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Robert Bauchmüller, Mette Gørtz and Astrid Würtz Rasmussen

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AKF, Danish Institute of Governmental Research
Købmagergade 22, DK-1150 Copenhagen K
Phone: +45 43 33 34 00
Fax: +45 43 33 34 01
E-mail: akf@akf.dk
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Long-Run Benefits from Universal High-Quality Pre-Schooling

Robert Bauchmüller[1]
Graduate School of Governance, Maastricht University

Mette Gørtz
AKF, Danish Institute for Governmental Research
SFI, Danish National Centre for Social Research

Astrid Würtz Rasmussen
Dept. of Economics and Business, Aarhus University

Abstract

This paper investigates the role of pre-school quality for children's cognitive development at the end of elementary schooling (age 16). We use a unique dataset based on Danish administrative registers where pre-school children are linked to their pre-school and its pre-school teachers. Based on this, we generate five main quality indicators of pre-schools. Child outcomes are language test scores from final (9^{th} grade) elementary school exams. Controlling for child background factors, we find that a higher number of staff members per child, a higher share of male staff, a higher share of staff with a pedagogic education, and a higher share of teachers with non-Danish ethnic background lead to significant improvements in children's test results in Danish at the end of the 9^{th} grade. Boys benefit more from pre-school quality than girls. We address possible selectivity by using instrumental variables estimation. For two of the quality indicators, i.e. the share of male staff and the share of non-native staff, IV estimates show significant positive effects which are numerically higher than OLS estimates.

Keywords: pre-school, daycare, care quality, male role model, staff-per-child ratio, staff turnover, non-native staff, pedagogic staff, child development, early childhood education (JEL: I21, J13, J24)

[1] Address of correspondence: Maastricht University, Graduate School of Governance, Post-box 616, 6200MD Maastricht, The Netherlands. E-mail: robert.bauchmuller@maastrichtuniversity.nl

Summary

Social science research is increasingly acknowledging the importance of early childhood development in forming children's cognitive and non-cognitive abilities and health. One way of disrupting negative social heritage is to give children from all backgrounds access to high-quality daycare. This paper examines whether preschool quality is important for children's cognitive and language development at the end of elementary school (age 16).

The analysis is based on a unique dataset based on Danish administrative registers where preschool children are linked to their preschool and its preschool teachers. Based on these data, we generate five main quality indicators of preschools: 1) the staff-to-child ratio (number of teachers per child), 2) the share of male staff in the preschool, 3) the share of pedagogically trained staff in the preschool, 4) the share of non-native staff, and 5) the stability of the staff (inverse staff turnover in the attended preschool). Child outcomes are test scores from final (9^{th} grade) elementary school exams.

Our research questions are the following: How much did preschools vary in terms of these five quality measures in the second half of the 1990s? Are individual 9^{th} grade test results in written Danish correlated with these quality measures? Can we establish a causal relationship between the quality of preschool and individual preschool experience?

Controlling for child background factors, we find that a higher number of staff members per child, a higher share of male staff, a higher share of staff with a pedagogic education, and a higher share of non-native staff lead to significant – albeit moderate - improvements in children's test results in Danish at the end of 9^{th} grade.

We also analyze which groups of children benefit mostly – and least – from high-quality daycare. We find evidence that boys benefit more from preschool quality than girls, but the effects are relatively smaller for children from poor households. Moreover, non-native children benefit from a lower staff turnover.

We estimate the model by ordinary least squares estimation (OLS) and instrumental variables estimation. For most quality indicators, IV estimates show significant positive effects, which are numerically higher than OLS estimates.

1. Introduction

Social science research is increasingly acknowledging the importance of early childhood development in forming children's cognitive and non-cognitive abilities and health. Early investments have important multiplicative effects on later development stages and lead to high private and social returns (Cunha, Heckman, Lochner & Masterov 2006). Hence, one way of disrupting negative social heritage is to give children from all backgrounds access to high-quality daycare.

Empirical evidence on the effectiveness of public investments in early childhood care and education is of relevance for policymakers. Do early childhood interventions show the desired effects on children's cognitive and non-cognitive skills – making them ready for school and integrating those who grow up in underprivileged conditions? Esping-Andersen (2006; 2008) argues that the assurance of high-quality daycare could be the single most effective policy of homogenising early childhood investments and reducing inequalities in educational attainment and income.

While many countries have recently started to extend their daycare provisions to cover children at earlier ages, Denmark had extensive daycare provisions already in the 1990s. In 2000, Danish average pre-school enrolment of children aged 3-5 was around 90%. This is at the level of other Nordic countries, lower than in countries with obligatory early schooling, but somewhat above the OECD average enrolment rate of about 70%; see figure A-1 in Appendix A (OECD 2009). In comparison with the OECD average country, Denmark has high quality daycare institutions, high daycare expenditure levels per capita, generous family-friendly schemes, substantial public investments in early childhood provisions, high requirements for staff qualifications, and a low number of children per staff member (OECD 2007). Enrolment in daycare is highly subsidised, reducing the link between parental income and access to daycare.

Despite few evaluation studies on short-term effects of such early childhood care (Datta Gupta & Simonsen 2010; Jensen 2009), there is little evidence of its long-term effects. We provide new evidence for the long-term impact of early childhood investments by studying child outcomes measured by grades from final exams in the 9th grade of elementary school. Moreover, we extend the literature on daycare arrangements in pre-school age by studying whether the variation in various quality aspects can explain some of the variation in later child outcomes. With pre-school we henceforth refer to daycare institutions for 3-6 year-old children. Little is known yet about which pre-school quality characteristics are most beneficial for children, and whether disadvantaged children benefit over-proportionally from high-quality pre-school. To shed some light on the equalisation potential of pre-school attendance, we study the heterogeneity of quality effects across several subgroups of vulnerable children.

Based on an extensive register data set with information on child outcomes (9th grade final exam results), children's pre-school affiliation and the staff in each pre-school institution, we generate the following quality indicators: 1) the staff-to-child ratio, 2) the share of male staff in the pre-school, 3) the share of pedagogically trained staff in the pre-school, 4) the share of non-native staff, and 5) the stability of the staff (inverse staff turnover in the attended pre-school). Using OLS and instrumental variable (IV) analyses, we address the following questions: How much did pre-schools vary in terms of these quality indicators in the second half of the 1990s? Are individual 9th grade test results correlated with these quality measures? Can we establish a causal relationship between the quality of pre-school and individual pre-school experience? When identifying the causal effects of pre-school quality on child outcomes, we use IV analysis. However, it is difficult to find suitable instruments which capture parents' potential selection of pre-school institutions. We test several different instruments in our specifications.

Recently, many countries, including Canada and a few US states, have begun to implement universal daycare in line with the Danish daycare system. The insights gained from evaluating the Danish experience are relevant for countries in the process of implementing and expanding their daycare provisions.

The paper is organised as follows: Section 2 reviews the literature on early childhood interventions. Section 3 describes the data and institutional framework of pre-schooling in Denmark. Section 4 elaborates on our generated quality indicators. Section 5 presents the evaluation methodology used. Section 6 presents our regression results of ordinary and two-stage least square estimations, and Section 7 concludes.

2. Early childhood interventions

Recent research emphasises the importance of early childhood development for long-term outcomes, both cognitive-intellectual and non-cognitive, psycho-emotional and social abilities (Heckman, Stixrud & Urzua 2006). Long-term outcomes are measured at adolescence, e.g. high-school enrolment, crime rates, health, early pregnancies, job aspirations, labour-market success, career outcomes, life expectancy etc. This research suggests that higher stocks of skills in one period create higher stocks of skills in the next period making investment in future periods more productive (Cunha & Heckman, 2007; Heckman 2008). Early childhood is considered a sensitive period for brain development and language acquisition, and early learning is crucial for later learning (Heckman, Krueger & Friedman 2002). Hence, interventions aimed at improving the situation for e.g. disadvantaged children should start as early as possible when the brain structure and synapses are more plastic (Knudsen, Heckman, Cameron & Shonkoff 2006).

Child development in terms of cognitive as well as non-cognitive skills can be formulated in a production function approach where child development depends on current as well as past mode and intensity of care, purchased inputs, and exogenous determinants (production shocks) (Heckman 2008; Ruhm 2005; Todd & Wolpin 2003). There is considerable heterogeneity in child outcomes already in early childhood, and much of this heterogeneity can be explained by environmental factors such as family background (James J. Heckman, 2008). According to Mayer (1997), consumption of goods that are important for children's psychological and material well-being is dependent on parental taste rather than on parental incomes. Investments in better schooling is not necessarily a matter of constrained parental resources but rather a matter of children not being able to acquire a favourable family environment (Cunha et al. 2006). Participation of disadvantaged children in targeted high-quality childcare programmes is particularly beneficial and can be considerably more effective than giving families of disadvantaged children unrestricted cash transfers (Currie 1998).

Previous evaluations of long-term effects of daycare arrangements focus on small-scale programmes targeted at disadvantaged children. These studies are often randomised controlled trials with particular emphasis on identifying causal effects. Some studies suggest that gains from pre-schooling eventually fade out, especially, if continual and sufficient support for children at risk is not assured (Reynolds 1993, 2000), but most studies suggest lasting effects of daycare (see, for example, Barnett 1992, 1995; Nores & Barnett 2009; Vandell et al. 2010). Schweinhart & Weikart (1981) examine the results of the Perry pre-school programme, a longitudinal experiment of an early educational intervention on children at risk. In this study, a group of 65 African American 4-6 year old children were randomly assigned to a pre-school programme. The evaluation of child outcomes at the age of 15 showed that children who had attended the Perry pre-school programme had persistent lower probabilities of needing special education or showing delinquent behaviour, and increased scholastic achievement and motivation for schooling and homework.[2] Another well-known example of randomised social experiments is the Abecedarian programme in Chapel Hill, North Carolina (Campbell et al. 2008). Attendance in the Abecedarian programme produced similar positive effects in particular on cognitive child outcomes at the age of 15.

The literature on the introduction or expansion of universal daycare finds mixed results. Baker, Gruber & Milligan (2008) evaluate a large scale change in the childcare system in Quebec, Canada in the late

[2] Sensitivity analyses by Heckman et al. (2010; 2011) account for compromises that occurred in the randomisation protocol. Still, the benefit estimates of the Perry programme remain statistically significant for both males and females and returns are shown to be above the historical return on equity.

1990s. The authors neatly explore before-after Quebec-versus-other regions variation and find significant negative effects of the transition to a regime with large-scale highly-subsidised childcare on behavioural and motor-social skills. Deming (2009) exploits family-fixed effects to evaluate effects of the more universal pre-school programme of Head Start studying the National Longitudinal Survey of Youth for a recent American child cohort. He finds that Head Start participation improves young adult outcomes (measured by a composite index), in particular for disadvantaged children. Ludwig & Miller (2007) find evidence of positive long-term effects on years of schooling of attending a Head Start programme for children of the poorest counties in the US. They exploit a discontinuity in Head Start caused by a technical assistance to pre-schools of a selected group of counties in 1965. Currie (2000) presents evidence in favour of extending the pre-school programme Head Start to a universal programme which encompasses in particular poor children who benefit over-proportionally from the programme. Looking into the effect of pre-school quality, she argues that especially the teacher-child interaction is important in generating positive effects. Reducing group sizes, improving teacher training and other observable quality aspects that are tangible by policymakers would all make positive interactions more likely.

