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Extracurricular educational programs and school readiness: evidence from a quasi-experiment with preschool children

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Abstract

This paper adds to the literature on extracurricular early childhood education and child development by exploiting unique data on an educational project in Germany, the Junior University (JU). Utilizing a quasi-experimental study design, we estimate the causal short-term effect of JU enrollment on cognitive outcomes and show that attending extra science courses with preschool classes leads to significantly higher school readiness. Although the size of the effect is relatively small, the results are plausible and pass various robustness checks. Moreover, in comparison with other programs this intervention is cost-effective.

Keywords: early childhood education, early interventions, school readiness

JEL Classification: I20, I21, I28, J13

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1. Introduction

Early childhood conditions and development have been shown to be of great importance for educational attainment, earnings, and the probability of employment (Almond/Currie 2011). Early investment yields high returns, as has been argued in a fast growing literature (among others Cunha et al. 2006; Currie 2001; Barnett 1995; Duncan/Magnuson 2013; Lochner 2011). Moreover, negative shocks in early childhood result in greater long-term damage if the child has a disadvantaged background (Currie/Hyson 1999). Whether early disadvantages can be cured, and in particular whether they can be cured by early intervention programs, is still an open question. However, there is some evidence that they can (Duncan/Magnuson 2013; Ruhm/Waldfogel 2012; Belfield et al. 2006; Heckman et al. 2010; Deming 2009). International studies find long-lasting effects of child care on attainment and other non-schooling outcomes (Heckman/Raut 2013), even if the effect of child care on cognitive test scores might not be long-lasting (Blau/Currie 2006). While education policy and schooling laws, as well as the quality and structure of formal child care and schooling have been on the agenda for several years (e.g. Hanushek 1997, 2003; Krueger 2003; Eberts/Hollenbeck/Stone 2002; Lavy 2002), additional voluntary (educational) activities have not yet been a focus of research. Although leisure activities like sports (outside the kindergarten, preschool or school setting) and their effects on educational attainment have been studied (e.g. Stevenson 2010; Pfeifer/Cornelißen 2010; Felfe/Lechner/Steinmayr 2011), the effects and channels of other out-of-school activities have not yet been fully understood or evaluated. Moreover, since extracurricular educational activities cause additional costs, it is not enough to identify positive effects; issues of cost effectiveness also arise.

In addition to the question of the impact and effectiveness of voluntary early childhood education programs, it is unclear how to organize them. For instance, if the goal is to foster children’s interest in science, should early science education take place in kindergarten, or should it, at least to a certain extent, be centralized? Moreover, preschool educators (here broadly referred to as 'teachers') are not science experts, which could well be an argument for centralized preschool science education. Nor are science labs typically part of a kindergarten's endowment. Hence, there may be cost as well as learning advantages in centralizing early childhood science education - for example in a specialized regional organization.

An example of an initiative to bring science into the kindergartens by educating preschool teachers - hence, a decentralized approach - is the 'Haus der kleinen Forscher' (House of the little scientists), supported by the Federal German Ministry of Education and Science (Bundesministerium für Bildung und Forschung, BMBF) with a grant of almost €8 million in 2012.[1] However, there has as yet been no evaluation of either the causal effects or cost effectiveness of this major program. An alternative, in particular for more densely populated urban regions, may be a greater centralization of extracurricular science education, which may explain the existence of science labs for children and adolescents and children's universities in many countries.[2] These institutions offer classes to foster interest in science and research. Typically the courses are short, e.g. single courses during school vacations or after school and target children in primary or secondary school. Whether attending these science classes has a positive effect on schooling, let alone later-life educational and labor

[1] The 'Haus der kleinen Forscher' is a joint initiative of the Federal Ministry and the Telekom foundation (the annual report 2013 is available at: http://www.haus-der-kleinen-forscher.de/fileadmin/Redaktion/4_Ueber_Uns/Stiftung/Jahresbericht_2013.pdf.)

[2] For example HandsOn Science in the UK and US, ScienceLab Kinder.Wissen.Mehr in Germany (Schettler 2010). Children's universities can be found across Europe, especially in Germany and the UK.

market outcomes, is an open question. The evaluation of voluntary extracurricular programs is often impeded by selectivity issues, as the participation decision is not random. And with short courses largely unrelated to school life and lacking any form of sanction, children can opt out easily once they lose interest. Thus it is unclear whether brief stimuli of this sort haven any causal direct or indirect effects, and, if so, how they could be identified.

The present paper adds to the literature on voluntary and extracurricular early childhood education and child development by exploiting a quasi-experimental setting in an educational project in Germany. The Junior University[3] (JU) is a non-profit educational institution fully financed by private donations and explicitly intended as complementary to kindergarten[4] and school. In this paper we study the short-term effect of JU enrollment on the school readiness of children. To measure JU's return to educational outcomes we use data from different sources. In addition, we exploit a quasi-experimental design to estimate a causal effect. Our results show that attending JU leads to higher school readiness, i.e. an enhancement of both cognitive and non-cognitive abilities. Although the effect of JU attendance on school readiness is relatively small, the results are plausible and pass various robustness checks. In addition, we provide evidence for the effectiveness of extracurricular preschool education.

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[3] Full name: *Junior Uni - Wuppertaler Kinder- und Jugend-Universität für das Bergische Land gGmbH* (gGmbH = non-profit company with limited liability). More information (in German) on the Junior University is available at www.junioruni-wuppertal.de.

[4] Most children in Germany attend *kindergarten* at age three and leave at age six, when primary school begins. The last year in kindergarten is called *preschool (class)*. Hence, in comparison with the US, the terms kindergarten and preschool are used the other way round.

The paper is organized as follows: in Section 2 we present further details about the Junior University. Section 3 describes the data, and in Section 4 we discuss our empirical strategy. Section 5 presents the results, robustness checks and some tentative cost benefit analyses. Finally, Section 6 makes some concluding remarks and briefly discusses the results.

2. The Junior University

The Junior University (JU) was launched in December 2008 as a permanent private non-profit institution, entirely financed by private donations. It is located in Wuppertal, a city with a population of about 350,000 in the German federal state of North Rhine-Westphalia. The JU offers courses for children and adolescents with a focus on science, mathematics, and engineering. Its pedagogical concept was developed by a physics professor well known in Germany for the TV science show 'Löwenzahn' he created for children and his wife, a school teacher familiar with teaching disadvantaged children.

The JU aims to raise children's and young people's interest in science by offering mainly hands-on experimental courses. Unlike other children's universities in Germany, it is not a temporary institution within a University but a permanently established independent body. Furthermore, it is explicitly not targeted only at gifted or advantaged students, but addresses all children between the age of 4 and 20 (usually until the end of secondary school), independent of their educational or social background. The courses offered run in sets of four, six, or eight 90 minute units, either on a weekly basis or as full-day courses. They address different age groups (4-6, 7-10, 11-14, and 14 and older) and are taught not by school-teachers, but by university professors, undergraduate and graduate students, local entrepreneurs, or citizens with special interests and skills. The course fee is low, varying between €5 and €10 depending on the course duration, even though this nowhere near covers costs. The low fee was chosen to attract children from low-income families but if families cannot pay even this fee, a private sponsor (e.g. a local company) will cover the costs. Hence, there are no financial entry barriers for children from low-income families.

Enrollment at JU can be either as a single student or as a group - the latter form is popular, in particular, among kindergarten preschool classes (last year before primary school entry). For instance, from December 2008 through spring 2012 the JU offered 1,091 courses and received 13,648 applications. Since the courses are quite popular, with the number of applicants exceeding the number of places each year, allocation is on a first come first served basis. However, slots for preschool classes have not so far been limited, and almost a quarter (21.26%, 232 courses) of the courses were offered for preschool groups with a total number of 2,964 registered preschool children.

