (i.e. about six to seven years old). For education we focus on the college/no-college gradient, and for income we both evaluate the median split and the gradient by the provided income groups (-5,000 USD, 5,001-10,000 USD, and so on, it total 13 groups). It is worth noting that the panel is not balanced. While almost 15 thousand completed the reading assessment in grade 1, less than nine thousand completed the assessment in grade eight. We apply the ECLS-K cross-sectional weights to make the sample representative for the cohort of children starting kindergarten 1998-99. As Appendix Table A.1 reveals, the final sample consists of between 8,727 and 15,425 children for each grade level.

### **2.1.2 DK: Administrative Register Data**

For Denmark our point of departure is the Danish National Test in reading (Danish), which is a mandatory assessment in Danish public schools. These tests are taken in grades 2, 4, 6, and 8. We link the test data to administrative registers to obtain information about parental background. The parents' educational background and income are measured when the child is six years old. To make the dataset comparable to the U.S.

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<sup>3</sup>For the development of the mean test score difference, we focus on reading test scores. We have also run the analyses using math test scores. The results are qualitatively similar, but the mathematics data only contains two measurement points, namely in 3rd and 6th grade. These results are available on request.

data, we also focus on the college/no-college gradient as well as the median household income split. We also create 13 income groups that are designed to have the same distribution as the U.S. group (i.e. 3. percent of the population is in the first group in both populations, and so on). The final sample consists of approx. 250,000 children for each grade level (see Appendix Table A.1).

### **2.1.3 Data caveats**

For the U.S. we apply a large scale survey and for Denmark we use administrative registers. It is important to mention several caveats that pertain to this data. First, the selection into the datasets is potentially very different in the two countries. While the U.S. data suffers from the usual attrition issues of survey data, the Danish data is based on mandatory tests that only cover public schools (approximately 80% of a cohort). In Appendix Figure A.1 we assess the importance of this sample selection in Denmark. As we have information on the ninth grade GPA for the entire cohort, we can compare the distribution of GPA for children in our sample to the distribution for children not included. In all analyses we therefore weight the observations based on the relative representation (compared to the birth cohort) within each cell, where the cells are defined by parental income percentile and education (college/no college).

Secondly, the Danish data is considerably newer than the U.S. sample. While the children in the ECLS-K are on average born in 1993, the children in the Danish data are on average born in the year 2000. To assess the stability of the gaps over time, Appendix Figure A.2 shows the gap in the ninth grade GPA for children born 1986 to 1996. We do not observe signs of notable changes over time.

Thirdly, as we use test-scores from different tests in the two countries, differences in the socio-economic gradient could stem from differences in the tests. To assess this issue we replicate the main findings using PISA data in section 3.3.

Finally, while the U.S. data is longitudinal the Danish data consists of several birth



cohorts measured at several points in time between 2010 and 2014. In the Danish data we are able to follow the same birth cohorts from 2nd through 6th grade or from 4th through 8th grade. Figures based on this subset of the data are consistent with results using the full dataset.

## 2.2 Empirical Strategy

Comparing test scores across tests and countries is challenging because the underlying test distributions may differ. The distance between test scores in one test may vary considerably from distances using a different test. To assume cardinal comparability may therefore be unfeasible. Instead, we focus on ordinal differences by comparing percentile ranks.<sup>4</sup> Percentile ranks are computed for each subject at each test time separately for each country. In this way, rather than indicating a specific test result, the percentile scores indicate a location in the distribution of test achievements at a particular point in time.

We use these percentile ranks in three ways. First, we show how the mean percentile ranks differ in the U.S. and in Denmark between children conditional on parental income and education in grades 0 through 8. This provides an intuitive measure of the mean inequality. Second, to explore the distributions behind these means we compute percentile-percentile plots (see also Nielsen, 2015). For a given percentile rank in the group of children of non-college educated parents (below median income households) we calculate the share of children of college educated parents (above median income households), who obtain the same or a lower raw test score. For example, given that the 20th percentile in the non-college group achieved a test score of  $\bar{y}$ , what fraction in the college group scored at most  $\bar{y}$ ? If the test performance is unrelated to whether

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<sup>4</sup>Note that focusing on ordinal ranking does not completely solve the issue of non-comparability across tests. It may still be that differences in ranks across socio-economic groups arise because the tests measure different abilities with differing social gradients. We address this issue by replicating our main findings using the PISA 2012 data.

the parent's have a college degree (above median income), we would expect the fractions to be the same and the relationship to be a 45 degree line. These plots mimic the intuition of a Lorenz-curve and by calculating pseudo-gini coefficients we achieve a measure of the inequality over the full distribution. Third, we split the parental income into thirteen income groups and calculate the mean percentile rank within each income group in each country to compare the income gradient.