Felfe & Lalive (2010) use the German Reunification to identify effects of extending centre-based early childcare. They use the slow convergence of previously rather diverse childcare provisions in the different regions in Germany to study the causality, heterogeneity and persistency of effects on cognitive and non-cognitive development. They find positive effects of extending high-quality centre-based care in particular for disadvantaged children on both development domains, lasting at least until the age of 10. Berlinski, Galiani & Gerler (2009) evaluate the large extension of pre-primary education of 1993 in Argentina and find various positive effects on cognitive and behavioural skill development by the time children reach the third grade. An evaluation of the Uruguayan extension of pre-primary education in the mid-1990s by Berlinski, Galiani & Manacorda (2008) shows positive results on school attendance and years of schooling by the age of 15. Havnes & Mogstad (2009, 2010) show that the 1975-introduction of large-scale, publicly subsidised daycare for 3-6-year-old children in Norway has a small and insignificant impact on adult earnings using non-linear difference-in-difference methods. However, they find that the effects are positive across the earnings distribution, in particular below the median. In a subsample analysis they find that girls and children with low educated mothers benefit the most from childcare. Dumas & Lefranc (2010) evaluate the effect of the massive extension of pre-schooling in France in the 1960s and 1970s on long-term outcomes such as school achievements and subsequent wage levels. Using an instrumental variable technique based on regional variation in access to pre-schooling, they find evidence that effects are sizeable and persistent and larger for children from disadvantaged socioeconomic background.

A number of papers compare differences between *types* of care, i.e. formal centre-based care vs. informal private care (Bernal & Keane 2006; Datta Gupta & Simonsen 2010; Gregg, Washbrook & ALSPAC Study team 2003; Waldfogel, Han & Brooks-Gunn 2002). Bernal & Keane (2006) use the National Longitudinal Survey of Youth for children born by single mothers in 1979. Their findings suggest that children benefit from being enrolled in formal care (centre-based care and pre-school), but experience adverse outcomes when participating in informal care (which is less expensive). Datta Gupta & Simonsen (2010) investigate the relationship between type and intensity of mode of daycare and non-cognitive abilities for children at the age of 7. They find no significant differences in non-cognitive skills when comparing children who attended pre-school versus children cared for at home. However, they find that private daycare seems to be negatively related to non-cognitive abilities for boys born by mothers with a low level of education. Moreover, the intensity of childcare is important: an increase in the time a child spends in daycare has a significantly negative effect on child outcomes. They also study the effects of parental vs. non-parental childcare during the age of three on outcomes at the age of eleven and find no differences on the overall and risky behaviour, neither on objective or self-evaluated abilities (Datta Gupta & Simonsen 2011).

Lasser & Fite (2011) argue in favour of universal high-quality pre-school provisions and their potential positive effects on child development, stressing the importance of teacher preparation. A few studies

try to assess the importance of the quality of universal daycare offered. Blau (1999) suggests that daycare characteristics have little association with child development. In contrast, Gregg et al. (2005) show that daycare does not have adverse effects on child development and conclude that high quality centre-based care may neutralise potentially negative effects of maternal employment. A recent study by Chetty et al. (2010) evaluates the long-term impacts of the Project Star which introduced randomness in the allocation of a large number of children to a variety of classroom qualities in Head Start pre-schools in Tennessee in the late 1980s. They find evidence that higher staff-to-child ratios do not have significant effects on outcomes at age 27, whereas smaller pre-school class sizes, a longer teacher experience in kindergarten and a stronger peer group – as measured by end-of-class test score averages – are positively associated with better cognitive outcomes such as, for example, better school attainments and higher earnings. Despite the random allocation of quality provisions in Project Star, Chetty et al. (2010) concede that in particular the effects of teacher experience could be endogenously driven by unobserved characteristics of the teachers.

In our study, we focus on establishing whether variation in the quality of daycare is related to long-term child outcomes. Our approach is inspired by the recent advances in the literature on the economics of education which focuses on the contribution to cognitive and intellectual development of individual schools and teachers (cf. Heckman 2008; Machin, McNally, Kramarz & Quazad 2006; Rivkin, Hanushek & Kain 2005).[3] Like Havnes & Mogstad (2010) and Datta Gupta & Simonsen (2010), our paper takes a closer look at a universal daycare system in the Scandinavian tradition; extending quality evaluations of pre-school programmes such as the one made by Chetty et al. (2010). Havnes & Mogstad (2010) assess the consequences of attending universal daycare or not, Datta Gupta & Simonsen (2010) study the implications of some broader types of daycare, and Chetty et al. (2010) evaluate the long-term impact of quality variations in Head Start pre-school classrooms. Our contribution above the previous literature is to exploit the variation in the quality of pre-school across institutions in order to establish long-term effects on children of pre-school quality.

3. Data and institutional framework

3.1. Data

We use a unique longitudinal dataset based on administrative register data in Statistics Denmark. Furthermore, we exploit the daycare register, which provides individual information on children in daycare since 1995. The daycare register covers about 95% of the municipalities. Children and staff in pre-school institutions are linked at the institutional level (cf. Gørtz & Andersson 2010).[4] 2275 pre-school and age-integrated institutions were successfully matched for the year 1998. By international standards, this dataset is quite unique. The duration (years being registered) of pre-school attendance is derived from the daycare register. Those records also provide information on the type of daycare institution (pre-school kindergarten and age-integrated institution) and ownership (municipal and self-owned); see section 3.2. Our sample consists of children who finished 9th grade exams in 2008. These children are typically 15-16 years old at the test and were born around 1992. The registers provide comprehensive information on each citizen's origin and socioeconomic background; most variables are available for 1981-2008. Based on the merged dataset, we generate indicators for the children's family background such as parental education, household income and number of siblings. We use information from the daycare register of 1998, i.e. the last year before this cohort entered elementary school. Indicators of pre-school quality (see section 4) are constructed based on information about pre-school teachers from the general registers. As we study the effect of a variation

[3] This literature emphasises that only a fraction of the variation across schools can be explained by observable characteristics of the schools, whereas much of the heterogeneity is due to unobserved factors like e.g. the values and quality of the management of the school, peer effects from other children at the school etc.

[4] In 1998, about 1.6% of the pre-school kindergarten registers and 7.5% of the age-integrated institution registers were reported at the municipal instead of institutional level. For those municipalities we generated the pre-school quality characteristics at the municipal instead of institutional level.

in pre-school quality, our results are valid only for the sample of children who actually attended a pre-school.

As outcome variable, we measure children's cognitive development at the end of elementary schooling. We use school administrative data from final exams in Danish language problem-solving for 9th graders for an almost complete cohort in 2008. These tests were introduced in 1975, are nationally comparable and evaluated independently from the schools. Previous research has shown that such test scores are strong predictors for future educational and labour market outcomes (Connolly, Micklewright, & Nickell 1992; Currie & Thomas 2001).

3.2. Organisation of daycare and pre-school in Denmark

The majority of Danish daycare facilities are organised and operated by the municipalities. Municipalities provide early daycare at nursery centres for the 0-3-year-olds, pre-schools for children aged 3-6, age-integrated institutions for the 0-6-year-olds, and after-school programmes for school children. These are all centre-based daycare provisions. 45% of all institutions are so-called self-owned institutions, i.e. semi-private non-profit organisations which basically function as municipal institutions, but with more autonomy and influence from the parents.[5] Parental payment is the same for kindergarten and age-integrated institutions within the municipality, but fees vary across municipalities. Fees are set based on actual daycare costs in the municipality, but the municipality can decide how large a part of the cost that should be borne by the users (parents); this share is usually 20-30% of the cost of a daycare opening. The law sets an upper limit on the share of costs which the municipalities are allowed to shift to the parents.

In addition, municipalities can organise family daycare where young children (usually 0-3 year-olds) are cared for by a child minder, usually in her/his private home. This paper focuses on centre-based pre-schools and age-integrated institutions for the 3-6-year-old age group.

Municipalities are responsible for allocating children to public daycare institutions. Parents cannot freely choose among institutions, but they submit an application with a prioritised list of preferred institutions within their district to the municipal administration. The child's position on the waiting list is usually determined by date of birth. Some centres have long waiting lists, but the centres are not directly involved in the allocation of children to institutions. As excess supply is costly, municipalities try to distribute children so as to fill all centres. The position on the waiting list determines the access probability to a particular institution. However, once parents limit their choice to a specific institution, they usually forgo the right to a guaranteed slot and hence may have to wait longer for a daycare opening.

Children with specific needs may jump the waiting list, and it is prioritised that younger siblings are enrolled in the same institution as their older sibling. However, the municipal authority does the final allocation, and parental preferences are merely guiding in the allocation process.

Guaranteed access to childcare from the age of 12 months (GAPS) has been part of government policy from the mid-1990s. This policy has been transmitted to municipalities in a varying pace; about 72% of the studied children attended pre-schools in municipalities with GAPS.[6] The implementation of GAPS coincides with a substantial increase in the attendance in daycare centres, in particular for the age group below 3 years.

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[5] Quality legislations regarding educational quality and general provisional conditions for hygiene and safety are the same for both types of ownership; differences in observed quality factors between municipal and self-owned institutions are numerically small, albeit significantly different from 0. Nonetheless, inclusion of a dummy for differences between the two types of institutions indicates that there are no significant differences in outcomes between the two types of ownership; hence we leave these differences out of our analysis.

[6] By 2000, around 75% of the municipalities offered GAPS, and by 2006 almost 100% of the municipalities report guaranteed access to childcare.

3.3. Attendance rates and parental selection

Danish daycare provisions are utilised at a large scale. In 1998, almost 70% among the 1-year-old children attended some kind of daycare arrangements (Statistics Denmark 1998). Children aged 3-6 mainly attend pre-school kindergartens as well as age-integrated institutions. In 1998, 9 out of 10 children attended any type of formal daycare arrangement during pre-school ages (see Table 1), and the attendance rates have continued to rise in the last decade.

Table 1: Child and pre-school population in 1998

	Pre-school kindergarten		Age-integrated institution		Total child population	Attendance rate for any daycare [a]
3 years	30019	42.3%	20071	28.3%	71000	86.9%
4 years	39146	57.0%	22025	32.1%	68686	90.3%
5 years	40720	58.8%	21334	30.8%	69281	93.1%
6 years [b]	7873	11.9%	9679	14.6%	66139	84.8%

Source: (Statistics Denmark 1998; figures per 01.01.1998).

a These rates are based on attendance figures for any type of daycare, including pre-school kindergarten and age-integrated institution. They are based on our own calculations assuming that no child is attending several daycare arrangements at a time.

b Children usually enrol in elementary school in the school year in which they turn 6; pre-school statistics are collected late in the calendar year.

We cannot reproduce the national statistics provided by Statistics Denmark in Table 1 with our matched data as there are gaps in the daycare registers preventing us from clearly identifying who did not attend a centre; a rough comparison for the covered municipalities shows that our data are in line with the national figures. There is no indication that the lack of data is correlated with child outcomes or experienced quality. Our data also show that about two in three children who attended a pre-school went to a kindergarten rather than age-integrated institutions. This proportion is the same across disadvantaged subgroups (as further discussed below), except for non-native children of whom only three in five children attended a pre-school kindergarten.

The aim of this paper is to establish the causal effect of pre-school characteristics on children's cognitive outcomes. In order to interpret a possible correlation between pre-school characteristics and child outcomes, we need to consider whether children's sorting into pre-schools is a consequence of their parents' expectations about the potential benefits of the pre-school in terms of child development. Children's sorting into pre-schools is a consequence of a number of prior choices by their parents. First, parents choose a municipality of residence. This decision is based on characteristics of the municipality: general quality of living, access to nature, prices and quality of houses, local labour-market conditions, access to transportation networks, quality of public schools in the municipality, agreeability of peers in the area, and availability and user fee of daycare arrangements. Secondly, within municipalities, parents choose to settle down in a particular district. We argue that this choice is more likely to be governed by information on public schools rather than information on pre-schools in the local area. Thirdly, given the chosen district, parents prioritise between daycare institutions in the district. This ranking is based on perceived quality, feedback from e.g. neighbours and friends, experiences of siblings, or the parents' pedagogic values and priorities. However, there is no guarantee for getting their first choice due to waiting lists, and the final allocation of children into institutions is done by the municipal administration with the parents' priorities used mainly as a guideline. Hence, based on these characteristics of municipal allocation and our assumptions about parental choices and their implications for children's sorting into childcare institutions, we argue that there is quite some exogeneity in the allocation of children into pre-schools. Nevertheless, we propose and test a number of instrumental variables in the paper in order to deal with possible endogeneity.