Since our focus here is on preschool education, we will restrict our attention to kindergarten children who attend JU with the entire preschool class and preschool teacher. In 2011 Wuppertal had 185 daycare institutions (comprising both private parental initiatives and public kindergartens) of which 84 participated in JU courses with at least one preschool class. Hence, a problem in our identification strategy may arise here due to the selectivity of the participating kindergartens, as this might lead to a selective group of participating children. The heterogeneity of the districts in Wuppertal, as well as the level of ethnic and social segregation, is high, with some kindergartens located in highly disadvantaged areas of the city, and others not. However, the 84 participating kindergartens do not represent a positive selection from the total available set. For instance, there is no significant difference in the distance from kindergarten to JU between participating and non-participating institutions. The average share of immigrant children in the participating kindergartens is 0.32 (where minimum is = 0 and maximum is = 1), whereas the average share in the remaining kindergartens is 0.31. Moreover, socioeconomic status variables, like average disposable income or share of welfare recipients don't differ between participating and non-participating kindergartens, too. However, among participating kindergartens there is still substantial heterogeneity, e.g. in the share of immigrant children.

3. Data

To estimate the short-term causal effect of JU attendance on cognitive and non-cognitive abilities before school entry we generated a unique dataset that allows us to distinguish between the treatment group (children enrolled at JU with the entire kindergarten preschool class) and the control group (peers from the same kindergarten who did not participate) in a quasi-experimental setting. The data stems from various sources and includes individual level information, residential city block information and income information on a postal code level. Data on individuals is drawn from the *Schuleingangsuntersuchung* (SEnMed - school entrance medical examination) a compulsory standardized school readiness assessment that provides information on abilities, kindergarten enrollment and baseline characteristics like age, gender, residence, and ethnic origin. We supplement this with a large set of administrative data on the city block level to describe the children's neighborhood. A city block is a small administrative unit averaging about 150 residents, of which Wuppertal hast some 2,400. This data provides detailed information on ethnicity, employment, and welfare dependency. To further enrich our city block data, we add income indicators that are available on the slightly more aggregated postal code level. The different data sources are described in greater detail in the following sections.

3.1. School entrance medical examination

The school entrance medical examination (SEnMed) is a compulsory standardized examination, undergone at an average age of 5 years and 11 months. As such it serves as a census of all preschool children. It is conducted to assess the previous and current health status and cognitive and non-cognitive abilities of preschoolers in order to attest school readiness. The data includes health status since birth (e.g. birth weight, obesity, ear and eye conditions, social and emotional development) and cognitive and non-cognitive abilities. In addition, individual characteristics like age, gender, residence, and ethnic origin are recorded, as well as information on the kindergarten and the prospective primary school.

In our analysis we use data on two cohorts of 5,669 preschool children born between 2003 and 2005, whose SEnMed took place between 2009 and 2011.[5] The children's abilities were assessed using state-wide standardized tests.[6] Theoretically, the lowest possible score to achieve in the tests is zero (no task completed) and the maximum depends on the number of tasks within a test area. There are nine test areas corresponding to different ability dimensions such as visual and analytical skills, numerical and quantitative skills, language skills, speech, and fine and gross motor skills. Typical tests to assess these different ability areas are the retracing of figures, visual discrimination (finding figures that follow logically from other figures), counting, estimating and comparing quantities, neglect tests to assess visual and selective attention, using prepositions, plural forming and repeating made-up words. Gross motor ability is assessed by asking children to jump on one leg, or to walk on a straight line.

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[5] The first cohort comprises 2,809 children born between 09/01/2003 and 08/31/2004, whose SEnMed took place between mid-August 2009 and mid-July 2010. The second cohort comprises 2,860 children born between 09/01/2004 and 09/30/2005, whose SEnMed took place between September 2010 and July 2011.

[6] The tests are confidential and not available for publication.

On the basis of these test results and the child's health status, physicians decide whether a child should be enrolled in primary school or held back for a year. Hence, for the physicians, the overall test results represent a one-dimensional latent scale of *school readiness*. Following this principle, our analysis reduces the nine dimensions of ability to a one-dimensional scale of school readiness. The scale is generated via an exploratory factor analysis in which we predict a school readiness index using the regression method. The results of the factor analysis confirm the conjecture of a one-dimensional factor, with some 97% of the variance in the ability items explained by the first factor.[7] Therefore we use the factor of school readiness as our outcome variable. To better interpret the estimation results we transform the factor to a scale between 0 and 100. The highest value of school readiness (100%) corresponds to a score of 129 successfully completed tasks.[8] The distribution of school readiness for the full sample (n = 5,669) is shown in Figure 1.

-- Figure 1 about here --

The performance bands in Figure 1 characterize five different groups: the very low performing 5%, low performing 20%, average 50%, high performing 20%, and the very high performing 5%. Average school readiness is 79.7% (SD = 12.6%) and the variable is left-

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[7] The overall KMO criterion is 0.8285; item KMO criteria lie between 0.7070 and 0.9251.

[8] The score of 129 results from the sample and represents the empirical maximum. The highest possible value of school readiness cannot be calculated theoretically, as the range of some test areas is unrestricted (e.g. results of the test for gross motor skills represent the number of attempts within a given time).

skewed. The weakest 5% achieve only 56% school readiness, the medium 50% achieve 74%-89% school readiness.

In addition to information on abilities, there is a large set of baseline variables in the SEnMed data. Table 1, column (1) summarizes the data and in column (2) we differentiate between the available two cohorts. The sample comprises 5,669 children, 51.08% of whom are boys; 36.57% of the children are immigrants, where migration status is defined by the language spoken with the child during the first four years. If the parents report a language other than German, the child is said to have a migration background.

-- Table 1 about here --

On average, the children have attended kindergarten for 2.74 years, which is common in Germany. About 46.60% have one sibling; 4.25% have four or more siblings. The share of overweight or obese children is slightly larger than the share of (severely) underweight children. About 78% have a healthy weight. Table 1 column (2) indicates few significant differences between the two cohorts. The difference in 'age at SEnMed exam' and 'time in kindergarten' is plausible and due to an earlier cutoff date for primary school enrollment in North Rhine-Westphalia in 2011. Due to the earlier cutoff date, the second cohort comprises 13 months of births with on average younger children than those of the first cohort. The significant difference in 'behavioral problems' can be explained by the different sizes of the cohorts. It is not compulsory to assess behavioral problems in the SEnMed, and due to the larger second cohort the assessment was more often omitted (there is a corresponding increase in the category 'examination was not possible'). As there is no apparent explanation for the significant difference in 'partial hearing loss' between the two cohorts, we control for this variable in the estimations.

3.2. *Administrative data on socioeconomic status*

The child's address information is used to match individual data (from the SEnMed) and information on socioeconomic status by assigning every child to the city block or postal code area in which he or she lives. The additional data does not assign children to a specific social group based on socioeconomic status, but indicates the probability of a specific group affiliation. For instance, if 20% of the city block children live in low-income families, a child living in this city block is said to have a 20% probability of living in a low income family. Enriching individual-level data by city block data is important because the SEnMed data does not provide individual-level information on socioeconomic status. Thus, following a pattern established in earlier work (Schneider et al. 2012; Riedel et al. 2010) the city block information is used as a proxy for a child's socioeconomic status. In this way the residential milieu is described by the risk of poverty (defined as the share of welfare-dependent private households[9]), the unemployment rate, the share of immigrants, etc.

Since city block data only indicates low status (like unemployment, poverty, etc.), variables that describe medium or high level socioeconomic status neighborhoods have to be added. Here we use additional data on disposable income per household[10] that differentiates

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[9] In Germany, people in need receive benefit payments either because they are (1) long-term unemployed, or (2) unemployable, or (3) employed but with an income below subsistence level.

[10] The data is provided by the microm GmbH which collates micro-geographical and spatial data for marketing and research purposes at different regional levels (e.g. municipalities or postal code areas).

more clearly between families with higher socioeconomic status. This data is only available for the eight-digit postal code area[11] that covers 368 districts in Wuppertal (Figure 2).

