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ABSTRACT

Sibling Rivalry: A Look at Switzerland with PISA Data

In this paper we analyse the sibling size and birth-order effect on educational achievement in Switzerland on the basis of PISA data. We find an overall modest size and birth-order effect. The sibling size effect, however, is a product of a substantial and significant negative size effect for families with lower socio-economic status and foreign origin and a positive sibling size effect in small, native families with a high socio-economic status compared to single-child families with the same background. Thus, subgroups of the population seem to be confronted with binding budget constraints, although education is free. The hypothesis that parents of larger families spend on average less time with their children is also tested and shows the expected negative effect of the sibling size. We present an extended version of the sibling size model that can account for these effects and discuss the consequences these results might have for social and educational policy.

JEL Classification: D1, I2, J2

Keywords: education, parental background, sibling size, birth-order

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I. Introduction[1]

In the psychological, sociological and economic literature of the past four decades it has been argued, that the educational achievement of children and thus their well-being in their adulthood depends to a great degree on the interactions within the family, in which the child is raised.[2] These interactions concern the ones between the child and parents as well as with brothers and sisters. Thus the size of the family, the birth-order, the sibling-gender-composition as well as the child spacing (because of the sequential nature of births) have to be taken into account when analysing the effects of these interactions within families on the educational achievement.
One of the most discussed interactions is the potential competition of siblings for the financial and time budget of their parents. In the case of budget constraints in time and money, everything else equal, more children will dilute the limited resources of the family. Hence, the larger the family, the lower the parental investments in each child and the lower the educational outcome.
Recent studies have shown, with the exception of the USA, that compared to studies using older data sets, family size effects tend to become smaller and even disappear over time. This development is explained partially by the fact that families became much smaller, that education is free in most of the industrialised countries and that remaining budget constraints are fought with distributional policies that target larger families with child allowances, free child care and other measures.
For educational policy, a negative effect of the size of a family on the educational outcomes of their children would therefore be a serious challenge. It would mean that some parents still face binding budget constraints and that their children do not have the same chances in the educational system as children from smaller families. Public investment in the human capital of children in families subject to capital constraints could therefore be needed to restore equity.

This paper attempts to shed light on the family size and the birth-order effect on educational achievement using Swiss PISA data. The paper consists of six sections. After the introduction, section II gives a short overview on the past literature and situates the present work, section III describes the data used and section IV presents the empirical results. Section V revisits the sibling size theory and tries to present an extension to the classical model that could better explain the results found in this paper. Section VI concludes.

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[2] See e.g. Haveman & Wolfe (1993).

II. Literature and Hypothesis

Although not only economists have looked at the effects of family size on childrens' outcomes, the approach of Becker (1960) to the economics of the family has influenced a great number of empirical studies in the past four decades. In his initial work on fertility decisions he introduced the notion of "quality of children" and presented the decision of families on the number of children they would have as a joint decision about quantity and quality of their descendants. Whereas this initial work was more interested in explaining the pattern of fertility in the twentieth century, Becker also discussed the implications for the investment (private and public) in human capital and the potential need for redistributional policies (see e.g. Becker & Tomes, 1986).

The size of families was only one argument within the literature on the sibling effect. The gender composition of the sibship, the birth-order, and the spacing of births were also looked at.

In the case of gender composition it was assumed, that if the marginal rates of return to investments of parents in their children were not equal, they would not invest the same amount of money and time in each of their children. As most labour markets showed a certain degree of wage discrimination against women, it was assumed, that on the basis of this, one could expect that girls would be treated differently than boys. In this case, girls growing up with brothers would – everything else equal – have benefited less from parental investment than girls growing up with sisters only.[3] However the direction of these effects is theoretically unclear. If parents pursue achievement maximisation, they would unevenly distribute their wealth and time, whereas if they were lead by fairness, they would tend to invest more in the disadvantaged children in order to equalise outcomes.

Spacing and birth-order are two additional aspects of sibling configuration that could make a difference in parental investment. Close spacing of children reduces the moments in which parents can devote all their time to a single child, whereas regarding the birth-order the same happens for the so-called "middle" child(ren). The oldest and the youngest child are both likely (depending on the spacing) to profit from a period where they are the

[3] Gender composition effects were found in the studies of Butcher & Case (1994) or Garg & Morduch (1998), while Kaestner (1997), Hauser & Kuo (1998) found no significant gender composition effects in their studies. Bauer and Gang (2000) found no composition effects for households with two children and some effects for households with more than two children. Another strand of literature tests the differences of parental influence on their children when taking the gender effect into account. They look specifically at mother-daughter or father-son relationships (e.g. Mare & Chen, 1986a&b) (and vice versa), generally in the framework of intergenerational income mobility (e.g. Chadwik & Solon, 2002).

single child, at least in the pre-school period or later in life[4]. As the investment of parents in their children in the pre-school period proves to be crucial, this could make a significant difference in the impact on the educational outcome.