4. Pre-school quality

The study of quality aspects of early childhood care and education is still a rather new field in the social science literature. Behrman & Birdsall (1983) stressed that looking at the quantity of schooling alone might be misleading as the variation in quality is substantial. This is also likely to be the case for pre-schooling. Classical quantity measures are the duration in daycare as measured by the number of years and weekly hours of attendance as provided in surveys or given in administrative records (Datta Gupta & Simonsen 2010).

By international standards, Danish pre-schools are generally characterised by relatively high expenditure levels and high quality requirements (Datta Gupta & Simonsen 2010). There are extensive requirements of qualifications of childcare staff, and the number of children per staff (the child-to-teacher ratio) is lower than in almost all other EU and OECD countries (OECD 2007).

Despite the high-quality pre-school offerings at the average national level, there is a relatively large variation in the resources spent on pre-schools across municipalities in Denmark. Also, there are within-municipal differences across pre-school institutions. The variation across municipalities and pre-schools within municipalities is in terms of pedagogical principles, the quality of management, peer group composition, and characteristics of the staff including e.g. level of education, experience, seniority, sickness absence, the share of male teachers and teacher turnover (Gørtz & Andersson 2010).

Numerous quality aspects can be of importance when assessing the quality of pre-school. Central structural measures include type of care, staff qualifications and motivation, group size, physical facilities, education materials, cooperation with other institutions, accessibility, social composition of institutions, the pedagogic approach, applied curriculum and parental involvement (Marshall 2004).

We use our merged register dataset to generate structural quality characteristics for pre-schools in 1998 when our cohort was around 5 years old and hence attended the last year in pre-school. We have information available on both children and employees in each pre-school institution. In this study we focus on five quality indicators per pre-school institution that we presume to have positive impacts on child outcomes:

1. The number of staff members per child (i.e. the staff-per-child ratio)
2. The share of male staff members
3. The share of staff with a pedagogic education
4. The share of non-native staff members
5. The stability of staff per institution compared to the previous year

Underlying our choice of the *first* quality indicator, the staff-per-child ratio, is the hypothesis that increasing the number of staff members per child results in more time being spent with each child, improving the child-teacher interaction (see, e.g. Frede 1998). More time implies more attention to the child's individual needs and development, following the same argument as in the discussion on the impact of the child-teacher ratio in school research (cf. Card & Krueger 1996). For policymakers, it is crucial to know what gains can be expected from investing in additional staff members.[7] Camilli et al. (2010) find in their meta-analysis of 123 comparative studies of early childhood interventions support for positive effects of small-group instructions. The staff included in the first quality indicator capture

[7] There might be an inference problem if children with special needs are placed in institutions with more staff per child, since we are not able to observe whether a child has special needs; our estimates for the impact of the staff-to-child ratio might be downward biased. This problem is taken into account by using measures for staff-per-child ratios on the institutional level but in the instrumental variable estimations also on a county level. The latter measure averages out the variation due to children with special needs, assuming that there is an equal share of them across municipalities.

pedagogically trained staff and non-pedagogically trained staff, and other types of staff such as administrative and support staff. Multiple staff is often assigned to a single class, especially for such young children.

Our choice of the *second* quality indicator, the share of male staff members, is motivated by a rather recent discussion that links mounting school problems of particularly boys to the lack of sufficient male role models in their early childhood (see, for example, Thomas S. Dee, 2005a, 2005b; 2006) which assumes that boys need a specific type of care which presumably is provided by male staff. A majority of employees in pre-schools is female, not only in Denmark but across all OECD countries.[8]

Our focus on the *third* quality indicator, the share of pedagogically trained staff, is fundamentally based on the presumption that higher educated staff is better equipped to address the individual needs of a child and to emphasise learning and school preparation. Municipalities have targets on the share of the staff that should have a formal pedagogical education implying a medium-length of further pedagogic education (3½ years of education at bachelor level). Often the staff directly involved in taking care of the children is a combination of pedagogically trained staff and non-pedagogically trained staff, so-called pedagogue assistants. The latter group is not required to have any pedagogic education and is paid a lower salary than trained pre-school teachers.

As our *fourth* quality indicator, we use the share of non-native staff members. A higher share is likely to have positive effects on child outcomes.[9] Dee (2004, 2005a) suggests two theoretical arguments for such positive effects: *active teacher biases* and *passive student responses*. *Active teacher biases* imply that a teacher's behaviour to the child is likely to be influenced by the teacher's perception of the child. Majority teachers' behaviour to a minority child, as for example those with non-native backgrounds, could be biased by stereotypes about the minority group while minority teachers would be better suited to serve minority children as they have a better understanding of their particular cultural experiences. *Passive student responses* imply that a child sees a minority teacher as a role model or good example for integration with the majority group. Accordingly, a more culturally and ethnically diverse staff is likely to better prepare children for a more diverse society and helps in particular minority children to better integrate into society. Other lines of argument stress the importance of having caregivers speaking the native language of children at early age; a more culturally diverse staff is better able to nurture minority children's home language (Kagan & Garcia 1991). Also, the recruitment of minority group children is facilitated by increasing the number of minority teachers. And increasing the number of minority teachers eases the staffing situation of 'difficult-to-staff' or 'high-attrition' schools (Clewell & Villegas 1998). Despite some empirical evidence showing the expected positive effects of a culturally more diverse teaching staff at schools (see Villegas & Jordan Irvine 2010, for a recent review), there is little known yet about whether those arguments also hold for pre-school staff and in particular about the distribution of effects across children.

We define our *fifth* indicator, the staff stability (corresponding to one over staff turnover), as the share of the staff in a given year that was also employed in the same institution in the previous year. If a large share of staff changes at a centre from year to year – in this case 1997 to 1998 – there is less retention of centre and child-specific knowledge. Accordingly, the needs of individual children and of particular groups at the pre-school can be less adequately addressed. Also, a higher turnover rate demands that more resources are invested in the hiring process. Conversely, a more stable group of staff members reflects stability of human capital at a pre-school and may lead to better child

[8] Usually, men have mostly been represented in the management of daycare institutions, but in recent years Danish policymakers have encouraged men to take up more care jobs. A 1997 Governmental Child Committee proposed that "*initiatives to further the recruitment of men in child and youth educator study programmes and teacher study programmes as well as initiatives to increase the number of men employed in daycare facilities for children should be considered*" (cited in: OECD 2000).

[9] The UN Convention on Children's Rights of 1990 encourages the recognition of cultural diversity, in particular within early childhood care and education services.

outcomes.[10] This hypothesis follows the argument of similar studies on the effects of teacher turnover at elementary schools. Ronfeld et al. (2011), for example, find that a higher teacher turnover for 4th and 5th graders has a broader, harmful influence on student achievement – disruptional effects are beyond potential positive compositional effects.

Table 2 shows summary statistics of our five quality indicators, based on the linked Danish administrative data. On average, one staff member takes care of about five children. Staff members include not only the trained pre-school teachers, but also the pedagogic and facility support staff in the pre-school institution. Overall, one in ten staff members is male, and about every second staff member is a pedagogically trained pre-school teacher, but the variation is substantial. For both types of pre-school institutions, i.e. kindergarten and age-integrated institutions, about one in three employees changes school each year. The means of the quality indicators by type of pre-school did not significantly change in the period 1996 to 1998, and quality factors are only very weakly correlated with each other.[11]

Table 2: Quality characteristics

Pre-school kindergarten	**Obs.**	**Mean**	**Std. dev.**	**Min.**	**Max.**
Number of staff members per child [a]	20345	0.228	0.065	0.071	0.727
Share of male staff members (0-1 scale)	20345	0.114	0.103	0.000	0.667
Share of staff with a pedagogic education (0-1 scale)	20345	0.462	0.125	0.000	1.000
Share of non-native staff members (0-1 scale)	20345	0.038	0.070	0.000	1.000
Share of staff working in same centre in previous year [b]	20345	0.677	0.140	0.150	1.000
Age-integrated Institution					
Number of staff members per child [c]	10099	0.228	0.065	0.082	0.605
Share of male staff members (0-1 scale)	10099	0.134	0.106	0.000	0.571
Share of staff with a pedagogic education (0-1 scale)	10099	0.436	0.110	0.000	1.000
Share of non-native staff members (0-1 scale)	10099	0.052	0.073	0.000	0.714
Share of staff working at same centre in previous year	10099	0.654	0.129	0.182	1.000

a A small number of outliers in staff-per-child ratios, values below the 0.5%- and above the 99.5%-centile, are recoded as missing values.

b The number of observations for which the stability of the staff body could be calculated is slightly smaller than the main sample as indicators were only calculated for those institutions which existed or could be traced in the datasets in both years (1997 and 1998). Missing values have been replaced by average values in order to extend the information to the same sample size as the other quality indicators.

c These values are reweighed towards the same averages as for pre-school kindergartens. The original values for this indicator for age-integrated institutions are a mean of 0.265 and an original standard deviation of 0.082.

The quality indicators are rather complete in terms of coverage; they are normally distributed, except for the shares of male and non-native staff members which are skewed to the left on a 0-to-1 scale. For age-integrated institutions, we need to impute quality indicators for that part of the institution which is directed towards 3-6-year-olds. Age-integrated institutions usually separate children by age

[10] Despite the possibility of high turnover rates at some pre-schools, we do not expect that at such pre-schools most of the staff body keeps changing, but that usually some positions within the staff body such as volunteers and assistants are more prone to changes than others, e.g. heads of groups.

[11] The five chosen quality indicators are also very weakly correlated to some other staff characteristics such as age and work experience, except that centres with more non-native or male staff tends to have somewhat younger staff.

groups and have a similar setup as kindergartens for 3-6-year-old children. Hence, we reweigh staff-per-child ratios to the same overall average and variance for staff-per-child ratios as for kindergartens.

We expect that higher values of the quality indicators lead to positive development gains for children. If the effects persist over time, we are able to link the variation in child outcomes when children leave elementary school to their pre-school history.

5. Methodology

Our empirical model rests on a production function for child development as the model discussed in Section 2. This approach finds its inspiration in work by Heckman (2008), Ruhm (2005) and Todd & Wolpin (2003). We model the production of child *i*'s outcome (CO_i) as a linear function of individual characteristics of the child including the length of the child's pre-school history (X_i), family background factors which are assumed to account for part of the variation in children's initial development (F_i)[12], quality characteristics of the pre-school institution of child *i* (I_i), and characteristics of the pre-school peer group (P_i). Moreover, the child outcome is determined by an average baseline score β_0, and varies according to a general error term as shown in equation (1):

$$\mathrm{CO_i} = \beta_0 + \beta_1 \mathrm{X_i} + \beta_2 \mathrm{F_i} + \beta_3 \mathrm{I_i} + \beta_4 \mathrm{P_i} + \varepsilon_i \qquad (1)$$

The set of peer indicators reflects each pre-school's share of boys, non-native children, and children with single parents, low educated parents, and the share from poor households. As child characteristics, we control for gender (a dummy for being male), the child's age (in the pre-school period 1998), and a dummy for being native (born by Danish born citizens). The family background factors include a dummy for living in a single parent household, the number of children in the household, the mother's age and her level of unemployment, the highest educational level of the parents, as well as a logarithmic term of gross income per household, all measured during the child's pre-school period in 1998.[13] An overview of descriptive statistics on the variables in our regressions is provided in Table A-1.a.