-- Figure 2 about here --

Table 1 also reports descriptive statistics for the city block and postal code variables. The average share of welfare recipients with children per city block is 29.08%, the average share of immigrant children is 53.66%, and the average disposable income amounts to €38.79 thousand per year. The decreasing welfare dependency between the cohorts reflects a global trend: between 2008 and 2010 the overall welfare dependency rate in Wuppertal declined from 20.26% to 18.58%.

4. Empirical strategy

The effect of attending JU courses on school readiness is assessed in this study by taking the two cohorts of preschool children examined in the SEnMed (SEnMed in 2009-2010 and 2010-2011) and applying the one-dimensional factor of school readiness discussed above. By taking children from two cohorts, we can exploit variation *within* kindergartens with respect to JU attendance, because we observe kindergartens that enrolled preschool classes at JU in one year but not in the other. We use this within kindergarten variation to estimate the causal effect of JU attendance by comparing the performance of children from the same kindergarten. The effect can legitimately be interpreted as causal, because JU attendance is exogenous. This is discussed in the following section.

4.1. Exogeneity of the treatment

[11] As defined by microm.

The structure of our data is illustrated in Figure 3.

-- Figure 3 about here --

As this figure shows, our data comprises 5,669 children examined in the SEnMed, 1,273 of whom have attended at least one course at JU (22.46%). Most of these children (1,055; 82.88%) were enrolled in a four-week course along with their preschool class (as opposed to private enrollment). As they are not affected by self-selection issues, these children and their kindergarten peers are appropriate subjects for analysis. Kindergartens typically enroll the entire preschool class of on average 14 children at JU. Hence, as we have two cohorts of children examined in the SEnMed, we observe (1) *within* kindergarten variation in participation at JU because one class attends courses and another does not - the children who do not attend JU are labeled 'untreated' or 'control'. And (2) we also observe *within* preschool *within* class variation because some children attend JU with their preschool class but take the SEnMed prior to attendance; children of this group are labeled 'pre-treated'.

Selectivity in kindergarten entry due to JU participation is an issue for neither group of children. The children in the sample entered kindergarten about two years before the JU was launched and thus also before preschool courses were established. Hence there is no self-selection of children in kindergartens or preschool classes due to JU participation. Even if parents want their children to enroll at JU, it is unlikely that they will change kindergarten solely for this purpose. First, even if the kindergarten does not participate in JU, the individual child can be enrolled for classes anyway. Second, to change kindergarten is generally not easy. Daycare provision in Wuppertal, as in many other German cities, is inadequate and parents have to apply for a free place very early, i.e. one or two years before their child's third birthday. In this situation to change kindergarten requires convincing arguments and may well involve other opportunity costs, like greater distance between home and new kindergarten.

Besides selectivity issues regarding participating and non-participating kindergartens, potential selectivity into the treatment, pre-treatment or untreated control group within a kindergarten has to be discussed. To support the exogeneity of the treatment assumption, we run mean comparison tests for the control variables between all these groups (treatment vs. control; treatment vs. pre-treatment, and pre-treatment vs. control). As our sample of interest (n = 1,896, Figure 3) includes children from 70 kindergartens[12], we have to calculate clustered tests. As noted earlier, the city of Wuppertal is segregated and this is reflected in kindergarten segregation as well. Thus, observations within kindergartens are likely to be correlated. Standard χ^2-tests or t-tests for the control variables would be biased upwards, and we would get downwardly biased p-values. Hence, to account for within kindergarten correlations we calculate cluster-adjusted tests as discussed in Donner/Klar (2000) where the kindergarten is the cluster variable.[13] Table 2 presents the results of mean comparison tests.

-- Table 2 about here --

[12] 14 of 84 kindergartens were eliminated from the analysis as they report only one participant or non-participant across the two cohorts. Here within kindergarten variation is not applicable.

[13] Note for Table 1: The results do not change considerably if we account for within-kindergarten correlation, but the significant difference between cohort 1 and 2 in ‘average time in kindergarten’ and ‘average % of welfare recipients with children per city block’ disappears.

There are no obvious selectivity issues for either the control group (children not enrolled at JU) or the pre-treatment group (children examined in the SEnMed before enrolling at JU). The treatment depends only on the decision of the kindergarten teacher to send the entire preschool class to JU and not on the children's individual characteristics. However, different preschool classes within a kindergarten might have different teachers of different quality, which might affect the decision to attend JU courses, as well as the child's ability. Thus a motivated, high-quality teacher might take a preschool class to JU and positively affect student outcomes in general. In this respect, JU participation within a kindergarten might not be purely random and high ability groups may be more likely to participate in JU courses. This creates yet another identification challenge: to rule out that the treatment effect reflects the quality of the preschool teacher. As we have no information on preschool teachers we cannot even tell whether different preschool classes enrolled (or not enrolled) at JU are taught by the same person, let alone what that person's quality as an educator might be. Nevertheless, this does not threaten our identification strategy, because a preschool class consisting of both pre-treated and treated children will in any case be taught by the same person. Hence, if assignment to one of these groups is random and JU attendance increases school readiness, children in the treatment group will be expected to show higher school readiness than their pre-treated peers. For this approach to be valid, we have to ensure that being allocated to the treated or pre-treated group is in fact random.

Unlike other cities, submission to SEnMed - and this determines membership of the pre-treatment or treatment group respectively - depends in Wuppertal solely on date of birth, not on attended kindergarten, family name, prospective school catchment area, or district of residence. SEnMed is, therefore, exogenous to other individual characteristics. Parents are notified of the upcoming SEnMed toward the end of their child's sixth year, 3-4 weeks before the scheduled SEnMed date. Consequently, children of the same average age of about

5 years and 10 months to 6 years will undergo examination on different dates throughout the year. However, children in JU classes are not sorted according to age. Thus children of a single preschool class both with and without SEnMed will participate in the same JU course and within this group older children are more likely to be examined before attending JU and therefore to be allocated to the pre-treatment group.[14] Hence, we can expect differences between treated and pre-treated children by age (pre-treated children should be older) and average time in kindergarten (should be shorter). In addition, however, there could be sorting by postponing the SEnMed date. Some families might forget to attend the examination, have time constraints, or want their children to be older and more mature when they are examined. To check the exogeneity assumption on the observed SEnMed date, we calculate the difference in months between the theoretical SEnMed date (on average 5 years and 11 months) and the observed SEnMed date and conduct mean comparison tests on the difference ($\Delta SEnMed$) for the treated and pre-treated children. If the exogeneity assumption holds, there should be no differences in $\Delta SEnMed$.

Table 3 reports the mean comparison test for the difference in theoretical and observed SEnMed date in months ($\Delta SEnMed$). It turns out that parents of treatment group children are not more likely to defer their child's SEnMed than parents of pre-treatment

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[14] For example, a child born on September 1, 2004 should take the SEnMed in September 2010 (SEnMed starts after the summer vacation) when she/he is about 6 years old. A child born on September 30, 2005 will take SEnMed in July 2011 (before the summer vacation), when she/he is some two months younger. Both children will enter primary school in September 2011 and may attend a JU course with their kindergarten preschool class in February 2011. The slightly older child will be allocated to the pre-treatment group, the younger child to the treatment group.

group children. Hence, children in both groups are equally likely to receive treatment before or after SEnMed and there is no selectivity on this issue either. Moreover, there are no significant differences either in age or in average time in kindergarten (c.f. Table 2, column (2)), which also supports the exogeneity assumption. Hence, the pre-treatment group is not a selective group either of all children or of treated children.