### 3 Results

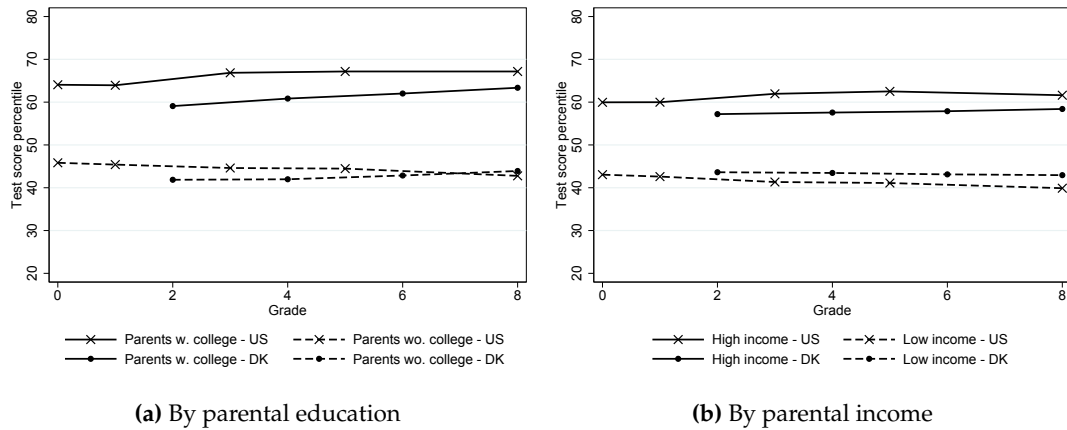
#### 3.1 The development of the test score gap

We first replicate the findings by Beuchert and Nandrup (2014) and Bradbury et al. (2015) by showing differences in test-score means across groups. In Figure 1a we show the mean test score for both children of college-educated parents and children of parents with at most a high school degree. In the U.S. (Denmark) the gap between these two groups of children is 18 (17) percentile ranks in grade zero (two). While the gap widens considerably in the U.S. to grade eight (to 24 percentile ranks), the increase in the gap is much smaller in Denmark (to 19 percentile ranks). Throughout all grades, the gap in means is largest in the U.S.

If we split the sample by household income, the gap in reading test scores is 17 (14) percentile ranks in the U.S. (Denmark) at school entry (i.e. grade zero and grade two, respectively), and 22 (15) percentile ranks in grade eight. These findings are in line with the findings of Bradbury et al. (2015) for the U.S. and Beuchert and Nandrup (2014) for Denmark.<sup>5</sup>

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<sup>5</sup>Note however that both Bradbury et al. (2015) and Beuchert and Nandrup (2014) apply slightly different educational groupings.