Due to left censoring in the daycare registers, we cannot observe whether children attended any other daycare institutions before 1995, i.e. before the child was around 3 years old. But we account for the length of the pre-school attendance as of the year 1995, which means that we have uncensored, full pre-school spells for the ages 3-6 years.[14,15] We also add a squared term of the length of the last pre-school spell to allow for possible non-linearity, e.g. due to decreasing returns to pre-schooling.

Throughout the empirical analysis, we focus on grades from compulsory final examination in Danish by the end of 9th grade (equivalent to finishing elementary schooling).[16] Children typically take the exam when they are aged 15-16. Hence, we study effects of pre-school about ten years after attendance which implies a rather large time gap between participation and testing. However, we consider the school trajectory to be partly a continuation of the initial pre-school experience. Thus, the test outcomes after elementary schooling show the full effect of pre-schooling. The Danish grading system uses as of 2006/2007 the so-called 7-scale which ranges from -3 (unacceptable) to +12 (excellent), and a score strictly higher than 0 implies a pass; about 1.2% of children failed the Danish final examination in 2008. For easier comparison with other studies, we have standardised the grades

[12] No information about initial development is available in the used data sources for the studied children.

[13] We do not use father's unemployment as this variable has a large number of outliers. Including it in our regressions would produce a minimal effect on child development – constant over all specifications and smaller than the mother's effect.

[14] There is some evidence that attendance among infants (less than one year of age) is harmful for kids (e.g. Belsky & Rovine 1988; Ruhm 2000), so kids who experienced daycare before the age of 1 might have developed adversely.

[15] The length of pre-school attendance varies between one year (1998) and four years (1995-1998). On average pre-school kindergartens are attended for 2.75 years while age-integrated institutions are attended for 3.06 years. The slightly longer attendance in age-integrated institutions is due to the continuation of many children from early ages.

[16] Private schools, attended by 12% of pupils in 2001/2002, have the right to also use the national leaving examinations; however, their testing is not controlled by public authorities (Eurydice 2008).

to a mean of 100 and a standardized deviation of 15 to make them more comparable to the international literature and changes more readable. See Table A-2 for a direct comparison of the original and standardised scores.

As we are also interested in establishing whether high pre-school quality is particularly beneficial for children at risk, we include a number of interaction terms between the quality measures and subgroup indicators. We study the effects of all five quality indicators across the following subgroups: 1) non-natives, i.e. born by non-Danish born citizens, 2) boys, 3) children of low educated parents (max. elementary education), 4) children of single parents, and 5) children living in households in the bottom quintile of gross incomes (we henceforth refer to these households as 'poor' households). For simplicity we include only significant interaction coefficients in the results tables, together with the quality variables and control coefficients.

When choosing the appropriate estimation technique, the crucial question is whether the quality of the pre-school institution (I_i) is exogenous to the child outcome in Equation (1). If I_i is exogenous, OLS is consistent and efficient. However, if I_i is endogenous, OLS is inconsistent. Endogeneity may occur if the choice of pre-school institution is not completely random, e.g. if parents can influence the choice of pre-school institution (see also Duncan, Magnuson & Ludwig 2004). We assume that parents prefer high-quality pre-schooling, and if high-ability kids sort into higher-quality institutions, estimation by OLS might consequently overstate the effects of the institutions. In that case, estimation by OLS will produce an upward-biased estimate of β_3 and will consequently not identify true causal effects of the quality of the pre-school on children's outcomes. Hence, we expect the estimated β_3 to be smaller when applying the IV method than when estimating by OLS if pre-school quality is endogenous. Due to the concern about endogenous pre-school quality, we use both IV and OLS analysis of Equation (1). If parents cannot influence the choice of pre-school institution, the estimated OLS and IV coefficients are both consistent, but estimation by OLS is efficient.

We introduce instrumental variables that are highly correlated with the quality of the pre-school institution, but seem unrelated to child outcomes. The instrumental variables use various exogenous sources of randomness in the pre-school quality allocation process and hence overcome potential biases that are due to unobserved factors (Angrist & Krueger 2001). The eight instruments investigated are: 1)-5) overall characteristics of pre-schools at a larger geographical area for the five quality measures; 6) information about the political majority of the local government prior to pre-school enrolment; 7) demographic changes in the pre-school population across municipalities over the preceding years; and 8) whether the municipality has a policy of guaranteed access to pre-school (GAPS). These eight instruments' strength and validity are assessed. The strength is directly assessed in first-stage t-statistics. Regarding validity, we cannot directly test the exclusion restriction (Angrist, Imbens & Rubin 1996), so instead we argue for the validity in each of the cases and perform tests of over-identifying restrictions.

Our *first five* instruments for the pre-school institution's quality use the overall characteristics of pre-schools in a larger geographical area. In our preferred specification we use the county level. This instrumental variable approach exploits the variation in pre-school institutions across 14 counties to instrument for the quality of the specific pre-school institution a child attains. The procedure of using aggregates of our explanatory variables in larger geographical entities as instrument for the explanatory variables at the local level follows Dustmann and Preston (2001).[17] Applications and discussions of aggregate regional indicators as instruments for identifying school quality effects can be found in Heckman, Layne-Farra & Todd (1995) as well as Card & Krueger (1996).

In our case, the validity of such instruments relies on the presumption that pre-school quality in the larger geographical area does not directly affect individual child outcomes, but is nevertheless related

[17] Dustman & Preston (2001) investigate the relationship between ethnic minority group concentration and attitudes towards ethnic minorities in Britain. They instrument for ethnic minority group concentration in a neighbourhood by using the minority group concentration in a larger geographical area.

to pre-school quality in the institution the child attends. Parents' influence on the *overall* pre-school quality in the county is marginal, and it is unlikely that parents move across counties due to pre-school characteristics.[18] Parental sorting *within* the county does not affect the overall composition in the county, and within-area sorting should therefore not affect validity.

To ensure the strength of the instrument, we need a high correlation between county-level quality and specific institution-level quality, and variation in the pre-school institutions across counties. The latter is clearly the case; the county aggregates of the five studied quality indicators show variation across Danish counties, see Table A-3. However, for our identification of possible quality effects, it is also important that there is some variation within the municipality.

The links between parents' socioeconomic status and children's educational outcomes might be effective via neighbourhood factors rather than via parental selection of pre-school arrangements. However, this only strengthens the argument for using the county-level instrumental variables approach for identifying the effect of pre-school quality on children's outcomes, as we take care of sorting across either neighbourhoods or pre-school institutions using this method.

The *sixth* instrument for quality of the pre-school institution uses information about the political majority of the local government prior to pre-school enrolment, i.e. the share of conservative votes. [19] We use the counts of valid votes of the 1993 municipal elections as provided by Statistics Denmark (2006b). Given a stronger valuation of the family as pre-school provider, it is likely that a more conservative administration provides less money for pre-school institutions, thus potentially providing lower quality pre-schooling than a non-conservative administration. Quality variations across municipal majorities are shown in Table A-4.[20] However, it is unlikely that parents move to another municipality due to the political majority of their local government.

The *seventh* instrument is related to demographic changes in the population of pre-school age children (see Table A-5). As a single change variable, we use municipal changes in the size of the population of 3-year-old children between 1995 and 1996, which is at the beginning of the studied pre-school period (Statistics Denmark 2006a). If there is a sudden positive (negative) change to the population size it might affect the quality of pre-school offerings, e.g. if pre-schools have to take care of more (fewer) children, or if the waiting lists increase (decrease). Parents cannot anticipate such a shock to the population, and given the costs of moving to a new municipality it is very unlikely that they will respond to such a shock by moving (see also Datta Gupta & Simonsen 2010, p. 33). Unpredicted crowding will be less severe in primary and secondary schooling as municipalities have more time to plan for this.

Finally, the *eighth* suggested instrument is related to the municipality's policy of guaranteeing (or not guaranteeing) access to pre-school (Glavind 2007). Datta Gupta & Simonsen (2010) use this instrument for the choice of a pre-school rather than family care. The municipal policy of guaranteeing parents a slot for their child in a pre-school institution is known as GAPS (Guaranteed Access to Pre-school). However, parents cannot themselves choose a desired institution. When a municipality provides GAPS, the length of the waiting list is naturally affected as the municipality is obliged to provide the necessary number of slots. GAPS provides variation in the take-up of pre-school across municipalities, as a higher take-up rate is expected in municipalities with GAPS. Datta Gupta &

[18] The mobility across county borders in Denmark is low; only around 3% of individuals in the labour force move across county borders per year (Deding & Filges 2004). Moreover, Simonsen (2005) shows that there is limited movement to and from municipalities providing generous childcare policies. Thus, we do not have to worry about between-area sorting due to parents moving to other counties in order to pursue better daycare for their children. It is possible that the quality of municipal childcare provisions is somewhat correlated to the quality of elementary schools; thus we also assume that parents do not sort primarily according to the quality of schools.

[19] We define a vote for the Conservatives, the Liberal Democratic Party or the Progress Party as a conservative vote.

[20] Conservative municipalities vary also in the socioeconomic composition of families. In such municipalities more children are born by native Danish parents, live in wealthier and better educated households and less often with single parents, but with more children in the same household.

Simonsen (2010) show that there is no clear evidence that parental location choice is biased towards municipalities providing GAPS. Moreover, we find that quality indicators vary significantly with respect to the availability of GAPS, which confirms that GAPS is a valid instrument (Table A-6). We do not find any reverse causality between quality indicators of previous years and provision of GAPS, which is in line with Datta Gupta & Simonsen (2010). They argue that, if sufficient funds are available and municipalities try to reduce excess capacities, we could expect most of the variation in the provision of GAPS to stem from unexpected variations in demand such as variations in the cohort size.

6. Results

We first present our main results using ordinary least square estimation (OLS) in section 6.1. In section 6.2, we present the findings of two stage least square estimations (2SLS), and in section 6.3 we discuss the size of effects.

6.1. Ordinary least squares estimation

Table 3 presents results for ten different OLS estimation models. In the first estimation we include our five quality indicators jointly (see model 1) to test whether they catch separate variation in the outcome variable. Then we study the quality indicators separately (models 2, 4, 6, 7 and 9). And finally, for each quality indicator we test whether the effects vary across subgroups at risk of school failure (models 3, 5, 8 and 10). The following subgroups showed significant interactions with our quality indicators: non-native children and boys.[21]

The set of control variables for individual child and family background characteristics is included in all models; the estimated coefficients show the expected signs, are almost all significant and vary little across model specifications. The only exception is the length of a pre-school spell, which has no significant impact.[22]

[21] Regression outputs for all subgroup quality interactions, including those that did not show any significant effects, are available from the authors upon request.

[22] The insignificant effect of pre-school length may be explained by the fact that the spell length varies only slightly. We study only children who attended a pre-school, since we can only generate quality indicators for this group. Children who did not attend a pre-school would be likely to benefit from pre-school attendance, in particular of a higher quality. The fact that we cannot include this group of children introduces a possible downward bias of our estimates.