-- Table 3 about here --

But, besides selectivity issues conditional on birth date, there are two significant and several insignificant, but possibly relevant differences between treated and pre-treated children (Table 2), for example for the variable 'vaccination certificate presented'. Newborns receive a certificate of vaccination in which all vaccinations are recorded. Parents are requested to bring this certificate along to the SEnMed. Some 90.75% of pre-treated children presented the certificate of vaccination, as opposed to 94.68% of the treated children. The percentage of children with tetanus vaccination[15] also differs significantly between these two groups, but as this figure can only be determined for children who presented the certificate, this difference is plausible. It should be noted in this respect that the differences in other variables between treated and the pre-treated children (Table 2, column (2)) and treated and non-treated children (Table 2, column (1)) while being numerically apparent, are not statistically significant. Assuming that providing the required medical documents correlates with social status, we may conclude that the pre-treated and non-treated children are on average less advantaged. Parents not only bring in the requested certificates less often, the children also tend to have a lower birth weight and to live in neighborhoods with higher

[15] In Germany, children generally receive tetanus vaccination.

immigrant ratios. However, none of this threatens our identification strategy, because JU attendance and the date of SEnMed do not depend on these variables (the kindergarten can decide who participates in a JU class, but not on when children take the SEnMed; see above) and hence is still exogenous. Nevertheless, in our models we control for these background variables and for possible non-linear and indirect effects. We also run different robustness checks, in particular a matching model, to support the exogeneity assumption.

4.2. Estimation approach

To analyze the effect of JU attendance we use our dependent variable 'school readiness' as introduced in Section 3.1. The effect is estimated using a fixed effects model where we explain school readiness by a dummy representing JU participation (JU; 1=treatment, 0=non-treatment), individual level information, and regional controls discussed above (Section 4.1, Table 2):

$$y_{ick} = \alpha + \beta X_{ick} + \gamma JU_{ick} + \mu_k + \lambda_c + \varepsilon_{ick}, \quad (1)$$

y_{ick} is the school readiness of child i of SEnMed cohort c in preschool k. X_{ick} are background characteristics (e.g. dummy for being a boy), and JU_{ick} is the dummy indicating that the child attended JU courses with the preschool class. μ_k reflects unobserved time-invariant preschool characteristics, including shared preferences of parents and kindergarten quality. λ_c represents cohort specific characteristics, ε_{ick} is the individual error term.

Although we have argued that JU attendance is exogenous with respect to kindergarten and control variables, our model and data may still suffer from a lack of relevant individual-level information, which may further affect school readiness. This applies in particular to family socioeconomic status. To account for these background characteristics we include information on the city block level and income information on a postal code basis as discussed in Section 3.2. The individual controls used are taken from

SEnMed, so the data were collected post-treatment. This might affect the quality of some controls. Time-invariant or pre-treatment variables like gender, immigration status or birth weight are clearly not affected. Other variables, assessed during SEnMed that are exogenous to the treatment but not to the outcome (like number of siblings or obesity) can also be included in equation (1). Remaining variables, however, cannot be used because they are endogenous either to other exogenous variables or to the outcome.

4.3. Robustness checks

To check the robustness of our results and to further support our identification strategy, we estimate the effect of JU attendance using different groups. In our first check we estimate equation (1) using data on pre-treated and treated children only. If JU attendance has a causal impact on school readiness, treatment group children who attend JU before their SEnMed should have significantly higher school readiness than pre-treated children whose abilities cannot be affected by JU attendance simply because this came later.

In the second robustness check we compare pre-treated children with non-treated children. As the pre-treatment group is made up of children who attended JU with their preschool class after their own SEnMed, we do not expect a significant effect from JU treatment, as in this case school readiness cannot be affected by JU input. If, however, we estimate a significant coefficient for the JU dummy, the treatment is more likely to capture unobserved individual or family characteristics, or even effects induced by the preschool teacher, rather than the causal effect of JU attendance on school readiness.

The third robustness check is done by comparing regression results and results of the first and second robustness check with results of a matching estimator. As discussed in Section 4.1, there are differences in some exogenous variables between the defined groups, though most of these differences are statistically insignificant. To rule out any selectivity problem latent in these differences that might bias our estimated JU effect, we estimate the average treatment effect on the treated using different propensity score matching methods.

5. Results

5.1. Junior University effect

Table 4 summarizes regression results, where we start with a basic model in column (1).

-- Table 4 about here --

The model is estimated by OLS and includes kindergarten and SEnMed-cohort fixed effects. We regress school readiness on the treatment dummy (JU participation, 1=treatment/0=non-treatment), a gender dummy (male=1) and a dummy for immigrant status (immigrant=1/native=0). In addition, we control for linear age effects. As the dependent variable is standardized, the effects of all variables can be interpreted as changes in school readiness in percentage points.

In the first model the JU treatment variable is positive and statistically significant. Children attending JU courses with their preschool class perform better than their kindergarten peers who did not enroll at JU. The additional achievement of 3.36 percentage points corresponds to about 4.34 (of 129) additional tasks completed at SEnMed. The negative coefficients for boys and immigrants are both statistically significant and plausible. Girls and native Germans tend to perform better at SEnMed.[16]

[16] In this basic model we already explain the variation in the dependent variable fairly well. Using four variables (treatment, gender, immigrant status, and age in months) and kindergarten and cohort fixed effects we get an R^2 of about 0.26. One might think that this

Nevertheless, there are some other variables not included in (1) which may also affect school readiness and have to be controlled for. Therefore we add additional controls and estimate different specifications, like non-linear age effects and interaction effects. In model (2) we exclude age as such but include age at kindergarten entry, to avoid multicollinearity with kindergarten duration. In addition we include the number of siblings. In this specification the JU dummy coefficient decreases to 2.73 but remains highly significant. In model (3) we add information on health status: low birth weight, obesity/overweight, (severe) underweight, non-presentation of health certificate, U7a[17] conducted, non-presentation of vaccination certificate, with tetanus vaccination, reduced visual acuity, partial hearing loss, and behavioral problems. Model (4) also includes socioeconomic information on the city block and postal code area level. The city block information covers the share of households with children receiving welfare payments and of immigrant children below the age of six. The postal code information covers the average disposable income per household in €10 thousand. In both models, (3) and (4), the estimated treatment effect drops only slightly. In model (5) we exclude city block information and generate an index for low economic and social status from the city block data. The index comprises the following variables weighted by principal factor analysis: share of immigrants,

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is mostly due to fixed effects, but it is not. If we exclude kindergarten and cohort fixed effects, we still get an R^2 of about 0.16. This is due to the fact that gender, age, and especially immigrant status already explain a lot of the variance in school readiness. For instance, a model without fixed effects and only with the regressor ‘immigrant’ already explains 11.65% of variation.

[17] Medical screening conducted at the age of 34 to 36 months to attest physical condition.

share of immigrant children under the age of six, employment share[18], unemployment share, share of welfare recipients, share of households with children receiving welfare, and share of unemployable adults. The results are similar to those of model (4). To control for non-linear effects we include second, third and fourth order polynomials of age at kindergarten entry, kindergarten duration, city block social status index and average disposable income in models (6) and (7). In model (7) we also add interactions of gender with immigrant status and kindergarten duration with immigrant status. In doing so, we try to saturate the model with possible non-linear and indirect effects. However, the results of models (2) to (7) show a robust and significant JU effect. In model (7) the JU effect still amounts to 2.79 additional tasks completed.

5.2. Robustness checks

As discussed in Section 3.1, SEnMed data does not include individual-level information on the economic and social situation of a child's family. However, socioeconomic status is an important predictor of educational success in particular in Germany. Hence, it may turn out that our models suffer from an omitted variable bias. Exploiting our study-design, we can check the robustness by comparing different groups of children and by comparing the results with a matching estimator.

5.2.1. Pre-treatment group

As discussed in Section 4.3, we can compare the treatment (T) and the control group (U) with the pre-treatment group (P). When comparing the treated to the pre-treated children we expect non-zero JU coefficients similar to the coefficients in Table 4, provided the model is correctly specified and JU attendance is exogenous. When comparing the control group

[18]Minor employment with monthly income of ≤ €400 is not included.

(non-treatment) with the pre-treatment group, the JU-coefficient should be zero. If these hypotheses are confirmed, we interpret this as support of our identification strategy.

The results of the robustness check using the treated and pre-treated children are presented in Table 5, results for pre-treated vs. non-treated children are given in Table 6.