Regarding the educational outcome - the dependent variable in all the empirical analysis - three different measures are commonly used.[5] The most straightforward measure is educational achievement, measured in school tests[6] or like in this study in comparative test of competencies. The second measure, widely used in the empirical literature, is educational attainment, usually measured by grades or completed school years or levels.[7] Thirdly and evidently for economists, the impact on wages as an educational outcome can also be tested.[8] In the ideal case, the three outcomes would be linked with almost complete correlation and the choice of the dependent variable would not make any difference. However, we are well aware of the fact, that due to many exogenous (and endogenous) factors, high achievers in school tests are not attaining automatically higher school levels or stay longer in school and educational attainment is not always reflected in higher salaries. In order to test the effect of family size and configuration on educational outcomes we would expect to see them foremost – if any – in the school and test performance of pupils.

Many but not all of the empirical studies so far have made use of information that permitted the analysis of intrafamily sibling differences. The availability of information about all siblings of a family presents a clear advantage in so far as it avoids the problem of comparing siblings from different backgrounds. Interfamily differences are vulnerable to the influence of omitted variables or unobserved parental characteristics being correlated with the sibling size or the family configuration and can therefore provoke misleading estimates. It could well be, that more able parents have less children and invest more in the education of their children and vice versa. In this case smaller sibships would produce higher educational achievements but not because of competition for parental resources. However, intrafamily differences are not free of problems either. They are

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[4] The youngest child could additionally profit from the fact that parents have more resources while it is the only child because of rising income over the life cycle of parents. Ejrnaes & Pörtner (2002) develop a model that predicts higher educational achievement for the first and the last born child, without assumptions about preferences for specific birth-order.

[5] Besides the three outcomes mentioned here, other dependent variables, like health outcome (e.g. Garg & Morduch) have been used as well.

[6] Stafford (1976) uses teacher ratings of cognitive skills of pupils. Willms (1986) uses the number of siblings as one of his independent variables in explaining differences in exam results in Scotland. Hanushek (1992) uses results from the Gary Income Maintenance Experiment (which at the same time limits his sample to black, low-income families).

[7] e.g. Lindert (1976), Mare & Chen (1986), Hauser & Kuo (1998), Bauer & Gang (2000).

[8] e.g. Kessler (1991), Björklund & Jäntti (1994).

submitted to the problem of unobserved characteristics of the parents too. Even when taking into account the spacing between the siblings, there is the additional problem, that not all the siblings were raised in the same socio-economic living conditions. The first born child is likely to have parents that earn less and live in an environment that is not good as the one his siblings are born into later. The direction of the effect, however, is not clear, because parental income may grow over time, while the family gets bigger and they move to better school environments, but at the same time more siblings are competing for the parental resources, so that the net effect on achievement differentials might be insignificant.

Almost all studies, with the notable exception of the study of Hanushek (1992), measure the impact of contemporaneous or cumulated inputs in a cross-sectional analysis of achievement levels, a fact that can create problems. Hanushek had the advantage of a data set with several achievement observations over time. Therefore he was able to regress changes in inputs on changes in achievement ("value-added" specification). Unfortunately, most of the data sets at hand do not allow comparing the change in achievement for individuals over time.

Besides the problem, that family resources can differ in quantity and quality, another distinction should be made. Some resources are *divisible* and others are not. *Indivisible* resources, like the socio-economic status of the parents or the location of living have the same impact on the achievement of their children independent of the size of the family. Other resources, monetary and non-monetary, are divisible, and an additional child dilutes the resources available for the other siblings. Some resources can change their nature in order to be better adapted to the size of the family. Hanushek (1992, p.86) discusses in this respect the concept of "public time" versus "private time". Public time has the nature of a public good and all children can share it without lowering the amount available for the others. Private time is the time parents spend with a single child and that therefore can not be spent on the other children. The decision how parents divide their time into private and public time will probably depend on the size of the family. When the family gets larger, parents can substitute private time with public time but as public time most probably has a lesser educational value than private time, overall achievement will still be affected negatively. In any case, due to the fact that not all the family resources are indivisible and substitution of resources has limits, theory would predict that the size of the family has a negative effect on all siblings but the reduction in achievement should not be linear. As parents will also differ in the quality and quantity of indivisible resources, we can predict that the negative impact of the family size will be different over families and smaller for families with a bigger share of indivisible resources[9].

[9] According to the theories of Bourdieu (1983) or Coleman (1988) on social capital, parents differ in their possession of economic, cultural and social capital. Especially the latter two but also parts of the economic capital (prestige, power) are mostly indivisible. In this case we would expect that children from families from a higher

The present study will focus on the sibling size and birth-order effect. The data used here contains no specific data on gender composition and spacing and as a consequence, these family configuration aspects are not analysed further. Two other restrictions have to be accepted when using the PISA data, first, we only have one observation in time and therefore can only test the impact on attainment levels and second, because the data is restricted to 15 year old pupils we will have to carry out interfamily comparisons. We hope, however, that despite the shortcomings of the data set, compared to the optimal situation, the large-scale assessment with its rich background data will provide some new insights that will be complimentary to the ones gathered in previous studies.

social class should suffer the least from a dilution of parental resources due to the family size. Regarding private time of parents, which is perhaps the most divisible resource, richer parents have also the possibility to substitute their own time with purchased child care (on the decisions to demand for nonrelative child care see e.g. Joesch & Hiedemann, 2002 or Lundholm & Ohlsson, 2002).