Table 3: Full estimation output including all control variables (OLS regression)

Dependent variable:
Written final exam in Danish language skills at 9th grade (end of elementary schooling) in 2008, standardised scores (mean 100, std.dev. 15)

Estimated OLS Model	1	2	3	4	5	6	7	8	9	10
Pre-school quality										
Number of staff members per child	2.55* [1.73]	2.06 [1.46]	-0.61 [-0.35]							
Share of male staff members	1.89** [2.09]			1.76** [2.01]	0.02 [0.02]					
Share of staff with a pedagogic education	1.93*** [2.58]					1.59** [2.18]				
Share of non-native staff members	1.72 [1.31]						1.66 [1.27]	2.61* [1.94]		
Stability of staff	0.29 [0.38]								-0.06 [-0.09]	-0.35 [-0.51]
Subgroup effects										
Non-native children								-7.50** [-2.02]		4.81* [1.89]
Boys			5.49** [2.30]		3.47** [2.39]					
Peer group composition										
Share of boys in attended pre-school	0.90 [0.66]	1.09 [0.79]	1.06 [0.78]	1.08 [0.79]	1.10 [0.81]	1.03 [0.75]	1.05 [0.77]	1.08 [0.79]	1.11 [0.81]	1.12 [0.82]
Share of non-native children	-1.98 [-1.55]	-1.45 [-1.19]	-1.46 [-1.20]	-1.51 [-1.23]	-1.51 [-1.23]	-1.18 [-0.97]	-1.87 [-1.46]	-1.28 [-0.97]	-1.35 [-1.10]	-1.23 [-1.01]
Share of children with single parents	-1.04 [-0.79]	-0.84 [-0.64]	-0.81 [-0.62]	-1.08 [-0.83]	-1.07 [-0.82]	-0.74 [-0.57]	-0.84 [-0.65]	-1.04 [-0.80]	-0.82 [-0.63]	-0.88 [-0.68]
Share of children with low educated parents	-9.10*** [-6.57]	-9.66*** [-7.02]	-9.66*** [-7.02]	-9.45*** [-6.80]	-9.46*** [-6.81]	-9.85*** [-7.22]	-9.75*** [-7.14]	-9.71*** [-7.11]	-9.85*** [-7.19]	-9.86*** [-7.20]
Share of children from poor households (bottom quintile)	4.22 [1.53]	4.66* [1.69]	4.67* [1.70]	4.76* [1.74]	4.71* [1.72]	4.85* [1.77]	5.16* [1.88]	5.13* [1.87]	5.03* [1.83]	5.13* [1.86]
Child characteristics										
Length of attendance at last pre-school (in years)	0.75 [1.52]	0.80 [1.61]	0.79 [1.59]	0.75 [1.53]	0.75 [1.53]	0.69 [1.41]	0.78 [1.58]	0.80 [1.63]	0.76 [1.53]	0.77 [1.56]
Length of attendance at last pre-school, squared term	-0.12 [-1.23]	-0.13 [-1.36]	-0.13 [-1.34]	-0.12 [-1.22]	-0.12 [-1.23]	-0.11 [-1.10]	-0.13 [-1.32]	-0.13 [-1.37]	-0.12 [-1.25]	-0.12 [-1.28]
Gender (boy = 1)	-6.19*** [-38.16]	-6.19*** [-38.15]	-7.44*** [-13.06]	-6.19*** [-38.19]	-6.61*** [-27.43]	-6.20*** [-38.20]	-6.20*** [-38.18]	-6.20*** [-38.19]	-6.20*** [-38.18]	-6.19*** [-38.17]
Age (in 1998)	-2.19*** [-9.06]	-2.17*** [-8.98]	-2.17*** [-9.01]	-2.18*** [-9.05]	-2.18*** [-9.05]	-2.19*** [-9.07]	-2.17*** [-8.96]	-2.16*** [-8.93]	-2.17*** [-9.00]	-2.17*** [-8.99]
Non-native (not born by Danish born citizen = 1)	-3.30*** [-8.22]	-3.31*** [-8.27]	-3.32*** [-8.27]	-3.30*** [-8.23]	-3.30*** [-8.24]	-3.29*** [-8.21]	-3.31*** [-8.26]	-2.76*** [-5.63]	-3.31*** [-8.25]	-6.47*** [-3.82]
Family background										
Parenthood (single parents = 1)	-1.52*** [-6.80]	-1.53*** [-6.83]	-1.53*** [-6.85]	-1.52*** [-6.80]	-1.52*** [-6.81]	-1.52*** [-6.82]	-1.53*** [-6.84]	-1.54*** [-6.88]	-1.53*** [-6.83]	-1.53*** [-6.84]
Number of children in household (in 1998)	-1.15*** [-10.56]	-1.16*** [-10.60]	-1.16*** [-10.61]	-1.15*** [-10.60]	-1.15*** [-10.59]	-1.16*** [-10.67]	-1.16*** [-10.64]	-1.15*** [-10.54]	-1.16*** [-10.65]	-1.16*** [-10.65]
Mother's age (in 1998)	0.10*** [5.23]	0.10*** [5.30]	0.10*** [5.31]	0.10*** [5.26]	0.10*** [5.27]	0.10*** [5.29]	0.10*** [5.30]	0.10*** [5.29]	0.10*** [5.30]	0.10*** [5.27]
Maternal unemployment (annual days à 8 hrs, 1998)	-0.02*** [-5.13]	-0.02*** [-5.13]	-0.02*** [-5.15]	-0.02*** [-5.12]	-0.02*** [-5.13]	-0.02*** [-5.13]	-0.02*** [-5.12]	-0.02*** [-5.11]	-0.02*** [-5.13]	-0.02*** [-5.12]
Highest parental education (elem. educ.)	-3.82*** [-13.53]	-3.81*** [-13.48]	-3.81*** [-13.50]	-3.81*** [-13.51]	-3.81*** [-13.50]	-3.80*** [-13.47]	-3.81*** [-13.48]	-3.80*** [-13.45]	-3.80*** [-13.47]	-3.80*** [-13.46]
Highest parental education (low. ter. Educ.)	2.79*** [9.20]	2.81*** [9.27]	2.81*** [9.27]	2.81*** [9.29]	2.82*** [9.30]	2.81*** [9.27]	2.81*** [9.29]	2.81*** [9.28]	2.82*** [9.29]	2.81*** [9.28]
Highest parental education (mid. ter. educ./bachelor)	5.18*** [25.20]	5.22*** [25.38]	5.22*** [25.37]	5.22*** [25.31]	5.21*** [25.31]	5.22*** [25.36]	5.23*** [25.40]	5.23*** [25.39]	5.23*** [25.40]	5.23*** [25.41]
Highest parental education (high. ter. educ.)	8.09*** [30.37]	8.14*** [30.66]	8.13*** [30.64]	8.13*** [30.65]	8.12*** [30.63]	8.17*** [30.90]	8.15*** [30.78]	8.14*** [30.77]	8.16*** [30.75]	8.16*** [30.72]
Gross hh-income (logarithmic scale, in 1998)	0.23*** [2.61]	0.21** [2.47]	0.21** [2.47]	0.22** [2.52]	0.22** [2.50]	0.21** [2.46]	0.21** [2.44]	0.21** [2.48]	0.21** [2.43]	0.21** [2.46]
Constant	109.79*** [48.71]	111.08*** [50.92]	111.75*** [50.82]	111.46*** [51.83]	111.67*** [51.94]	111.12*** [51.68]	111.57*** [51.85]	111.41*** [51.75]	111.70*** [51.12]	111.85*** [51.18]
Observations	30444	30444	30444	30444	30444	30444	30444	30444	30444	30444

Note: Baseline category for Highest parental education = sec. education / voc. training; Robust z-statistics in parentheses, clustered at individual pre-school level (=2275 clusters); * significant at 10% level (|z|>1.64), ** at 5% level (|z|>1.96); *** at 1% level (|z|>2.58).

We initially study the effects of the five quality indicators jointly. We find that three of our five quality indicators, the staff-to-child ratio, the share of male teachers and the share of trained teachers, show a significant positive relationship with the child outcome, despite the fact that a 10-year-period has passed since their years of pre-schooling. The positive effect of a higher share of staff with a pedagogic education is even significant at a 1% significance level. The share of non-native staff members and the staff stability (share of staff that worked at the same centre in the previous year) are not significant. The fact that some of the effects are jointly significant provides evidence that our indicators cover distinct quality aspects. The importance of pre-school quality is reconfirmed when testing the quality indicators separately (models 2, 4, 6, 7 and 9).

Next we focus on the interaction between our quality indicators and a set of dummies for disadvantaged subgroups.[23] We find that a higher staff-to-child ratio is particularly positive for boys (model 3). Furthermore, as expected, we find that the presence of more male staff has a positive effect on outcomes for boys (model 5). In fact, both subgroup effects drive the overall positive effects of more staff per child and a higher share of male staff, respectively – the main effects are not significant when the interaction terms are included. Moreover, children benefit from more pedagogically educated staff, but there is no significant variation across subgroups (model 7). Finally, while the overall mean effect of staff stability (the share of staff staying at the same centre between 1997 and 1998) has no significant long-term effect on Danish language skills, non-native children benefit substantially from a more stable staff-body (model 10). The importance of staff stability in particular for non-native children could support the 'attachment theory' (Bowlby 1969). That is, stability among the pre-school staff body might partially compensate a lack of stability in the environment of non-native children that is due, for example, to a recent migration experience or yet imperfect integration of the family into the local setting.

Finally, non-native children benefit substantially less from a higher share of non-native staff (model 8). The negative interaction term between being a non-native child and the share of non-native staff (models 8) is somewhat surprising. Initially, one might expect that non-native staff would be better able to understand the needs of non-native children. However, non-native staff is less experienced in terms of estimated hours of work experience, has lower hourly wages, is less likely to have a pedagogic education and has a lower educational attainment in general. Another explanation might be that pre-schools with more non-native staff attract more non-native children who are from weaker family backgrounds, e.g. because there is a better communication with non-native parents possible. Correlations between the five peer group indicators and the share of non-native staff confirm an exceptionally strong correlation with the share of non-native kids in the pre-school (about 40%).[24]

We have also investigated whether boys from low-income families, boys from non-native families, or boys of single parents are affected differently by pre-school quality than other groups.[25] We find that non-native boys benefit more from higher levels of all quality indicators than native boys or non-native girls, except for higher shares of non-native staff. Moreover, poor boys benefit more from a higher share of male staff than poor girls.

6.2. Instrumental variable estimation

Our OLS regression presented above showed some remarkable results. We can interpret these results as causal effects if the allocation of pre-school slots through waiting lists has a partially random character, after controlling for various background factors that account for parental choices, pre-school compositions and children's initial ability. However, if we have not fully accounted for the

[23] Table 3 shows only estimates of significant subgroup interaction effects plus the main effects.

[24] The negative coefficients of the interaction term could also be due to reverse causality. This is the case if disadvantaged children are concentrated in pre-schools with higher levels of the quality indicators, e.g. more non-native staff being assigned to weaker peer groups. Indeed, we do find that non-native children are concentrated in centres with a higher share of non-native staff, see Table A-1.b.

[25] The outputs with interactions effects for boys of the disadvantaged groups are available from the authors upon request.

treatment allocation process, OLS may produce a biased estimate of the true causal effect. If high-ability parents (with high-ability children) e.g. sort into high-quality pre-schools, the OLS-estimate of the relationship between quality and child outcomes overestimates the true causal effect. Hence, OLS-estimates may be upward biased compared to IV results.

We now turn to the IV analyses to check whether effects are indeed upward biased. We use the following seven instruments: four variables representing county level aggregates of our five quality indicators, a variable for the share of conservative-liberals in the municipal council, a dummy for whether the municipality provided GAPS for 3-6-year-olds in 1995, and a variable for the relative change in the population of 3-year-old children in 1995. It is noteworthy that we find significant relationships between the quality indicators and all eight instrumental variables; see first-stage results in Table 4.a. For most specifications, an F-test shows that the IVs are jointly significant and provide F-statistics above the recommended level of 10 that is usually considered critical for the strength of an instrument. We use the set of all seven instruments on each of the five, possibly endogenous quality indicators. Table 4.b compares output for ordinary least squares (OLS) and two stage least squares (2SLS) regression outputs for the estimation model which includes all five quality indicators jointly (model 1) as well as five models on each of the indicators separately (models 2-6).[26]

For each of the 2SLS models we perform post-estimation tests to check whether 2SLS provides a better fit to the data than an OLS specification. First, we use a Wooldridge test (1995) to examine whether the quality indicators for which we want to use instrumental variables are exogenously determined.[27] Secondly, we use a Hausman test (1978) to check for systematic differences in the estimated coefficients in each IV and OLS specification (see Table 4.c). Systematic differences suggest that the OLS model is misspecified and thus inconsistent, whereas OLS is the most efficient model if there are no systematic differences in the estimated coefficients, given that the instrumental variables have sufficient power.