**Figure 1:** The reading test score gap in the US and Denmark

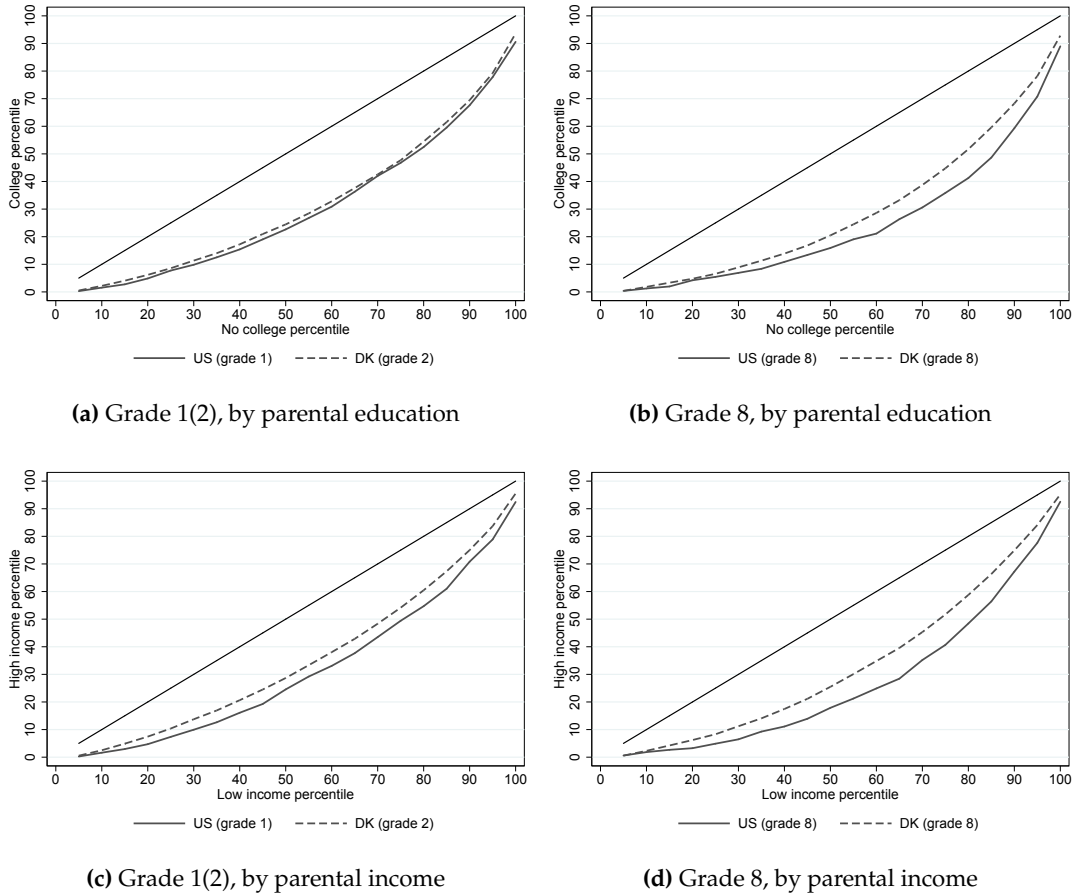
Notes: The test score is computed into a percentile rank in both countries. The high/low income split corresponds to above/below median income. For the U.S. income is household income, for Denmark income is the sum of father and mother's net income.

### 3.2 Percentile-percentile plots

The mean comparisons provide a useful first overview of the differences between the two countries and clearly links this paper to previous studies. Meanwhile, mean differences may be caused by specific parts of the test score distribution. It could for example be the case that all differences in mean test scores are driven by the lower tail of the test score distribution, i.e. that we observe many more students from the low resource group in the lower tail of the test score distribution in the U.S., while we observe equally many students from both groups in the other end of the distribution.

Figure 2 shows percentile-percentile plots for Reading in both countries by parental income and education. The test score of the tenth percentile in the no-college group in the U.S. (Denmark) corresponds to the first (second) percentile test score in the college-educated group in grade one (two). Focusing on the below vs. above median household income gap, the median test score among the low income children corresponds to the 25th percentile among the high income children in the U.S. and the 18th percentile in

Denmark (in grade 8). Across grades and parental characteristics, we observe that the dashed line closer to the 45-degree line along the entire distribution, suggesting that the socio-economic gradient is always smaller in Denmark compare with the U.S.



**Figure 2:** Percentile - Percentile Plots for Reading

Notes: The high/low income split corresponds to above/below median income. For the U.S. income is household income, for Denmark income is the sum of father and mother's net income. For both countries the percentile-percentile plots are calculated on ten percentile rank intervals. For both countries the percentile-percentile plots are calculated on ten percentile rank intervals. For the U.S. the reading test score is from grades 1 and 8. For Denmark is the reading test score is from grades 2 and 8.