-- Tables 5 and 6 about here --

Our first hypothesis for the pre-treatment and treatment group - JU coefficient not equal to zero and similar to that of Table 5 - is confirmed. Only if children attend JU before taking their SEnMed do they show higher school readiness. Hence the better performance of the treated is not explained by selectivity, because the pre-treatment group also participates in JU but after school readiness has already been assessed. As argued in Section 4 (Table 2), pre-treated children are not a selective group of all children. The children are similar with respect to the relevant variables and there are no age effects which might explain short-term differences in school readiness. In addition, we can rule out selectivity issues concerning the preschool teacher. Both groups, treatment and pre-treatment, have the same preschool teacher but different abilities. If the ability measured at SEnMed is only caused by the quality of the teacher we would expect a zero-effect of the treatment and similar school readiness. Hence, our results suggest that JU attendance is significantly and causally related to higher outcomes at SEnMed. It should be noted that not only the coefficient for the treatment variable is similar to that of Table 4 in each model specification but the R^2's are similar as well.

Table 6 summarizes the results of the second robustness check, i.e. the comparison of pre-treated and non-treated children. Again, our hypothesis is confirmed. The JU coefficient does not statistically differ from zero at any significance level and regardless of the specification. The coefficients of the other variables, their significance levels, and the R^2 are similar to those in the model specifications in Tables 4 and 5.

5.2.2. Matching results

As discussed in Section 4 there are some statistically insignificant but possibly non-negligible differences in the control variables between both pre-treated and treated children and non-treated and treated children. Hence, as an additional robustness check, we estimate the average treatment effect of the treated (ATT) using propensity score matching. We use model (7) (Tables 4, 5, and 6) and different specifications of the matching estimator to account for the variance/bias trade-off. Table 7 summarizes the results for all groups.

-- Table 7 about here --

The matching results for the main comparison group (treated vs. control) differ according to the varying specifications of the *k*-nearest neighbor algorithm and different number of observations on support. However, results are qualitatively similar and, in addition, similar to the results in Table 4. The results for the pre-treatment and the control groups are qualitatively similar to the results in Table 6. Hence there is no difference in school readiness between the untreated and pre-treated children, i.e. children attending JU after SEnMed. This supports our exogeneity assumption.

Applying matching to the pre-treated and treated children, gives slightly different results. The variation in the different ATT specifications (with or without caliper, value of caliper, with or without replacement) is higher than for the other group comparisons. In addition, the ATT in the fourth specification (Table 7, column (4)) is lowest and the estimated effect is only marginally significant (t-value is |1.84|). But it should be noted that this specification has very strict requirements for the matching process, and therefore the number of observations is small compared to the other specifications. Hence, the low significance of this single specification is not surprising. Overall, however, the matching results do not differ qualitatively from the OLS results in neither specification. And we already have a quasi-experimental design, as well as a fairly well saturated model, in specification (7) in Table 4. Hence, the matching results can be interpreted as a confirmation of our main specification.

As the robustness checks presented here confirm our assumption on the exogeneity of the treatment and its impact on school readiness, we are confident about measuring a short-term causal effect of JU in terms of additional educational input for preschool children on their cognitive and non-cognitive abilities.

5.3. Does the investment pay off?

Several studies have shown that early investments can pay off in later life. This is in particular true for disadvantaged children (Duncan/Magnuson 2013; Belfield et al. 2006; Heckman et al. 2010). At this point, we cannot quantify any potential long-term effect of JU attendance. However, doing some back-of-the-envelope calculations, we can discuss the relative cost effectiveness of the program.

The JU course fee for preschool children is €5, which does not, of course, cover costs, especially as public transportation is included in the fee. In addition, there are costs for public transportation for the kindergarten teacher of about €20 - which amount to €1.4 per child. The JU management board has calculated costs of about €100 per child and course. This covers the instructor’s salary, course materials and fixed costs (including rental for the building, utilities, staff, etc.). There are no additional costs, because the kindergarten teacher’s salary is paid anyway (the courses take place during regular kindergarten time).

Hence, the total cost per preschool class child is about €106. Compared to that, the Federal Statistical Office (2012) reports total costs for publicly funded day-care of about €6,100 per child per year; so a day in kindergarten costs about €17 per child.

Next, look at the returns on JU. Consider, for example, model (4) in Table 4. School readiness increases by 2.3 % when a child attends a JU class. If we compare this to the return to kindergarten[19] estimated in our model, the same increase in school readiness requires an additional five months in kindergarten. Hence to compensate non-participants, duration of kindergarten would have to increase from 2.74 to 3.16 years. This increase would result in additional costs of about €2,550 per child compared with merely €106 for JU. Clearly, JU cannot substitute or compensate for kindergarten attendance but our analysis shows that innovative extracurricular educational concepts can be combined with regular preschool education to significantly improve children's cognitive and non-cognitive skills. Children will be better prepared for school if they get additional (and exciting) educational input. In addition, compared to investments in other intervention or early childhood programs (Duncan/Magnuson 2013), the investment of some €106 per child and course at the Junior University is small. Our discussion is obviously no substitute for a cost-benefit analysis; hence policy conclusions cannot be drawn based on the numbers presented. However, they might serve as a starting point for the discussion.

Moreover, whether the estimated positive effect grows over time and/or is sustained, is still an open question. Evidence of the effects of early childhood education and interventions is mixed and it suggests that early investments fade out soon after the intervention (Blanden et al. 2014a, b). Hence, another issue to be addressed is how to ensure

[19] The effect of kindergarten duration estimated here is likely to be upward biased, as we do not account for potential endogeneity issues.

positive long-term effects. In the case of the JU, positive effects might be enhanced by repeated treatment, i.e. enrolling preschool classes or primary school classes more than once and possibly on a regular basis and enforcing and incorporating JU courses in kindergartens and schools.

6. Conclusion and Discussion

Early childhood education and returns to early investment have been on the research agenda for several years. Many studies analyze the impact of early childhood education on educational attainment, earnings and the probability of employment but only few focus on voluntary out-of-school activities and their impact on educational success. In this paper we contribute to this topic by analyzing the effect of a unique educational project in Germany on school readiness of children. The Junior University (JU) is a private educational institution intended to supplement kindergarten and school. Besides private enrollment, kindergartens are encouraged to enroll entire preschool classes (last year before school entry) at the JU, where children participate in mainly hands-on experimental science courses. Using within kindergarten variation in enrollment, we analyze the effect of participation on the school readiness of preschoolers.

Our main findings suggest that attending classes at JU significantly increases the cognitive abilities of preschool children by approximately 2.16%. To check the robustness of our results, we compare the treatment group to a pre-treatment group of children. The pre-treatment group received the treatment after their school readiness had been assessed. As a final refinement of our estimation strategy, we conduct additional matching for our groups. The estimated JU effect passes all robustness checks.

There are at least two possible explanations for this finding. First, the JU courses are unconventional hands-on experimental courses – taught by experts and not by the kindergarten teachers – to which children are typically not exposed at kindergarten or at home, e. g. building volcanoes of sand and blasting them with peas. The event character may increase attention and foster active participation, which transforms into an increase in cognitive and non-cognitive abilities. In addition, it is possible that the positive JU effect is further enforced by kindergarten teachers and parents. By talking about the courses, possibly repeating the experiments, and discussing what has been learned, a short-term course can become a long lasting experience. Secondly - and this is in line with the literature on investment in early childhood education - the children in our data are rather young (about five to six years of age) and accumulation of skills and knowledge is known to be higher in early life (e.g. Shonkoff/Philipps 2000, Cunha et al. 2006). Hence, doing even a little more than other children will significantly improve school readiness.