III. Data

In this paper we use the national PISA[10] data set 2000 for Switzerland. The full sample of the data has roughly 8'000 observations. Table 1 gives an overview of the variables used in the empirical part of the paper.

Reading literacy in PISA is standardised to 500 points (OECD average) with a standard error of 100 points (see OECD, 2001). Switzerland had an average score of 494 points, close to the OECD average. Most variables are taken from the PISA data set with some exceptions. The "ISEI" variable is constructed on the basis of the professions of parents independent of the fact whether they are employed or not. Therefore the variable "parents employment situation" was created in order to have additional information about the current income of parents. Regarding the education of parents, pupils apparently had problems with the questionnaire in Switzerland (for more explanations see Coradi Vellacott & Wolter, 2002). The variable used for parents' education corresponds to the one found in the original data set and additionally we created a variable that is not a direct picture of the formal education of parents but rather their closeness to education and culture. The variable has information about the cultural background in the family (e.g. number of books at home) and the use of education and culture in the socialisation process of their children (e.g. cultural goods and social interaction). We used both variables because they showed a high degree of independence from each other. In other words, parents with a high formal educational background did not automatically exhibit an intensive use of the acquired human capital in their interaction with their children.

We further use the variable "other language than official language" as a proxy for the distinction of Swiss nationals and foreign residents. Again, as with the question on the highest educational level of parents, the average number of pupils saying that they did not possess the Swiss nationality was far too low to be correct. We think that the variable on the language spoken at home comes closer to reality and serves our purposes well. We are aware of the fact that by using this variable we treat some Swiss pupils like foreigners (because they come from another language regions) and some foreigners (who speak a Swiss national language at home, like German, French or Italian pupils) like Swiss. Knowing from the literature on migration that migrates coming from neighbouring countries assimilate faster and differently than foreigners from countries that are geographically and culturally more distant to Switzerland, the use of the language as a proxy for the degree of assimilation seems to make sense.[11]

[10] Programme for International Student Assessment of the OECD (see OECD, 2001). For a short overview of the role of background factors for reading literacy in PISA see e.g. Fertig & Schmidt (2002).

[11] On the differences in the educational behaviour among different groups of migrants, see e.g. Gang & Zimmermann (2000). Although their study treats the German case, it should come close to the Swiss situation.

Table 1: Variable Definitions

	Dependent Variable
Reading	Achievement in reading literacy as defined in PISA
	Independent Variables
ISEI	Socio-economic index of occupational *status* (values range from 16 to 90)[12]
Parent education	Years of schooling of the parent with the highest educational attainment
Gender	Dummy: 1 for girls, 0 for boys
Italian	Dummy for pupils living in the Italian speaking part of Switzerland; not for all pupils speaking Italian at home
French	Dummy for pupils living in the French speaking part of Switzerland; not for all pupils speaking French at home
Youngest child	Dummy; value 1 if the pupil is the last-born in the family[13]
Middle child	Dummy; value 1 if the pupil is neither the first nor the last-born in the family
Single headed family	Dummy; value 1 if the family has only one adult person
Mixed family	Dummy; value 1 if at least one of the two adult persons in the family are not the father or the mother
Other family	Dummy: value 1 if none of the adult persons is considered to be father or mother
Parents employment situation	Dummy: value 1 if at least one adult in the family is full time employed and 0 otherwise
Other language than official language	Child speaks most of the time a language at home that is different from the language of assessment, from other official languages or from national dialects
Closeness to education	Composite index of four variables: the number of books at home, the frequency of discussions with parents on social, political and cultural themes, the possession of cultural goods and the possession of educational resources
Soccom	Composite index of three variables on interactions between parents and children: frequency of discussions about school, parents eating the main meals with the children and time simply talking together
NSIB	Number of siblings (discrete cardinal scale). The variable is also used as a dummy, with a dummy for every size of the family

[12] This is an internationally comparable and standardised method of ranking the parent's profession according to their (socio-economic) status (see Ganzeboom et al., 1992). The Index is used as a proxy for income and wealth. Direct information on income and wealth could not be obtained, because students filled in the background survey. This might have an influence on the results. Björklund & Jäntti (1994) report in their paper that when using direct income measures instead of proxies like education and occupation, the sibling effect is either substantially reduced or disappears fully.

[13] Note that the PISA assessment is taken at the age of 15 and that therefore it is possible, that the family size measured at that point is not completed. Compared to other studies we did not use the information on the exact position in the birth-order of the child tested in PISA.

The PISA questionnaire also contains a large set of questions about the interactions between parents and children. It is asked whether parents discuss political or cultural topics with children, whether they listen music, watch films or have their meals together, to name a few. We use one of these questions (variable “soccom”) that reflects best the time, parents spend with their children to analyse directly, whether our hypothesis, that an increased number of children reduces the time, parents can spend with each of them is correct.