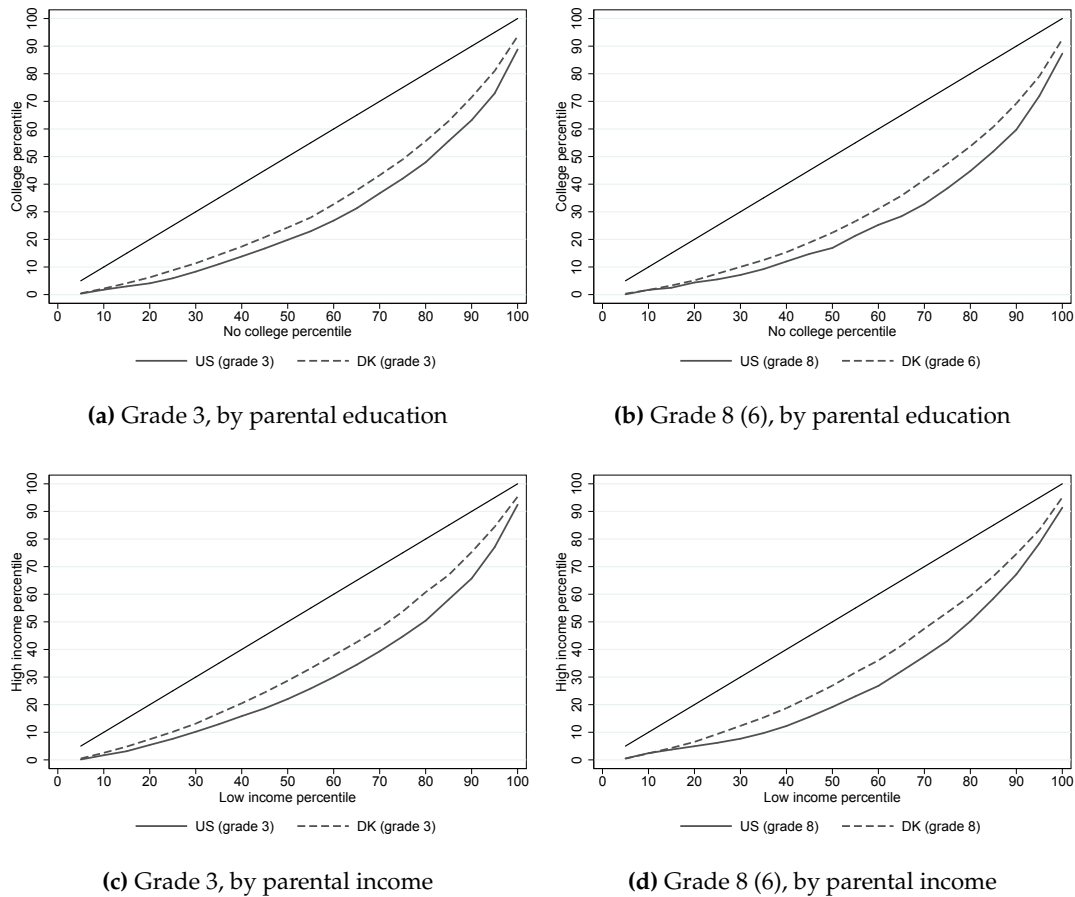
The differences between the two countries are slightly clearer when focusing on the socio-economic gradient along the test score in mathematics, as Figure 3 shows.

The median test score among the low income group corresponds to the test score of the 20th (29th) test score in the high income group in the U.S. (Denmark), in grade 3. These percentile-percentile plots show that the socio-economic gradient in test scores is observed in both tails: At the lower end of the test score distribution in grade 3, the test score of the 10th percentile for children of parents with an income below the median, corresponds to the test score of the 1.6th (2.4th) percentile among children of parents with an income above the median in the U.S. (Denmark). At the other end of the test score distribution in grade 3, we observe that the low-income group's 90th percentile test score corresponds to the test score of the 68th (75th) percentile in the high income group in the U.S. (Denmark).

As the 45 degree lines in Figure 2 correspond to perfect equality, we can quantify the degree of inequality by calculating the share of the area between the 45 degree lines and the graphs relative to the full area below the 45 degree line. I.e. Pseudo Gini Coefficients, where a lower coefficient indicates a greater degree of equality. We calculate the size of the area by a linear approximation for each 10 percentile point interval on the x-axis. The coefficients are shown in Table 1. As expected based on the visual inspection, the inequality is larger in the U.S. than in Denmark. As the graph suggests, the difference is especially pronounced when we split the groups by parental income. Focusing on parental education, we find that the pseudo Gini coefficient is 20 (31) percent larger in reading (mathematics) in the U.S. than in Denmark in grade 8.