[26] Instrumental variable regressions using subsets of instruments on those models are largely consistent with using the whole set of seven IVs. Those regression outputs are available from the authors upon request.

[27] In a separate sensitivity study we test whether the full set of IVs is jointly strong enough to predict each of the potentially endogenous repressors, following a procedure as described in Angrist & Pischke (2008, p. 218). We find that the joint set of IVs can significantly predict each of the endogenous repressors.

Table 4: 2SLS regression output, applying all 7 Instrumental Variables

a. 1st stage results

Estimated IV Model	1					2	3	4	5	6
Pre-school quality factors	Number of staff members per child	Share of male staff members	Share of staff with a ped. educ.	Share of non-native staff members	Stability of staff	Number of staff members per child	Share of male staff members	Share of staff with a ped. educ.	Share of non-native staff members	Stability of staff
Instrumental variables										
County aggregate: Number of staff members per child	0.78*** [12.12]	0.03 [-0.33]	0.14 [1.12]	0.05 [1.00]	0.76*** [5.03]	0.78*** [12.12]	-0.03 [-0.33]	0.14 [1.12]	0.05 [1.00]	0.75*** [5.03]
County aggregate: Share of male staff members	0.17*** [3.51]	0.89*** [11.05]	-0.21** [-2.19]	-0.06 [-1.43]	-0.51*** [-4.37]	0.17*** [3.51]	0.89*** [11.05]	-0.21** [-2.19]	-0.06 [-1.43]	-0.51*** [-4.37]
County aggregate: Share of staff with a pedagogic education	0.04** [1.91]	0.09*** [3.20]	0.98*** [26.55]	0.04* [1.83]	-0.51 [-0.85]	0.04*** [1.91]	0.09*** [3.20]	0.98*** [26.55]	0.04* [1.83]	-0.04 [-0.85]
County aggregate: Share of non-native staff members	-0.15*** [-4.69]	-0.02 [-0.37]	0.09* [1.64]	0.58*** [15.37]	0.07 [1.07]	-0.15 [-4.67]	-0.02 [-0.38]	0.09* [1.64]	0.58*** [15.37]	0.07 [1.07]
county aggregate: Stability of staff	0.23*** [5.52]	0.08 [1.14]	-0.08 [-0.99]	0.13*** [3.66]	0.53*** [5.09]	0.23*** [5.52]	0.08 [1.14]	-0.08 [-0.99]	0.13*** [3.66]	0.53*** [5.09]
Municipal election 1993	-0.02*** [-4.66]	0.02*** [-3.60]	-0.02*** [-2.43]	-0.04*** [-9.32]	0.02** [2.01]	-0.02*** [-4.66]	0.02*** [-3.60]	0.02** [-2.43]	-0.03*** [-9.32]	0.02** [2.01]
GAPS 1995 (for age 3-6)	-0.01*** [-7.49]	-0.00** [-2.48]	-0.01*** [-3.58]	-0.00 [-1.54]	0.02*** [10.34]	-0.01*** [-7.49]	-0.00** [-2.48]	-0.01*** [-3.58]	-0.00 [-1.54]	0.02*** [10.34]
Change child pop. 1995-96 (age 3)	0.00*** [-6.48]	0.00*** [-8.66]	0.00*** [4.40]	-0.00 [-1.97]	0.00*** [5.86]	0.00*** [-6.48]	-0.00*** [-8.66]	0.00*** [4.40]	-0.00** [-1.97]	0.00*** [5.86]
1. F-test for joint significance of the instruments	F=11.79 p=0.00	F=18.12 p=0.00	F=13.84 p=0.00	F=8.59 p=0.00	F=6.73 p=0.00	F=11.79 p=0.00	F=18.12 p=0.00	F=13.85 p=0.00	F=8.58 p=0.00	F=6.73 p=0.00
	IVs (marginally) strong					IVs strong	IVs strong	IVs strong	IVs (marginally) strong	IVs less strong
2. Test for over-identifying restrictions	χ^2=3.38 p=0.34 IVs valid					χ^2=12.62 p=0.08 IVs valid	χ^2=9.53 p=0.22 IVs valid	χ^2=15.60 p=0.03 IVs not valid	χ^2=10.74 p=0.15 IVs valid	χ^2=11.30 p=0.13 IVs valid

Note: Robust t-statistics in parentheses; * significant at 10% level (|t|>1.64), ** at 5% level (|t|>1.96); *** at 1% level (|t|>2.58). A critical F value for the test for joint significance of the IVs is 10 (as stated, for example, in Baum, Schaffer & Stillman 2003).

b. 2nd stage results

Dependent variable:
Written final exam in Danish language skills at 9th grade (end of elementary schooling) in 2008, standardised scores (mean 100, std.dev. 15)

	1		2		3		4		5		6	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Pre-school quality												
Number of staff members per child	2.55* [1.73]	-5.63 [-0.36]	2.06 [1.46]	11.07 [1.40]								
Share of male staff members	1.89** [2.09]	5.56 [0.46]			1.76** [2.01]	9.14** [2.07]						
Share of staff with a pedagogic education	1.93*** [2.58]	0.36 [0.08]					1.59** [2.18]	-0.14 [-0.03]				
Share of non-native staff members	1.72 [1.31]	24.18* [1.85]							1.66 [1.27]	18.64** [1.78]		
Stability of staff	0.29 [0.38]	-7.63 [-0.77]									-0.06 [-0.09]	-8.51* [-1.69]
Peer group	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Child characteristics	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Family background	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Constant	109.79*** [48.71]	118.93*** [15.31]	111.08*** [50.92]	111.40*** [32.17]	111.46*** [51.83]	113.23*** [41.81]	111.12*** [51.68]	114.48*** [39.35]	111.12*** [51.68]	113.45 [41.59]	111.70*** [51.12]	120.10*** [28.08]
Observations	30444	20501	30444	20501	30444	20501	3044]	20501	30444	20501	30444	20501

Note: Robust t- and z-statistics in parentheses, clustered at individual pre-school level (=2275 clusters); * significant at 10% level (|t or z|>1.64), ** at 5% level (|t or z|>1.96); *** at 1% level (|t or z|>2.58).

c. Post-estimation model tests

Estimated IV Model	1	2	3	4	5	6
3. Wooldridge's test of exogeneity of instrumented variables	F=1.22 p=0.29 Exog.	F=1.38 p=0.24 Exog.	F=2.39 p=0.12 Margin. endog.	F=0.12 p=0.73 Exog.	F=2.86 p=0.09 Margin. endog.	F=3.17 p=0.08 Margin. endog.
4. Hausman test for no systematic differences between IV and OLS	χ^2=34.43 P=0.08 No signif. diff.	χ^2=28.91 p=0.09 No signif. diff.	χ^2=31.06 p=0.05 Signif. diff.	χ^2=27.59 p=0.12 No diff.	χ^2=30.29 p=0.07 Margin. signif. diff.	χ^2=30.51 p=0.06 Margin. signif. diff.
Interpretation of estimation results	Prefer OLS	Prefer OLS	Prefer IV	Prefer OLS	Prefer IV	Prefer IV

For the specification of the full model (1), the results of the 2SLS estimation show that the quality indicators are not significant, except the share of non-native staff which shows a strong positive effect at a 10% significant level. The instrumented variables are exogenous in this specification according to Wooldridge's test of exogeneity. Moreover, the Hausman test does not point to systematic differences in the OLS and 2SLS estimates and thus suggests that OLS regression is the preferred estimation method. When we analyse our five quality indicators separately, the same holds for the specification for the number of staff per child (model 2) and the share of pedagogic staff (model 4). However, in the cases in which the Hausman test detects no differences between the 2SLS and OLS coefficients, it could be due to a lack of power.

The 2SLS results confirm the positive long-term effects of a higher share of male and non-native staff (models 3 and 5). For those models we find that the 2SLS estimates might correct for endogeneity in the quality factors. In fact, the 2SLS estimates are *higher* than the corresponding OLS estimates.

Whereas we could not find significant effects of the staff stability in an OLS specification, the 2SLS regression provides causal evidence of a stronger negative effect (see model 5). This could be due to the fact that the IVs are less strong in predicting this quality indicator.

The negative effect found for staff stability counters our initial expectation. We can only speculate for potential reasons. One potential explanation is that institution has a core staff which changes only little over time. In that case, a high turnover rate reflects that a pre-school is flexible in adjusting to current staffing needs. So in that way high staff stability reflects an inflexible employment scheme at the centre, which does not necessarily attract the most competent teachers.

6.3. Size of effects

To compare the effects across indicators, we study the effects from the OLS and IV estimations.[28] The IV estimates are somewhat higher than the OLS estimates. We report the size of our estimated effects as intervals given by the OLS and IV estimates, respectively. The main effects for a unit change in the five quality indicators range around 2-4 standardised points in the OLS estimations, and somewhat larger, namely 0-19 standardised points in the IV estimations.

For instance, an increase in the staff-to-child ratio of around one standard deviation (0.065 – which corresponds to a 30% increase in teacher resources) implies an increase in the standardised score of 0.17-0.72 (corresponding to an interval between 2.55*0.065 and 11.1*0.065). For the average pupil with an average test score at around 6.6 on the Danish grade scale, this translates into an increase in grades of 0.01-0.05. Hence, a substantial increase in teacher resources is associated with a rather modest increase in grades. However, one should note that almost 40% of the pupils received the grade 7 in written Danish. For comparison, across schools in the same area/municipality, "raw" average grade points (not controlling for background factors) often vary by about 0.1-0.5. For boys, the corresponding increase in grades doubles in the OLS specification (0.02 compared to 0.01), but interaction terms are insignificant in the IV specification.

An increase in the male share of the staff of one standard deviation (i.e. from a 10 to a 22% male share) implies an increase by 0.01-0.06 grade points (corresponding to OLS and IV estimates, respectively). Again, the effect is higher for boys in the OLS specification. Hence, the effect doubles for boys, and for poor boys, the higher male staff is associated with a difference in grade points of around six times the overall effect found in the OLS estimations.

An increase in trained staff by one standard deviation of 0.12 (from 45 to 57%) would imply an increase in the standardised score of 0.23 (=1.9*0.12) corresponding to 0.02 grade points.

We also found significant effects of the share of non-native teachers in the staff. Hence, an increase in the share of non-native teachers from around 4 to around 7% of the teachers is associated with a 0.02-0.09 higher grade point in written Danish.

We did not find any significant effect of higher staff stability in general. However, for non-native children, we find a substantial effect of more stability: An increase in staff stability of one standard deviation (implying a reduction in teacher turnover per year from 33 to 20%) translates into a 0.05 higher grade on the Danish grade point scale.

For comparison, being a girl rather than a boy is associated with a 0.42 higher grade in written Danish, having a parent with medium instead of lower education is associated with a 0.35 higher grade, and coming from a nuclear family instead of a single earner household implies a 0.10 higher grade for the average child.