IV. Results

a. General findings

In a first step, we analyse the impact of the number of siblings on individual test scores in reading literacy. Regression 1 in table 2 shows the coefficient of the linear specification of the sibling variable. The coefficient is highly significant but it's magnitude is not overly impressive. In regression 2 we add some control variables that represent structural differences (like language region in Switzerland or gender), reflect the different (observable) abilities of parents[14] (formal education, closeness to education, language spoken at home), control for the parent's budget constraints (like ISEI or parents employment situation) and control for aspects of the family configuration (birth-order). As expected, the coefficient for the number of siblings is reduced substantially but remains highly significant.[15] The birth-order also plays a significant role, with the oldest sibling always being better in achievement than the rest of the family.[16]

In regression 3 we add another set of independent variables, the configuration of adults in the family; variables that could also indicate constraints in time that can and will be devoted to the children. The inclusion of these variables does not change anything, except for lowering the influence of the variable of the employment situation of parents. There seems to be some correlation between the employment situation and the fact that the family is not composed of the two parents. The effect of the number of siblings on reading achievement, however, is not directly affected by the inclusion of these variables and remains significant.

Regression 4 is a first test of the assumption that the siblings size effect is linear. The inclusion of the squared term of the variable changes the results in so far, that now the linear effect turns insignificant and the squared term is significant. Although we can not deduce from this the exact form of the sibling effect, we have evidence, that the impact is not linear and that the children coming from the largest families must drive the effect. In the following regressions we therefore replace the linear specification with dummies for each size of the sibship (as done e.g. in Björklund & Jäntti, 1994).

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[14] We are well aware, that even when controlling for observable abilities, we might miss significant ability differences between parents that bias our results. The ways to correct for this potential bias would be experiments, instrumental variables or twin studies. Behrman & Rosenzweig (2002) find a substantial bias in the correlation of schooling of mothers and daughters due to heritable ability and assortative mating. Their study used a (very small) sample of identical twins.

[15] We also included the additional variables step-wise but it doesn't change the qualitative results.

[16] Hanushek (1992) showed in his paper that this effect might be artificial because when merging all family sizes together, the reference group (only child) could just capture some of the small family effect. Therefore we will analyse this effect separately in this paper.

Table 2: Regression on reading literacy (number of siblings)[17]

Regressions	1	2	3	4
Independent Variables	Coefficient	Coefficient	Coefficient	Coefficient
Constant	6.225*	6.102*	6.108*	6.093*
ISEI		0.002*	0.002*	0.002*
Gender (Girl=1)		0.041*	0.042*	0.042*
Italian		-0.023*	-0.022*	-0.021*
French		0.010	0.008	0.008
Youngest child		-0.015*	-0.016*	-0.018*
Middle child		-0.011	-0.012	-0.014
Single headed family			-0.015**	-0.014
Mixed family			-0.022	-0.022
Other family			-0.067*	-0.066*
Parents employment situation		0.032*	0.026*	0.025*
Other language than official language		-0.115*	-0.115*	-0.114*
Closeness to education		0.058*	0.057*	0.057*
Parent education		0.003	0.003*	0.003*
NSIB	*-0.020**	*-0.014**	*-0.014**	*0.005*
NSIB squared				*-0.004**
Mean dependent Var.	6.19	6.19	6.19	6.19
SD dependent Var.	0.202	0.202	0.202	0.202
Adjusted R-squared	0.01	0.27	0.28	0.28
Number of observations	7902	6838	6812	6812

*, ** Significance at the 1% level and the 5% level respectively; the reference person is male, lives in the German speaking part of Switzerland, in a classical family with both parents (for regressions 3 & 4), his mothertongue is the local language and he is the oldest child in his family. All observations are weighted with the students' weight.

The overall measure of the siblings size effect seems to indicate that there is a negative effect of the number of siblings on the individual educational achievement, although not high in magnitude[18] and not linear. To give some idea of the differences between different family sizes regarding literacy achievement, we show in table 3 the average scores.

These results encourage us to analyse the question further, using sub-samples of the data set, to see, whether the effect is the same for different

[17] All regressions were run on Stata 6.0. The complete national data set contains 7997 observations. Reductions in the number of observations can be explained with missing values. No imputation for missing values was carried out. Cook-Weisberg Test was used to test for heteroskedasticity. The hypothesis of constant variance could not be rejected for the regressions in table 2. In the sub-group specification used for tables 4 & 5, we had a problem with heteroskedasticity; therefore we used a log-linear specification in all the regressions. After that the hypothesis of homoskedasticity could not be rejected anymore. Ramsey regression specification error test was used for the regression in table 2. The hypothesis of omitted variables was rejected.

[18] One additional child lowers the average achievement by 0.069 of one standard deviation in reading literacy.

groups of the population or differs within and between groups. The group building follows the two variables that seem to have the highest single effect on achievement, the socio-economic background of children and the language spoken at home.