### **3.3 Percentile-percentile plots based on PISA 2012**

In light of the data caveats mentioned previously, we assess the robustness of our results using data from The Programme for International Student Assessment (PISA). The PISA is a worldwide survey among 15 year old school children conducted by the Organisation for Economic Co-operation and Development (OECD). The PISA data includes an assessment of competencies that is designed to be comparable across coun-



**Figure 3:** Percentile - Percentile Plots for mathematics

Notes: The high/low income split corresponds to above/below median income. For the U.S. income is household income, for Denmark income is the sum of father and mother's net income. For the U.S. the mathematics test score is from grades 3 and 8. For Denmark the mathematics test scores are from grades 3 and 6.

tries. In contrast to the ECLS-K and the Danish National Data, the PISA data only contains an assessment at the end of compulsory schooling. Moreover, for Denmark and the U.S. the information on parental background is relatively limited in the publicly available PISA data. Given the advantages (comparability across countries) and the disadvantages (no assessment at young ages and limited parental background information), the PISA constitutes a good supplement to the main data.

**Table 1:** Pseudo Gini coefficients

	--- US ---		--- DK ---	
	Edu	Inc	Edu	Inc
<i>A. Reading</i>				
Grade 1 (2)	0.42	0.40	0.39	0.32
Grade 8	0.53	0.48	0.44	0.36
<i>B. Mathematics</i>				
Grade 3	0.47	0.45	0.38	0.32
Grade 8(6)	0.51	0.46	0.39	0.32

Edu refers to the difference between children of college educated parents and children of parents with no college degree. Inc refers to the difference between above/below median income.

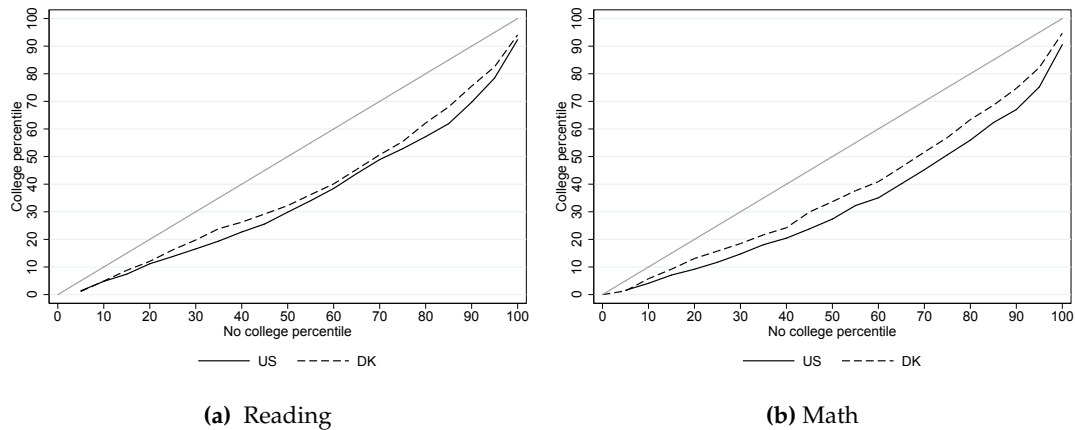
We use the publicly available version of the PISA 2012 (children born around 1997) and focus on the reading and mathematics tests. We are only able to divide the children into groups by educational background, as information on parental income is not available. Compared with the main data, the socio-economic gradient along the test score distribution is slightly smaller when using the PISA data, but especially in mathematics, the difference between the U.S. and Denmark is similar, as Figure 4 shows.

Table 2 presents the Pseudo Gini coefficients based on PISA 2012 data. As the graphical inspection indicated, the test score inequality is somewhat smaller in the PISA data. However, the relative difference between the U.S. and Denmark is actually slightly larger with the PISA data compared to the main data. The pseudo Gini coefficient is 24 (34) percent larger in reading (mathematics) in the U.S. compared with Denmark, when using the PISA data.

**Table 2:** Pseudo Gini coefficients based on PISA data

	US	DK
Reading	0.32	0.26
Mathematics	0.35	0.26

Notes: Data is from the public use PISA files (see description above).



**Figure 4:** Percentile - Percentile Plots for the US and Denmark based on PISA data

Notes: Data is from the public use PISA files. For the reading score we use the variable PV1READ and for mathematics we use the variable PV1MATH. Parental education is defined by the variable hisced, where the no-college group covers values 0-5 (ISCED 1-5B) and the college group is defined by value 6 (ISCED 6 and 5A). All observations are weighted using the variable W\_FSTUWT.