Acknowledgments

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7. Literature

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Figure 1 Distribution of school readiness (n = 5,669), density and performance bands

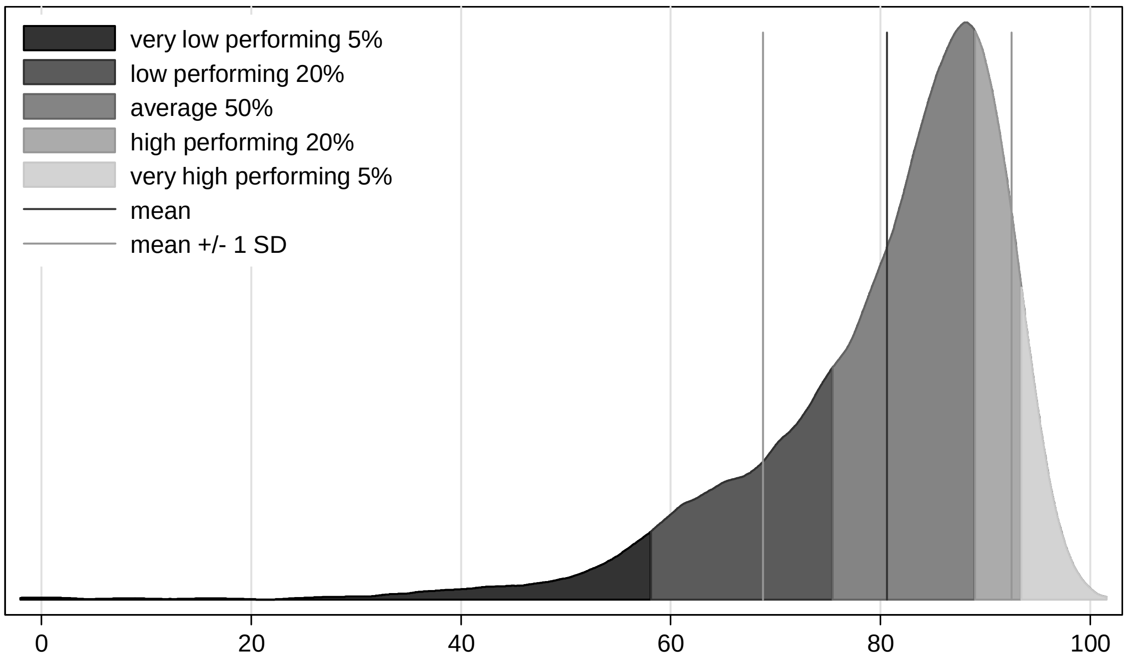

Figure 2 Average disposable income per household (hh) per year in Euros in Wuppertal