Table 3: Average literacy achievement per family size[19]

Family size	Literacy score	Significant differences
a. 1 Child	497.81	a > e & f
b. 2 Children	505.14	b > c & d & e & f
c. 3 Children	498.61	c > e & f
d. 4 Children	488.17	d > f
e. 5 Children	462.46	
f. > 5 Children	444.30	

b. "Foreigners" versus "Natives"; "Rich" versus "Poor"

We divided the full sample into eight sub-groups[20]. First the sample was divided according the four quartiles of the ISEI, the socio-economic status, with quartile 1 being the lowest quartile and quartile 4 the highest. Then we divided each quartile further into those pupils who spoke the official school language at home and those who did not. By dividing the sample first into the ISEI quartiles, we guarantee that "foreigners" and "natives" in each quartile come from an almost[21] comparable socio-economic background.

The results for the native speakers can be seen in table 4. We use the "full" model as in regression 3 in table 2 with all the independent variables and with the sibling size represented by dummies. The reference pupil in all cases is a boy with no siblings. The grouping of observations according to the socio-economic status of parents takes away some of the explanatory effect of variables reflecting differences in budget constraints between families but not everything. Furthermore the variable that describes the closeness of parents to education remains highly significant in all quartiles. The variables reflecting the configuration of adults in the family have a strong and significant negative effect in the upper half of the ISEI distribution, with the exception of single raising adults. The birth-order

[19] Average literacy achievement is calculated using plausible values and replicate weights.

[20] Instead of building sub-groups, we also used interaction terms of language, isei-quartile and number of siblings. This allows us to regress everything in one regression using all observations. The results are not presented here, but show qualitatively the same picture as the sub-sample regressions. An F-test on all interaction terms showed that the hypothesis that they are not different from 0 could be rejected. Due to the large number of interaction terms (40) we preferred to show the regressions by sub-sample, as they are more straightforward in their interpretation.

[21] The mean of the ISEI in the upper quartiles is slightly but not significantly higher for the native speakers and slightly lower for natives in the lowest quartile.

seems to play a role in the upper quartiles, in the sense that the oldest child fares better than his brothers and sisters.

Table 4: Regression on reading literacy per ISEI quartile (mothertongue speakers only)

ISEI quartiles	1	2	3	4
Independent Variables	Coefficient	Coefficient	Coefficient	Coefficient
Constant	6.068*	5.961*	6.188*	6.137*
ISEI	0.001	0.005*	0.000	0.002*
Gender (Girl=1)	0.066*	0.047*	0.030*	0.027*
Italian speaking part	-0.024	-0.020	-0.057*	-0.046*
French speaking part	0.006	0.006	-0.007	-0.025*
Youngest child	-0.011	-0.015	-0.019**	-0.033*
Middle child	-0.020	-0.019	-0.008	-0.027**
Single headed family	0.07	-0.021	-0.020	-0.015
Mixed family	-0.015	-0.009	-0.036**	-0.038**
Other family	-0.025	-0.049	-0.109*	-0.061**
Parents employment situation	0.024	0.035*	0.020	-0.016
Closeness to education	0.057*	0.047*	0.057*	0.047*
Parent education	0.004**	0.003	0.002	0.001
1 sib	*-0.007*	*0.002*	*0.010*	***0.053****
2 sibs	*0.019*	*-0.007*	*0.009*	***0.039*****
3 sibs	*0.008*	*0.008*	*0.001*	*0.032*
4 sibs	*-0.030*	*-0.001*	*-0.043*	*0.048*
More than 4 sibs	***-0.087****	*-0.025*	*-0.036*	*-0.018*
Mean dependent Var.	6.17	6.20	6.23	6.29
SD dependent Var.	0.185	0.175	0.165	0.154
Adjusted R-squared	0.15	0.11	0.14	0.13
Number of observations	1247	1374	1618	1431

*, ** Significance at the 1% level and the 5% level respectively; the reference person is male, lives in the German speaking part of Switzerland, in a classical family with both parents (for regressions 3 & 4), his mothertongue is the local language and he is the oldest child in his family. All observations are weighted with the students' weight.

Contrary to the overall effect in table 2, the sibling effect is at first sight rather blurred and only three dummies although with high coefficients remain significant, interestingly two of which are positive and not negative. At second sight, however, there seems to be a clear pattern in the results in the sense that the lower the socio-economic status of the parents, the sooner the sibling effect turns negative. Whereas for the "richer" parents, small sibship seem to produce better achievements than families with just one child. With less than four children, independent of the significance of the variables, the sibling effect does not even show a negative sign. Significant effects therefore are concentrated at both ends of the socio-economic distribution and with opposite signs, positive effects for small families in the top quartile and negative effects for large families only in the bottom quartile. Compared to the overall results in table 2, the division into sub-samples raises the standard errors but also the magnitude[22] of those effects that are significant.

Analysing the regressions for the non-native speakers in the same manner shows that many of the structural variables are no longer significant in the intra-quartile perspective, with the notable exception of the variable "closeness to education" which has a substantial and significant effect (for the three upper quartiles).