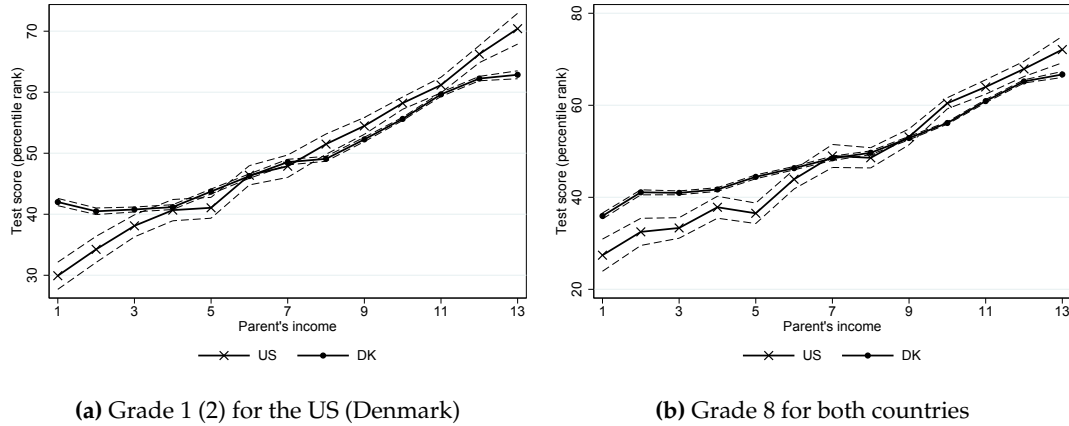
To sum up, using the PISA 2012 data we find differences between countries in test score inequality, that are qualitatively similar to the differences we find using the ECLS-K survey data (for the U.S.) and the Danish National Test data (for Denmark).

### 3.4 The income gradient

So far we have focused on two groupings, parents with college vs. without college and above vs. below median household income. To explore the gradient along the distribution of parental resources, we present the mean test score by household income group in Figure 5. Both at school entry (grade one and two, respectively) and in grade 8 we observe that the income gradient is considerably steeper in the U.S. than in Denmark. In other words, moving from one income bin to the next is associated with a greater difference in test scores in the U.S. than in Denmark. Especially in the lower and the higher bins the difference between the two countries is striking. The children in the lowest income groups do considerably worse in the U.S. than in Denmark, and vice



versa at the high income group. The test score difference between the highest and lowest income groups at school entry is about 50 percent larger in the U.S. compared with in Denmark.



**Figure 5:** Parental income and children's test score in reading

Notes: The test score is the percentile rank in both countries. The x-axis shows the 13 income groups given by the ECLS-K data. The first group covers the first 3.09 percent of the population. The following groups cover respectively 4.12, 7.27, 7.78, 7.27, 9.12, 5.80, 7.40, 9.41, 18.30, 9.78, 8.33 and 2.33 percent of the distribution. The median split is at group eight. Results for mathematics are very similar and available on request.

## 4 Discussion

In this paper we provide a comparison of the socio-economic gap in test-scores at grades zero to eight for the U.S. and Denmark. For both countries we observe a considerable gap at school entry, but the gap is much wider in the U.S. than in Denmark. Further, the gap seems to widen considerably more through grade school in the U.S. than in Denmark. Assessing the gap along the test score distribution confirms the mean comparisons. Children's test score attainment is much closer related to parental income and education in the U.S. than in Denmark. The difference is especially pronounced when focusing on parental income. When looking across the income distribution, the income

gradient in the U.S. stands out as somewhat steeper than in Denmark. The test score difference between the highest and lowest income groups at school entry is about 50 percent larger in the U.S. than in Denmark.

As a comparative analysis, the study involves a number of limitations. First, the socio-economic significance of a college degree may vary between the two countries. As a measure of parental resources, it may not indicate a difference in the same way. Second, in ECLS-K the reported household income does not specify whether it is gross or net income. In the Danish data we have access to both gross and net income and the results are qualitatively unchanged by choice of income definition. Third, the two data sources present each their set of potential selection issues. In the Danish data, only children enrolled in public schools are selected while the U.S. data suffers from the typical survey challenges, non-response and attrition. However, using data from the PISA 2012 that provides assessments that are comparable across countries, we find a qualitatively similar difference in the test score inequality between the U.S. and Denmark.