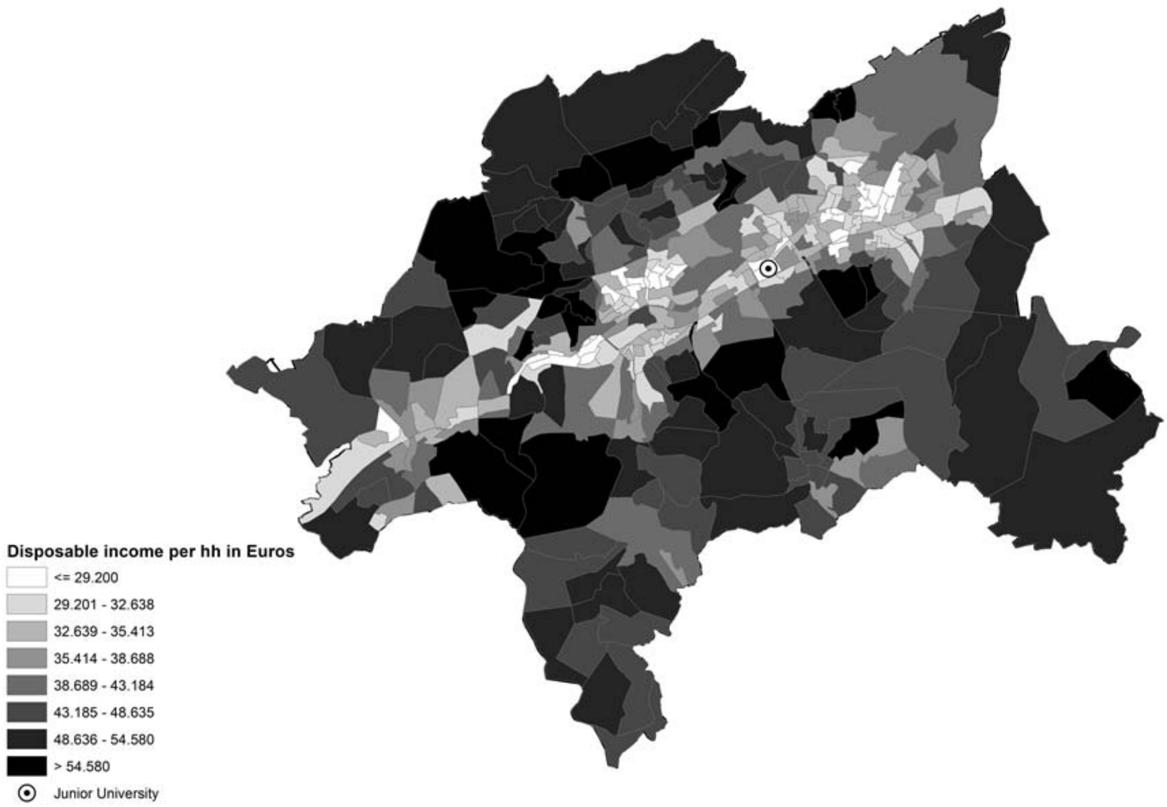

Figure 3 Study design

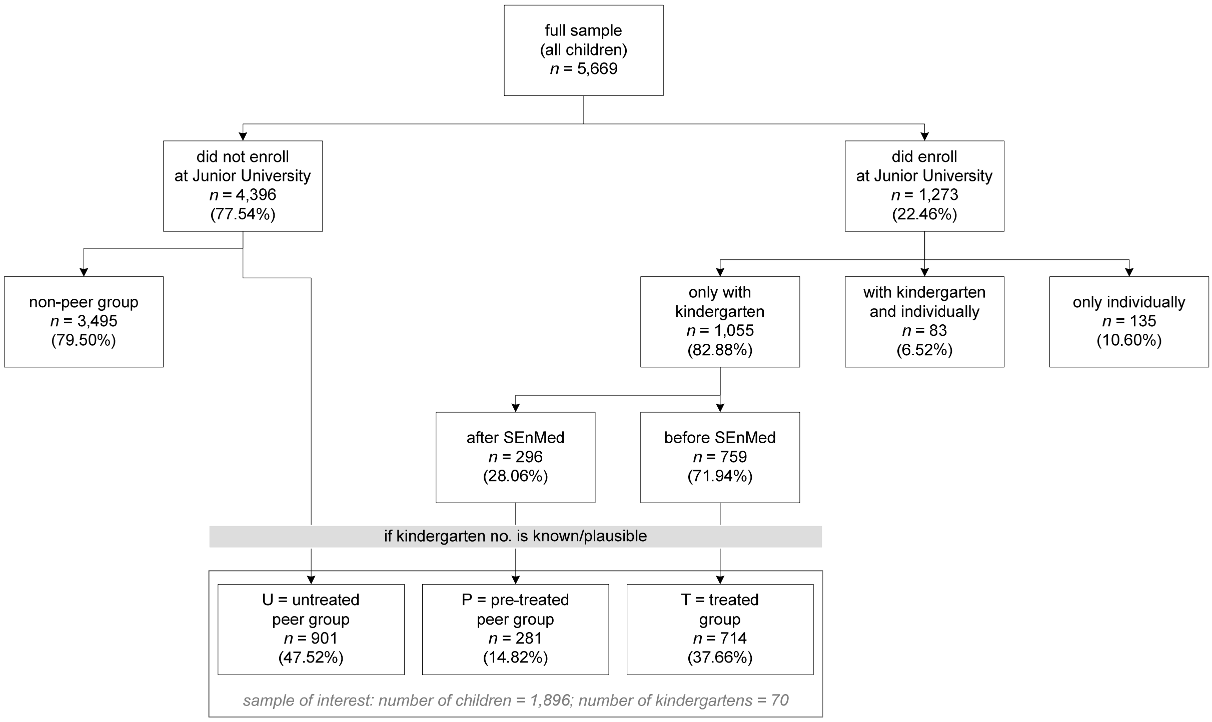

Table 1 Characteristics of the full sample and cohort comparison

		(1)	(2)	
		Total	Cohort 1	Cohort 2
Full sample size		5,669	2,809	2,860
Average age at examination		5.95 (0.2077)	**5.96** (0.2139)	**5.94** (0.2010)
% boys		51.08	50.44	51.71
% with migration background		36.57	36.67	36.47
Average time in kindergarten (in years)		2.74 (0.7519)	**2.79** (0.7481)	**2.68** (0.7519)
Number of siblings in %	0	21.86	21.72	21.99
	1	46.60	47.24	45.98
	2	20.14	20.08	20.21
	3	7.14	6.51	7.76
	4 or more	4.25	4.45	4.06
BMI category in %	severely underweight	2.77	2.48	3.05
	underweight	6.48	6.68	6.28
	normal (healthy weight)	78.37	78.39	78.36
	overweight	6.84	7.04	6.64
	obese	5.54	5.40	5.67
% low birth weight		7.35	7.76	6.95
% health certificate presented		93.91	94.16	93.67
% with U7a (medical screening at age 34-36 months)		87.22	87.46	86.99
% vaccination certificate presented		92.59	93.09	92.10
% with tetanus vaccination		91.69	91.81	91.57
% reduced visual acuity		21.50	22.11	20.91
% partial hearing loss		8.08	**9.97**	**6.22**
% with behavioral problems		6.28	**8.37**	**4.23**[a)]
Average % of welfare recipients with children per city block		29.08 (21.03)	**30.15** (21.48)	**28.02** (20.52)
Average % of immigrant children (< 6 years) per city block		53.66 (28.86)	53.34 (28.96)	53.96 (28.76)
Average disposable income (in €10,000) in postal code area		3.8788 (0.8940)	3.8870 (0.8912)	3.8707 (0.8968)

Notes: Standard deviation in parentheses; bold figures indicate significant differences between groups ($p \leq 0.05$) based on t-tests (for age, kindergarten, city block and postal code information) and χ^2-tests (for the other variables); [a)]Difference is significant due to a high increase in the category ‘examination was not possible’ (assessment is not compulsory).

Table 2 Baseline characteristics by treatment, non-treatment, pre-treatment, and exogeneity checks

		(1) Treatment (T) vs. non-treatment (U)		(2) Treatment (T) vs. pre-treatment (P)		(3) Pre-treatment (P) vs. non-treatment (U)	
		U	T	P	T	U	P
Full sample size		901	714	281	714	901	281
Average age at examination		5.94	5.96	5.94	5.96	5.94	5.94
		(0.0092)	(0.0099)	(0.0153)	(0.0093)	(0.0098)	(0.0168)
% boys		51.50	46.64	50.89	46.64	51.50	50.89
% with migration background		38.29	36.69	38.43	36.69	38.29	38.43
Average time in kindergarten (in years)		2.78	2.86	2.77	2.86	2.78	2.77
		(0.0447)	(0.0463)	(0.0770)	(0.0467)	(0.0415)	(0.0694)
Number of siblings in %	0	22.09	23.11	22.06	23.11	22.09	22.06
	1	43.29	50.00	48.75	50.00	43.29	48.75
	2	22.09	18.77	20.28	18.77	22.09	20.28
	3	7.99	5.32	6.05	5.32	7.99	6.05
	4 or more	4.55	2.80	2.85	2.80	4.55	2.85
BMI category in %	severely underweight	2.73	2.13	4.10	2.13	2.73	4.10
	underweight	7.29	5.96	7.46	5.96	7.29	7.46
	normal (healthy weight)	77.79	80.14	76.49	80.14	77.79	76.49
	overweight	6.72	7.52	7.46	7.52	6.72	7.46
	obese	5.47	4.26	4.48	4.26	5.47	4.48
% low birth weight		7.76	5.86	7.89	5.86	7.76	7.89
% health certificate presented		93.56	95.66	92.53	95.66	93.56	92.53
% with U7a (medical screening)		85.89	88.10	86.12	88.10	85.89	86.12
% vaccination certificate presented		92.67	94.68	**90.75**	**94.68**	92.67	90.75
% with tetanus vaccination		92.01	93.98	**89.32**	**93.98**	92.01	89.32
% reduced visual acuity		22.20	19.33	19.22	19.33	22.20	19.22
% partial hearing loss		8.88	6.30	9.25	6.30	8.88	9.25
% with behavioral problems		6.66	5.60	4.63	5.60	6.66	4.63
Average % of welfare recipients with		29.67	29.68	31.14	29.68	29.67	31.14
children per city block		(1.4863)	(1.5295)	(2.2657)	(1.3782)	(1.3576)	(2.2500)

Table 2 Continued

Average % of immigrant children (< 6 years) per city block	53.98 (3.5603)	49.95 (3.5925)	52.77 (4.8068)	49.95 (2.8951)	53.98 (3.1419)	52.77 (5.0998)
Average disposable income (in €10,000) in postal code area	3.8465 (0.1333)	3.9737 (0.1342)	3.8794 (0.1843)	3.9737 (0.1108)	3.8465 (0.1216)	3.8794 (0.1967)

Notes: Bold figures indicate significant differences between groups ($p \leq 0.05$) based on clustered t-tests (for age, kindergarten, city block and postal code information) and clustered χ^2-tests (for the other variables); cluster-adjusted standard errors in parentheses.

Table 3 Mean comparison test for difference between theoretical and observed SEnMed date, treatment vs. pre-treatment group

Group	n	Mean ΔSEM	Std. Err.	Std. Dev.
Pre-Treatment	263	0.6768	0.0834	1.3529
Treatment	688	0.6948	0.0535	1.4028
Combined	951	0.6898	0.0450	1.3885
Difference		-0.0180	0.1007	
H_0: Difference = 0	t-value	-0.1783	p-value	0.8585

Note: Standard t-tests, not clustered by kindergarten.

Table 4 Junior University effect on school readiness, treatment vs. control (non-treatment) group

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Junior University treatment (yes = 1/no = 0)	3.3618***	2.7252***	2.3069***	2.2937***	2.2349***	2.1976***	2.1623***
	(0.8499)	(0.6622)	(0.5645)	(0.5525)	(0.5513)	(0.5441)	(0.5448)
Gender (male = 1)	-2.6622***	-2.6081***	-1.9167***	-1.8872***	-1.9067***	-2.0126***	-2.1445***
	(0.4883)	(0.4682)	(0.4227)	(0.4159)	(0.4266)	(0.4291)	(0.4590)
Immigrant (yes = 1)	-5.7063***	-5.0087***	-4.6248***	-4.4213***	-4.2113***	-4.2155***	-6.8217***
	(0.7011)	(0.7165)	(0.7029)	(0.7771)	(0.7383)	(0.7317)	(2.4482)
Age at kindergarten entry		0.3835***	0.3704***	0.3977***	0.3948***	-1.4091	-1.3761
(in months)		(0.1135)	(0.1052)	(0.1062)	(0.1075)	(1.4642)	(1.4802)
Kindergarten duration (in months)		0.5216***	0.4573***	0.4768***	0.4758***	1.4510	1.4240
		(0.1195)	(0.1111)	(0.1104)	(0.1119)	(2.7572)	(2.8272)
Constant	46.6193***	51.3582***	51.6384***	47.2260***	48.1247***	-19.1311	-11.5994
	(10.0380)	(9.1582)	(8.9530)	(9.2210)	(9.3292)	(94.6656)	(95.4531)
Age in months	✓						
Number of siblings		✓	✓	✓	✓	✓	✓
Health status			✓	✓	✓	✓	✓
City block information				✓			
Disposable income in postal code area				✓	✓	✓	✓
SES index (city block)					✓	✓	✓
Kindergarten, age, SES index, and disposable inc. polynomials						✓	✓
Age, gender, immigrant and kindergarten duration interactions							✓
Observations	1,556	1,508	1,455	1,455	1,455	1,455	1,455
Kindergartens	70	70	70	70	70	70	70
R^2	0.2636	0.2938	0.3622	0.3663	0.3671	0.3746	0.3754
Adjusted R^2	0.2268	0.2548	0.3206	0.3235	0.3248	0.3270	0.3268

Notes: OLS estimates with kindergarten and cohort fixed effects; dependent variable is school readiness score; standard errors in parentheses are clustered at the kindergarten level; $^{+}$ $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; SES = socioeconomic status.