Table 5: Regression on reading literacy per ISEI quartile (does not speak the official school language)

ISEI quartiles	1	2	3	4
Independent Variables	Coefficient	Coefficient	Coefficient	Coefficient
Constant	6.089*	5.899**	5.906*	5.835*
ISEI	-0.002	0.005	0.004	0.005**
Gender (Girl=1)	0.022	0.048**	0.018	0.026
Italian speaking part	0.087**	0.094	0.020	-0.043
French speaking part	-0.088*	0.035	0.018	-0.095**
Youngest child	-0.063*	0.005	-0.014	-0.017
Middle child	-0.004	-0.011	-0.054	-0.072
Single headed family	-0.054	-0.020	0.002	-0.076
Mixed family	-0.002	0.068	-0.119**	-0.115
Other family	0.001	-0.052	-0.048	0.030
Parents employment situation	0.041	0.075*	0.027	-0.043
Closeness to education	0.071*	0.089*	0.087*	0.078*
Parent education	0.002	0.002	0.009**	0.006
1 sib	*0.009*	*-0.034*	*-0.052*	*-0.033*
2 sibs	*-0.033*	*-0.086*	*-0.054*	*0.003*
3 sibs	***-0.104***	*-0.105*	*-0.036*	*-0.064*
4 sibs	***-0.167****	***-0.214****	*-0.043*	*-0.085*
More than 4 sibs	*-0.085*	***-0.190***	*-0.022*	*-0.104*
Mean dependent Var.	6.01	6.06	6.13	6.21
SD dependent Var.	0.236	0.218	0.220	0.199
Adjusted R-squared	0.17	0.23	0.25	0.33
Number of observations	507	330	199	154

*, ** Significance at the 1% level and the 5% level respectively; the reference person is male, lives in the German speaking part of Switzerland, in a classical family with both parents (for regressions 3 & 4), his mothertongue is *not* the local language and he is the oldest child in his family. All observations are weighted with the students' weight.

Again, as in table 4, standard errors have risen, but nevertheless, dummies for large families (3 sibs and more) in the lower half of the socio-economic distribution show high and negative effects. Contrary to the native speakers, however, almost all the signs are negative even in the top quartile and there

[22] Negative effects are in the range between 0.5 and 1 standard deviation in reading literacy.

does not seem to be a negative single child effect as observed for native speakers.[23]

Table 6: Regression on social communication (log-linear specification)[24]

Regressions	1	2	3	4
Independent Variables	Coefficient	Coefficient	Coefficient	Coefficient
Constant	1.33*	1.287**	1.365**	1.362*
ISEI		0.001*	0.000**	0.000**
Gender (Girl=1)			0.037*	0.037*
Single headed family		-0.030*	-0.015	-0.015
Mixed family		0.000	-0.001	-0.002
Other family		-0.011	0.002	0.002
Parents employment situation		-0.000	-0.007	-0.007
Native speaker			0.005	0.005
Closeness to education			0.079*	0.079*
Parents' education			-0.002	-0.002
NSIB	***-0.024****	***-0.022****	***-0.023****	
1 sib				*-0.016*
2 sibs				***-0.049****
3 sibs				***-0.064****
4 and more sibs				***-0.098****
Adjusted R-squared	0.009	0.015	0.102	0.102
Number of observations	7734	7475	6815	6815

*, ** Significance at the 1% level and the 5% level respectively; the reference person is male, only child, lives in a classical family with both parents, his mothertongue is the official school language. All observations are weighted.

The calculations presented so far analysed the impact of family size and birth-order on the outcome of the supposed family interactions. PISA allows us to go one step further and test directly, whether the size of the family really reduces family interactions or not. The variable that suits our purposes best is the variable that describes the intensity of social interactions within families. They can be regarded as a proxy for the time

[23] An interesting result, which is not the subject of this paper and therefore will be handled rather shortly, is the observation, that especially in the case of the second group (foreign language) the regional dummies show significant differences between the Swiss language regions. In the French and the Italian speaking part of Switzerland foreigners seem to be better integrated than in the German speaking part. Without offering causal explanations for this result, it is perhaps noteworthy to mention that the school system in the "Latin" part of Switzerland offers in general more pre-school child care, selects at a later age and has a less important vocational track in the upper secondary education. These are all factors, which are often mentioned to have an effect on the social selectivity in schools.

[24] The dependent variable has a mean of 1.23 and a standard deviation of 0.27. This means that e.g. in a family with more than 4 children, social communication is reduced by 0.36 of one standard deviation, compared with a family with only one child.

parents devote to their children. If we part from the idea, that the negative impact on literacy achievement was caused by budget constraints, we should also expect that the family size has a significant link with the average time spent by parents with their children. Turning the argument the other way round, we could say that if we find a significant effect on the time spent with the children, this would back up our arguments on the sibling size effect on achievement (without being a proof for it). The only inconvenience with the variable is that as a matter of fact it only measures social interaction at the age of fifteen and we do not know whether it is really a simultaneous effect or not. It could also be that the outcome at the age of fifteen reflects the interactions that took place earlier, even in the pre-school period of the child. In this case, no sibling size effect on the amount of social interaction would not be a final proof that such an effect does not exist.