Our findings show that school test performance is clearly related to parental resources in both Denmark and the U.S., but less so in the former. In other words, inequalities in opportunities in terms of differences in cognitive abilities are smaller in Denmark than in the U.S. This does not necessarily translate into a greater degree of social mobility for several reasons. First, children's test scores are only one measure of opportunity, which might differ substantially from actual opportunities as perceived by children themselves. Second, the child's choices and the institutional setting in post compulsory schooling might affect how these opportunities are realized. Nonetheless, equality of opportunities in terms of school performance may very well be an important social aim in itself.

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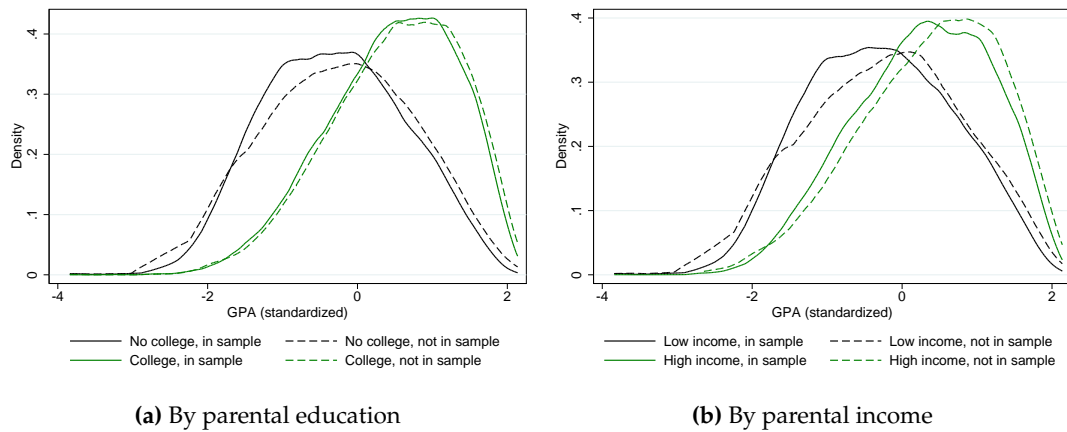
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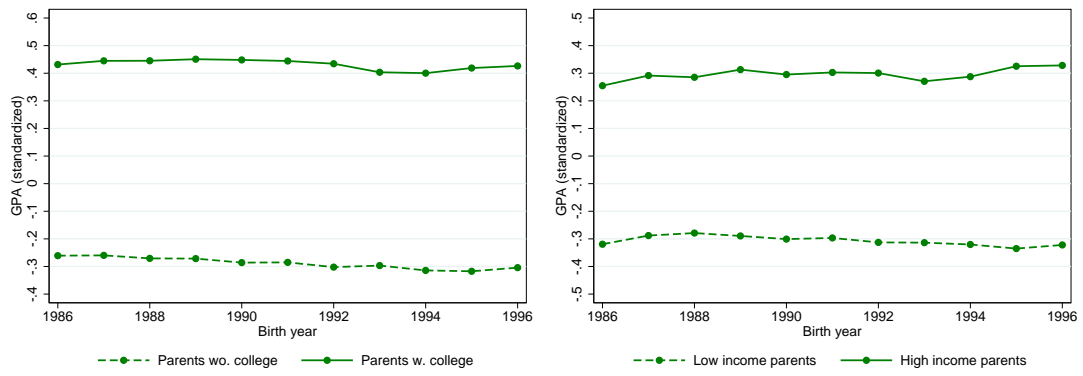
# Appendices

**Table A.1:** Observations in the U.S. and the Danish sample

	US	DK
	N	N
Testscore (reading), grade 0	14,888	
Testscore (reading), grade 1	14,977	
Testscore (reading), grade 2		266,933
Testscore (reading), grade 3	13,074	
Testscore (reading), grade 4		267,074
Testscore (reading), grade 5	10,408	
Testscore (reading), grade 6		267,874
Testscore (reading), grade 8	8,727	249,088
Testscore (math), grade 0	15,425	
Testscore (math), grade 1	15,250	
Testscore (math), grade 3	13,156	268,182
Testscore (math), grade 5	10,416	
Testscore (math), grade 6		267,467
Testscore (math), grade 8	8,782	



**Figure A.1:** Selection, Danish sample



(a) By parental education

(b) By parental income

**Figure A.2:** Test score GAP, 9th grade GPA by birth year