Table 5 Robustness check: Junior University effect on school readiness, treatment vs. pre-treatment group

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Junior University treatment (yes = 1/pre-treatment = 0)	3.1431***	3.0452***	2.9329***	2.8858***	2.7921***	2.7524***	2.7258***
	(0.9841)	(1.0652)	(1.0387)	(1.0325)	(1.0201)	(1.0085)	(0.9936)
Gender (male = 1)	-2.3839***	-2.3168***	-2.0029***	-1.9141***	-1.9169***	-2.0450***	-2.5659***
	(0.6909)	(0.6983)	(0.6161)	(0.6168)	(0.6227)	(0.6128)	(0.7949)
Immigrant (yes = 1)	-5.2800***	-4.6744***	-4.4245***	-3.8430***	-3.8122***	-4.0179***	-5.1447+
	(1.0335)	(1.0196)	(0.9779)	(1.0591)	(0.9607)	(1.0239)	(2.7310)
Age at kindergarten entry		0.3998	0.3930+	0.4436**	0.4315**	3.1005	3.1921
(in months)		(0.2416)	(0.2008)	(0.2042)	(0.2017)	(3.0766)	(3.0882)
Kindergarten duration (in months)		0.4936**	0.4560**	0.4962**	0.4854**	-0.0545	-0.0022
		(0.2406)	(0.2008)	(0.2033)	(0.2013)	(4.0683)	(3.9884)
Constant	41.5609**	48.5884**	48.6718***	43.0090**	44.3782**	-144.1923	-138.4654
	(19.3535)	(18.4639)	(16.2955)	(17.1223)	(16.7701)	(95.9849)	(96.9796)
Age in months	✓						
Number of siblings		✓	✓	✓	✓	✓	✓
Health status			✓	✓	✓	✓	✓
City block information				✓			
Disposable income in postal code area				✓	✓	✓	✓
SES index (city block)					✓	✓	✓
Kindergarten, age, SES index, and disposable inc. polynomials						✓	✓
Age, gender, immigrant and kindergarten duration interactions							✓
Observations	968	926	900	900	900	900	900
Kindergartens	70	70	70	70	70	70	70
R^2	0.2941	0.3026	0.3659	0.3747	0.3780	0.3906	0.3917
Adjusted R^2	0.2356	0.2375	0.2962	0.3034	0.3079	0.3118	0.3113

Notes: OLS estimates with kindergarten and cohort fixed effects; dependent variable is school readiness score; standard errors in parentheses are clustered at the kindergarten level; $^{+}$ $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; SES = socioeconomic status.

Table 6 Robustness check: Junior University effect on school readiness, pre-treatment vs. control (non-treatment) group

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Junior University treatment (pre-treatment = 1/no = 0)	0.8973	-0.4218	-0.7299	-0.7968	-0.7617	-0.7848	-0.7244
	(1.2154)	(1.0064)	(0.9528)	(0.9197)	(0.9474)	(0.9371)	(0.9413)
Gender (male = 1)	-2.6524***	-2.7307***	-1.9389***	-1.8703***	-1.9085***	-1.9899***	-2.1914***
	(0.6352)	(0.6033)	(0.5213)	(0.5251)	(0.5316)	(0.5254)	(0.6061)
Immigrant (yes = 1)	-5.2727***	-4.3774***	-3.9149***	-3.5352***	-3.5699***	-3.4013***	-8.7186***
	(0.7585)	(0.7572)	(0.7872)	(0.8658)	(0.8176)	(0.7838)	(3.1289)
Age at kindergarten entry		0.4968***	0.4259**	0.4622***	0.4466***	-0.5700	-0.6266
(in months)		(0.1649)	(0.1624)	(0.1605)	(0.1619)	(1.4199)	(1.4004)
Kindergarten duration (in months)		0.6660***	0.5353***	0.5648***	0.5536***	0.0665	0.1285
		(0.1740)	(0.1724)	(0.1685)	(0.1696)	(3.2439)	(3.4879)
Constant	36.4820***	39.1773***	41.6392***	36.6429***	36.7877***	-189.1900	-181.5392
	(13.1927)	(12.6884)	(13.0980)	(13.6848)	(13.5855)	(152.1291)	(151.7735)
Age in months	✓						
Number of siblings		✓	✓	✓	✓	✓	✓
Health status			✓	✓	✓	✓	✓
City block information				✓			
Disposable income in postal code area				✓	✓	✓	✓
SES index (city block)					✓	✓	✓
kindergarten, Age, SES index, and disposable inc. polynomials						✓	✓
Age, gender, immigrant and kindergarten duration interactions							✓
Observations	1,126	1,078	1,027	1,027	1,027	1,027	1,027
Kindergartens	70	70	70	70	70	70	70
R^2	0.2630	0.2999	0.3830	0.3896	0.3886	0.3995	0.4019
Adjusted R^2	0.2111	0.2445	0.3244	0.3295	0.3291	0.3325	0.3337

Notes: OLS estimates with kindergarten and cohort fixed effects; dependent variable is school readiness score; standard errors in parentheses are clustered at the kindergarten level; $^{+}$ $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; SES = socioeconomic status.

Table 7 Robustness check: matching results for OLS models (7), k-nearest neighbor matching with varying specifications

Groups and treatment status		(1)	(2)	(3)	(4)	(5)	(6)
	multiple neighbors:	yes	yes	yes	yes	yes	yes
	replacement:	with	with	with	without	without	without
	caliper:	*c* = 0.001	*c* = 0.002	--	*c* = 0.001	*c* = 0.002	--
treatment (1) vs. no treatment (0)	ATT	2.6888	2.8518	2.7247	3.0233	3.3729	3.1387
	t-statistic	2.56	2.77	2.22	2.98	3.63	5.11
	treated on support	319	435	626	234	277	626
	untreated on support	791	791	791	791	791	791
	average difference in propensity score	0.0004)	0.0007	0.0019	0.0004	0.0007	0.3238
		(0.0003)	(0.0005)	(0.0028)	(0.0003)	(0.0006)	(0.3068)
pre-treatment (1) vs. treatment (0)	ATT	-3.0111	-4.4234	-4.4793	-2.4309	-4.3333	-3.6029
	t-statistic	-2.27	-3.46	-3.54	-1.84	-3.39	-3.43
	pre-treated on support	143	180	236	122	154	236
	treated on support	543	543	543	543	543	543
	average difference in propensity score	0.0004	0.0006	0.0017	0.0004	0.0007	0.0663
		(0.0003)	(0.0005)	(0.0026)	(0.0003)	(0.0005)	(0.1230)
pre-treatment (1) vs. no treatment (0)	ATT	-1.1533	-1.5752	-0.8707	-0.7922	-1.3436	-0.1144
	t-statistic	-0.58	-0.92	-0.53	-0.39	-0.77	-0.09
	pre-treated on support	86	114	214	80	99	214
	untreated on support	606	606	606	606	606	606
	average difference in propensity score	0.0003	0.0006	0.0058	0.0003	0.0005	0.2114
		(0.0003)	(0.0005)	(0.0121)	(0.0003)	(0.0006)	(0.2595)

Notes: Propensity matching estimation; outcome variable is school readiness score; standard errors in parentheses; ATT = average treatment effect of the treated.