In table 6 we present the results in four regressions. Regression 1 just shows the “raw” effect of the sibling size, which is significant and negative. When we add control variables that control for time restrictions that could be due to the family configuration, the employment situation or the wealth of the family, the coefficient of the variable of interest is not affected significantly. The same result holds if we add another set of variables that could have an effect on the intensity of social communication within families. Girls seem to enjoy significantly more social interaction with their parents. The negative effect of the sibling size seems to be linear (adding a squared term of the sibling size variable does not change the results) but we also present (regression 4) the results with the dummy specification, in order to have a better picture of the magnitude of the effect.[25]

c. Birth-order

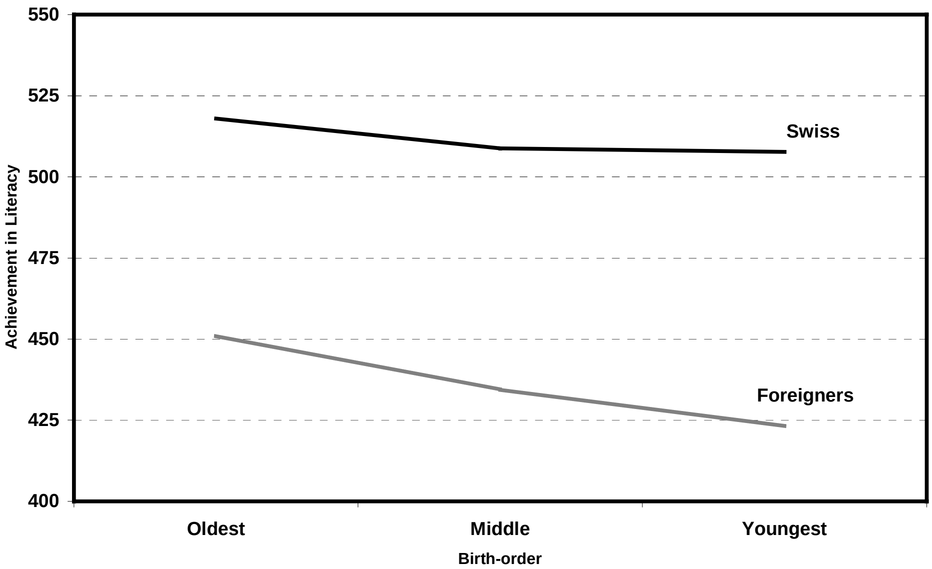
As we have seen in tables 2, 4 and 5, birth-order seems to play a significant role in almost all cases and in favour of the first born child. Graph 1 summarises the birth-order effect, separated for Swiss natives and foreigners. The predicted achievement is always higher for the first born child[26], although much more so for foreigners than for Swiss natives. As Hanushek has pointed out, this might be due to the fact that when merging all families together, first born children are much more likely to be in small families than the youngest or the middle ones. If this were the case, the birth-order effect would just reflect the family size effect. In order to analyse this question we regressed the birth-order on achievement using sub-

[25] The same analysis did not work with a variable that describes the family educational support. Probably interactions can be the cause of good achievement, at the same time they can also be caused by low achievement. So some of the good achievers get more help from parents but at the same time also some of the less good achievers. A regression shows that the amount parents spend with their children doing homework is a U-shaped curve depending on the level of achievement of the children.

[26] The oldest child is always significantly better than the youngest or the middle one (at 1% level of significance), whereas the difference between the youngest and the middle ones is not significant.

samples for each family size. The predicted achievements are depicted in Graph 2. Although we did the analysis for Swiss natives and foreigners separately, we present – for the sake of clarity - both results together.

Graph 1: Predicted achievement in literacy according to birth-order and nationality[27]



The results in Graph 2 lead to three conclusions about the birth-order effect. Conform to the results of Lindert (1977, p. 214) and Hanushek (1992, pp. 101-105) we find a) that once we measure the birth-order effect within a given family size, the first born child has still a higher achievement than the middle born children. This effect is the higher the bigger the family size is. With an increased family size, b) the results for the youngest ones start to improve relative to the other siblings.[28]

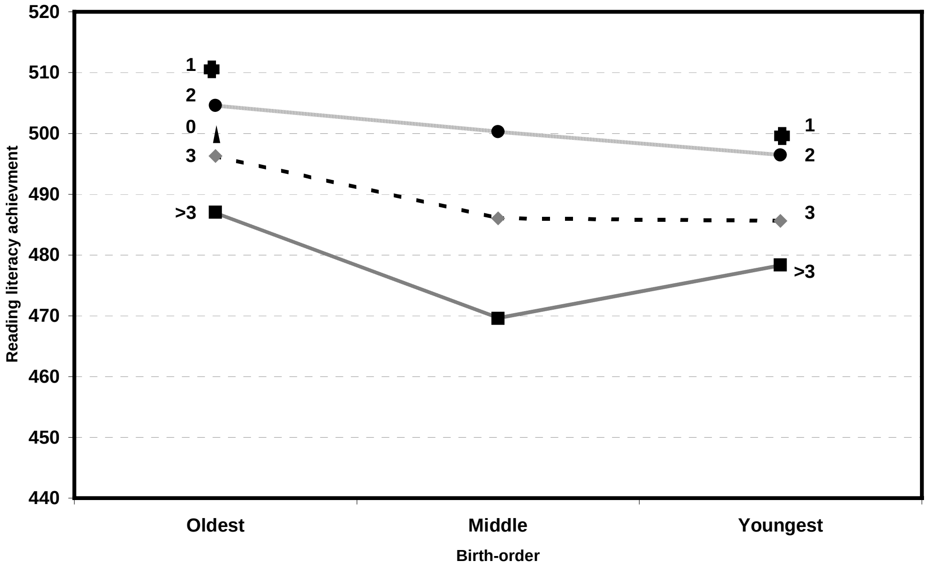
Contrary to the cited literature, we find, however, c) that the predicted achievement of the first born is lower if he or she is a single child compared to the first born children in small families (< 4 children).