7. Discussion and conclusion

Policymakers in many OECD countries consider extending early childhood care and education towards systems of (near) universal access through substantial public subsidies. Promoters of such

[28] Each coefficient of the explanatory variables is recalculated in terms of how much a standard error change in the variable changes the outcome variable. The effects of each explanatory variable can therefore be compared directly. The standardised beta coefficients are based on the same OLS regression specification. As the beta option cannot be combined with clustering, we use instead the robust option for the standard errors. The full outputs with standardised beta coefficients are available from the authors upon request.

extension policies argue that early investments in pre-schooling can lead to substantial gains in a country's human capital in the long-run, citing promising evaluation results from intensive, targeted early childhood investments. More universal access to such early investments also has a potential to reduce inequality in later child outcomes. Equalisation is reached not only through granting access to important development stimuli to children who might be deficient of such stimuli at their home environment, but also through early exposure to a diverse peer group. In this paper, we add unique exploratory evidence regarding important quality factors which need to be addressed in pre-schools to reach persistent development gains, in particular for disadvantaged children. We find some evidence of peer group effects since the pre-school's share of children with low educated parents is strongly and negatively related to child outcomes.

Pre-school quality constitutes of a wide range of factors. We focus on five quality factors: 1) the number of staff members per child (i.e. the staff-per-child ratio), 2) the share of male staff members, 3) the share of staff with a pedagogic education, 4) the share of non-native staff members, and 5) the stability of staff per institution compared to the previous year. Needless to say, these indicators do not capture all aspects of quality in pre-schools, but the merits of our chosen indicators lie in that they are objectively measurable and comparable across pre-schools and municipalities.

Overall, we find significant relationships between our pre-school quality indicators and children's Danish language skills, even after inclusion of various controls for the child's background. The importance of quality is shown by the fact that even 10 years after children's pre-school experience effects are still visible. The number of staff per child and the shares of male staff, pedagogic staff and non-native staff have a significant, positive impact on child development. Boys benefit more from a higher number of staff per child and a higher share of male staff, whereas non-native children benefit from a higher stability of the staff body. This indicates that pre-school quality factors contribute to equalise outcomes for boys and non-native children.[29]

Our evidence on quality impacts results from an evaluation of experienced quality variation across children who attended pre-schools in the second half of the 1990s. Thus, the results do not necessarily apply to the 10-15% of children in 1998 who attended other forms of care during pre-school ages than pre-school kindergarten or age-integrated institutions. Children with 'alternative' childcare experiences would most likely benefit from pre-schooling in particular of high quality. In that case, we may underestimate the true effects. Moreover, as effect evaluation methods rule out controlling for children's development after the pre-school, we cannot identify which part of child outcomes is the result of pre-school quality and which part was caused during the subsequent school career, e.g. if a better schooling choice is the result of a successful pre-school experience.

Our results are in line with the literature which finds positive long-term impacts of pre-school attendance (e.g. Baker et al. 2008; Berlinski et al. 2009; Berlinski et al. 2008; Deming 2009; Dumas & Lefranc 2010; Felfe & Lalive 2010; Havnes & Mogstad 2009). While those papers evaluate the effects of pre-schooling in general, we add new evidence of the effects of variation in pre-school quality. Moreover, we find that effects are not the same for all children across heterogeneous socioeconomic backgrounds and characteristics. Our results provide, for example, some support for the finding that boys benefit more from higher quality of childcare (e.g. Datta Gupta & Simonsen 2010). Contrary to Chetty et al. (2010) who argue that the effect of higher quality on cognitive development fades out after a few years, we find persistent quality returns even at the end of elementary school.

Our study illustrates that the quality of daycare has a lasting – albeit numerically modest – impact on child cognitive outcomes. The fact that we find long-lasting effects of pre-school even after 10 years of schooling is quite remarkable in an international context.

[29] Our results are based on linear estimations. A non-linear estimation of subgroup effects might reveal more information about policy targeting to specific disadvantaged subgroups.

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Dansk sammenfatning

Langtidsgevinster af adgang til dagpasningstilbud af høj kvalitet

Samfundsvidenskaberne anerkender i stigende grad betydningen af børns tidlige udvikling i formningen af deres kognitive og ikke-kognitive evner og helbred. En måde at bryde negativ social arv er at tilbyde børn fra alle sociale baggrunde adgang til dagpasningstilbud af høj kvalitet. Dette papir undersøger, hvorvidt børnehavers kvalitet har betydning for børns kognitive og sproglige udvikling ved afslutningen af folkeskolen.

Analysen er baseret på et enestående datasæt baseret på danske administrative registre. Data indeholder oplysninger om børnehavebørn og pædagoger. Baseret på disse data genererer vi fem kvalitetsindikatorer for børnehaver: 1) personale-til-børn-raten (antal pædagoger og -medhjælpere pr. barn), 2) andelen af mandlige pædagoger og -medhjælpere i børnehaven, 3) andelen af uddannede pædagoger i børnehaven, 4) andelen af personale med anden etnisk baggrund end dansk og 5) stabiliteten af personalestaben i den enkelte børnehave (omvendt proportional med personaleomsætning i børnehaven). Børns udvikling måles ved deres eksamensresultater ved folkeskolens afsluttende prøve i skriftlig dansk 9. klasse.

Vore forskningsspørgsmål er følgende: Hvor meget varierede kvaliteten målt ved de fire kvalitetsindikatorer for børnehaver i sidste halvdel af 1990'erne? Er børnenes 9. klasses eksamensresultater i skriftlig dansk korreleret med disse kvalitetsmål? Er det muligt at påvise en årsagssammenhæng mellem børnehavers kvalitet og eksamensresultater ved afslutningen af folkeskolen?

Når vi kontrollerer for børns baggrund, finder vi, at et højere antal pædagogisk ansatte pr. barn, en højere andel af mandlig stab, en højere andel af personale med pædagogisk uddannelse samt en højere andel af personale med anden etnisk baggrund end dansk er forbundet med signifikant – om end moderat – højere eksamensresultater for børn i 9. klasse.

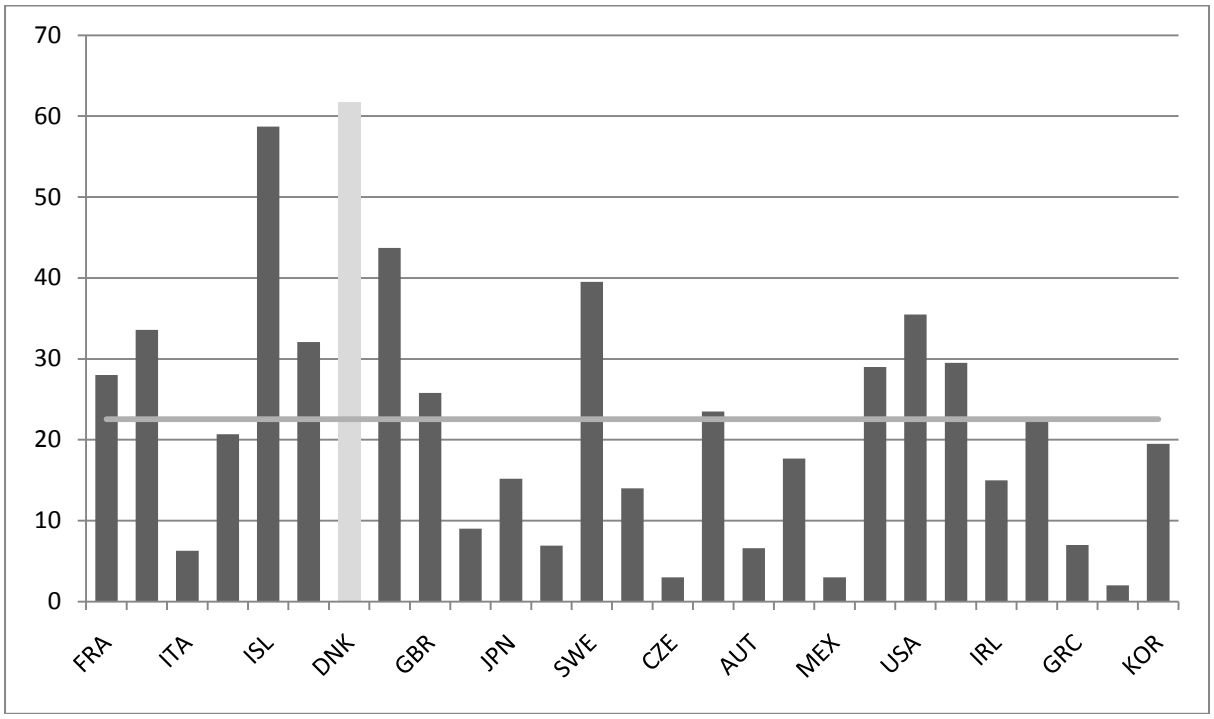
Vi analyserer også, hvilke grupper af børn som har størst – og mindst – udbytte af dagpasning af høj kvalitet. Vi finder, at drenge har mere gavn af højkvalitetsbørnehaver end piger, mens effekterne er relativt lavere for børn fra familier med lav indkomst. Endvidere har børn med anden etnisk baggrund udbytte af en lavere personaleomsætning.

Den empiriske model estimeres ved hjælp af mindste kvadraters metode (OLS) og instrument-variabel-estimation. For de fleste kvalitetsindikatorer viser instrument-variabel-estimation signifikant positive effekter, som er numerisk højere end OLS-estimaterne.

APPENDIX A

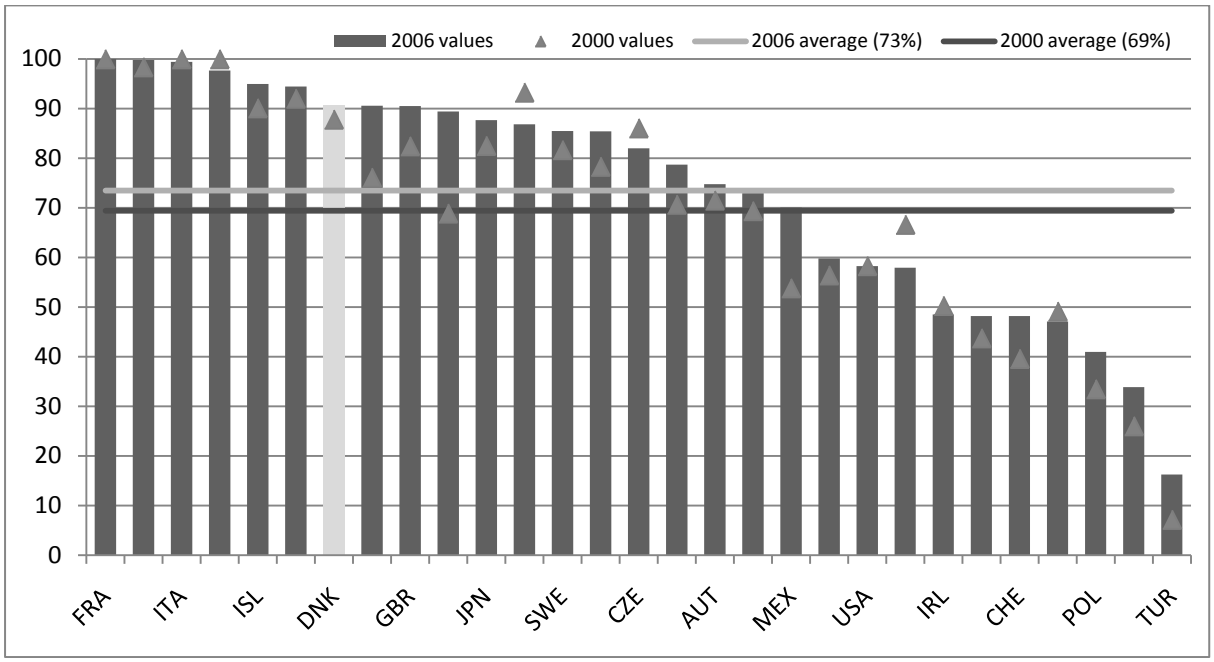
Figure A-1: Average pre-school enrolment across OECD countries

a. Average enrolment of children aged <3 in formal childcare, 2005 (or latest available)



Source: OECD (2009).

b. Average enrolment of children aged 3-5 in pre-school, 2000 and 2005



Source: OECD (2009).

Table A-1: Descriptive statistics

a. Control variables

Control variable	Variable name	N	Mean	Std. dev.	Min.	Max.
Share of boys in attended pre-school	peer_gender_male	30444	0.519	0.067	0.2	0.9
Share of non-native children	peer_nonnative	30444	0.058	0.103	0.0	1.0
Share of children with single parents	peer_singleparent	30444	0.204	0.107	0.0	0.8
Share of children with low educated parents	peer_par_educ1	30444	0.122	0.090	0.0	0.6
Share of children from poor households	peer_hhpoor	30444	0.043	0.057	0.0	0.6
Length of attendance at last pre-school (in years)	last_presch_spell	30444	2.661	0.862	1.0	4.0
Gender (boy = 1)	gender_male	30444	0.499	0.500	0.0	1.0
Age (in 1998)	age	30444	6.076	0.342	4.0	9.0
Non-native (not born by Danish born citizen = 1)	nonnative	30444	0.062	0.241	0.0	1.0
Parenthood (single parents = 1)	singleparent	30444	0.196	0.397	0.0	1.0
Number of children in household (in 1998)	child_count_all	30444	2.193	0.759	0.0	10.0
Mother's age (in 1998)	m_age	30444	34.968	4.569	21.0	53.0
Maternal unemp. (annual days à 8 hrs in 1998)	m_unempl_days	30444	9.019	22.176	0.0	125.0
Highest par. education (elem. educ.)	par_educ1	30444	0.101	0.301	0.0	1.0
Highest par. education (sec. educ./voc. training)	par_educ2	30444	0.483	0.500	0.0	1.0
Highest par. education (low. ter. educ.)	par_educ3	30444	0.081	0.274	0.0	1.0
Highest par. education (mid. ter. educ./bachelor)	par_educ4	30444	0.221	0.415	0.0	1.0
Highest par. education (high. ter. educ.)	par_educ5	30444	0.114	0.318	0.0	1.0
Gross hh-income (logarithmic scale, in 1998)	hh_inc_gross_log	30444	13.822	1.064	3.5	19.3

b. Quality indicators across subgroups of children

Control variable	Category value	Variable name	N	Mean	Std. dev.	5% t-test
staff_per_child						
gender (boy = 1)	0	gender_male	15243	0.228	0.065	difference not significant
	1		15201	0.227	0.064	
Non-native origin (not born by Danish born citizen = 1)	0	nonnative	28557	0.227	0.064	difference significant
	1		1887	0.245	0.069	
parenthood (single parents = 1)	0	singleparent	27363	0.228	0.064	difference significant
	1		3076	0.227	0.066	
highest par. Education (elem. educ.)	0	par_educ1	24466	0.227	0.064	difference significant
	1		5978	0.232	0.066	
Bottom decile of gross hh-income (in 1998)	0	hh_poor	29453	0.227	0.064	difference significant
	1		991	0.244	0.069	
pct_male_staff						
gender (boy = 1)	0	gender_male	15243	0.121	0.104	difference not significant
	1		15201	0.121	0.105	
Non-native origin (not born by Danish born citizen = 1)	0	nonnative	28557	0.120	0.104	difference significant
	1		1887	0.143	0.112	
parenthood (single parents = 1)	0	singleparent	27363	0.121	0.104	difference significant
	1		3076	0.120	0.107	
highest par. Education (elem. educ.)	0	par_educ1	24466	0.119	0.103	difference not significant
	1		5978	0.129	0.110	
Bottom decile of gross hh-income (in 1998)	0	hh_poor	29453	0.120	0.103	difference significant
	1		991	0.149	0.110	
pct_ped_staff						
gender (boy = 1)	0	gender_male	15243	0.452	0.120	difference significant
	1		15201	0.454	0.121	
Non-native origin (not born by Danish born citizen = 1)	0	nonnative	28557	0.454	0.121	difference significant
	1		1887	0.431	0.117	
parenthood (single parents = 1)	0	singleparent	27363	0.454	0.121	difference significant
	1		3076	0.449	0.121	
highest par. Education (elem. educ.)	0	par_educ1	24466	0.454	0.121	difference significant
	1		5978	0.447	0.124	
Bottom decile of gross hh-income (in 1998)	0	hh_poor	29453	0.453	0.121	difference significant
	1		991	0.439	0.112	
pct_nonnative_staff						
gender (boy = 1)	0	gender_male	15243	0.042	0.072	Difference not significant
	1		15201	0.043	0.071	
Non-native origin (not born by Danish born citizen = 1)	0	nonnative	28557	0.039	0.067	difference significant
	1		1887	0.094	0.111	
parenthood (single parents = 1)	0	singleparent	27363	0.041	0.070	difference significant
	1		3076	0.049	0.077	
highest par. Education (elem. educ.)	0	par_educ1	24466	0.041	0.070	difference significant
	1		5978	0.054	0.085	
Bottom decile of gross hh-income (in 1998)	0	hh_poor	29453	0.042	0.071	difference significant
	1		991	0.065	0.092	
staff_stability						
gender (boy = 1)	0	gender_male	15243	0.671	0.137	difference not significant
	1		15201	0.669	0.137	
Non-native origin (not born by Danish born citizen = 1)	0	nonnative	28557	0.671	0.137	difference significant
	1		1887	0.651	0.137	
parenthood (single parents = 1)	0	singleparent	27363	0.670	0.137	difference significant
	1		3076	0.668	0.136	
highest par. Education (elem. educ.)	0	par_educ1	24466	0.671	0.137	difference not significant
	1		5978	0.665	0.137	
Bottom decile of gross hh-income (in 1998)	0	hh_poor	29453	0.670	0.137	difference significant
	1		991	0.650	0.133	

Table A-2: Danish grades and the averages of their standardised scores

Danish exam grade		Average standardised scores	Frequency
-3	Unacceptable	50.15	46
0	Inadequate	65.86	601
2	Adequate	76.33	4471
4	Fair	86.80	13766
7	Good	102.50	20037
10	Very good	118.21	11172
12	Excellent	128.68	2569

Table A-3: Aggregated pre-school quality averages across Danish counties

	Municipalities [a]	Observations	Number of staff members per child	Share of male staff members (0-1 scale)	Share of staff with a peda-gogic education (0-1 scale)	Share of non-native staff (0-1 scale)	Stability of staff
	N	N	mean	mean	mean	mean	mean
Bornholm	5	332	0.249	0.106	0.365	0.023	0.697
Copenhagen Capital Region [b]	20	6368	0.250	0.155	0.421	0.074	0.650
Frederiksborg	19	2672	0.230	0.109	0.453	0.047	0.692
Fyn	32	2096	0.230	0.127	0.472	0.021	0.662
North Jutland	27	1933	0.203	0.098	0.490	0.025	0.653
Ribe	14	820	0.200	0.063	0.505	0.018	0.715
Ringkjøbing	18	824	0.190	0.102	0.440	0.013	0.661
Roskilde	11	1459	0.231	0.075	0.376	0.052	0.700
South Jutland	23	1923	0.214	0.078	0.478	0.062	0.705
Storstrøm	24	1674	0.218	0.100	0.460	0.022	0.712
Vejle	16	2207	0.206	0.123	0.479	0.025	0.661
Viborg	17	1015	0.211	0.100	0.476	0.019	0.668
West Zealand	23	2334	0.207	0.096	0.453	0.035	0.674
Århus	26	4787	0.247	0.158	0.467	0.039	0.649
Range of mean values			0.190-0.250	0.063-0.158	0.365-0.505	0.013-0.074	0.649-0.715

[a] Geographic division as it was valid before the 2006/2007 reform, 275 municipalities in total. No information available for the municipalities of Christiansø, Ærø, Brovst, Hals, Læsø, Thyborøn-Harboør and Hanstholm which all have small child-populations.

[b] Includes the municipal regions Copenhagen and Frederiksberg.

Table A-4: Quality difference of conservative municipalities (based on 1993 election)

	Observations	Number of staff members per child	Share of male staff members (0-1 scale)	Share of staff with a ped. education (0-1 scale)	Share of non-native staff (0-1 scale)	Stability of staff
	N	mean	mean	mean	mean	mean
Non-conservative majority	21518	0.231	0.125	0.456	0.045	0.668
Conservative majority	8926	0.220	0.111	0.447	0.036	0.673
5% t-test		difference significant	difference significant	difference significant	difference significant	difference significant

Table A-5: Municipal child population aged 3, %-change from 1995 to 1996 by centile

	Observations	Number of staff members per child	Share of male staff members (0-1 scale)	Share of staff with a ped. education (0-1 scale)	Share of non-native staff (0-1 scale)	Stability of staff
	N	mean	mean	mean	mean	mean
1st Centile	3102	0.227	0.104	0.435	0.069	0.673
2nd Centile	3021	0.227	0.112	0.471	0.037	0.663
3rd Centile	3108	0.218	0.124	0.425	0.052	0.672
4th Centile	3038	0.226	0.106	0.463	0.044	0.687
5th Centile	3157	0.257	0.174	0.451	0.048	0.623
6th Centile	3977	0.239	0.160	0.442	0.058	0.658
7th Centile	2057	0.224	0.121	0.451	0.044	0.686
8th Centile	2927	0.223	0.115	0.451	0.048	0.667
9th Centile	3113	0.216	0.096	0.473	0.032	0.673
10th Centile	2942	0.216	0.084	0.472	0.025	0.706
Value ranges		0.215-0.257	0.085-0.174	0.425-0.473	0.025-0.069	0.623-0.706

Table A-6: Availability of guaranteed pre-school place scheme in municipality

Provision of a guaranteed pre-school scheme for the age group 3-6 by the municipality in 1995	Observations	Number of staff members per child	Share of male staff members (0-1 scale)	Share of staff with a ped. education (0-1 scale)	Share of non-native staff (0-1 scale)	Stability of staff
	N	mean	mean	mean	mean	mean
NO	5817	0.243	0.129	0.448	0.048	0.647
YES	14684	0.231	0.125	0.444	0.044	0.667
5% t-test		difference significant	difference significant	difference significant	difference significant	difference significant

Note: We use GAPS information provided by an inventory of Glavind (2007). Our indicator checks whether GAPS was provided to the pre-school age group 3-6 in the year 1995 when the majority of the studied children got enrolled at pre-school. For a number of municipalities no information on GAPS was available, reducing the sample size to N=20499. There is no indication that the lack of GAPS information is systematically correlated with the treatment or outcome variables.

Long-Run Benefits from Universal High-Quality Pre-Schooling

This paper examines whether pre-school quality is important for children's cognitive and language development at the end of elementary schooling (at the age of 16). We use a unique data set based on Danish administrative registers where pre-school children are linked to their pre-school and its pre-school teachers. Based on this, we generate five main quality indicators of pre-schools. Child outcomes are test scores from final (9th grade) elementary school exams in written Danish. Controlling for child background factors, we find that a higher number of staff members per child, a higher share of male staff and of staff with a pedagogic education, and a relatively higher share of teachers with non-native Danish background lead to significant improvements in children's test results in Danish at the end of 9th grade. Boys benefit more from pre-school quality than girls; non-native children benefit from a lower staff turnover. We take care of possible selectivity by using instrumental variables estimation. For the number of staff members per child and the share of male staff, IV estimates show significant positive effects, which are generally numerically higher than the OLS estimates.

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