Together with the birth-order effect we also find a distinct single child effect, which was already visible in table 4. A single child effect has also been

[27] Predicted literacy achievement is calculated using means for the ISEI and the closeness to education of parents within groups.
[28] For the family size of five children e.g. the predicted achievement of the youngest one is significantly higher than the achievement of the first born child. We do not present those results graphically because the number of observations is rather low for very large families.

found in other studies.[29] Besides the interaction between parents or adults in the family and their children, the interaction between the siblings themselves seems to play a similarly important role.

Graph 2: Predicted achievement in literacy according to birth-order and family-size[30]



Although birth-order effects seem to be smaller than family-size effects, they are significant and reinforce the argument, that some of the parental resources are divided amongst all children. For the middle children the competition for parental resources is *ceteris paribus* the fiercest, whereas the first born profits from a period (the length depends on the spacing of births) where it is the only child and the youngest child has the same situation later in life. Even more important might be the fact that it is likely that also the youngest child has all the parental attention (private time) during some of the pre-school period because the older siblings are already going to school or to the kindergarten. In order to test the causality of these explanations, however, we would need detailed information on the spacing of births and the employment pattern of both parents in the pre-school time. Information we do not have in PISA.

[29] "Rather, several of our regressions which allow for non-linear effects suggest that having one or two siblings can be better than being the only child." (Björklund & Jäntti, 1994, p. 13).
[30] Predicted literacy achievement is calculated using means for the ISEI and the closeness to education of parents within groups. Numbers in the graph indicate the number of siblings.

V. The Sibling size model revisited

In its basic version, the model that predicts a negative sibling size effect, starts from the idea that limited parental resources have to be divided by the number of siblings and therefore any increase in the family size will dilute the beneficial effect family resources can have for their children. Although this rule applies to all levels of income and endowments, it is clear that parents with different budgets of money and time face different constraints. Richer parents can purchase resources, poor parents can not always do they same and they do not always have access to credit. Besides the possibility of using outside, non-relative, sources to counterbalance the sibling size effect, the proportion of indivisible resources is also likely to depend on the parents' education, wealth and status.[31]

Outside factors, like the provision of free education, free child-care or generous child allowances also have to be taken into account when predicting the size of a sibling effect.[32]

Credit constraints, the quality of parental resources and the amount (quantity and quality) of indivisible resources therefore lead to a reinterpretation of the model. We would expect that children from better off parents (both in terms of income and education) would not suffer significantly from the presence of siblings. Those parents would be almost completely unconstrained. At the same time children in poor families with the same size of sibship would be significantly affected by the presence of siblings, as their parents face binding budget constraints.

We try to propose an extension of the classical family size model, as simple as possible, that tries to take into account the various research findings and at the same time fits the results found in this paper.

The family size effect on the educational achievement (E) of student i in family j depends on the size of the parental resources (R) and the number of children (C).

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[31] Behrman & Rosenzweig (2002, p. 334) refer in their paper to information intensive versus time intensive resources that impact outcomes. If it is the first effect that matters most, education of parents leads to better schooling outcomes of their children, independent of the time parents spend with each child.

[32] Björklund & Jäntti (1994) have explained the differences in the sibling size effect between Sweden, Finland and the USA with the relatively more generous child allowances in the Nordic countries and the provision of free education of the same quality level for all children. Bauer & Gang (2000) have argued in the same manner, when explaining the absence of any substantial sibling effect in Germany: "It may well be that as incomes increase and education is more freely and cheaply available, gender effects and size effects disappear." (p. 248)

$$E_{ij} = \frac{R_j}{C_j} \quad (1)$$

An improved model explaining the effect of the size of the sibship on educational outcome should make a distinction between indivisible (*iR*) and divisible resources (*dR*). As explained earlier both the magnitude and proportion (α) of the indivisible resources will probably depend on the socio-economic status (*SeS*) of the parents. We therefore reformulate equation 1 as follows:

$$R_j = \alpha iR_j + (1-\alpha)dR_j \quad (2)$$

$$E_{ij} = \alpha iR_j + \frac{(1-\alpha)dR_j}{C_j} \quad (3)$$

where $\alpha_j = \varphi(SeS_j)\ , \qquad \varphi > 0 \quad (4)$

$$iR_j = \kappa(SeS_j)\ , \qquad \kappa > 0 \quad (5)$$

$$dR_j = \lambda(SeS_j), \qquad \lambda > 0 \quad (6)$$

For the sake of simplicity we don't make an additional assumption about the linearity of the equations 4-6. What becomes evident from equation 3 and 4 is that with an increasing socio-economic status of the parents and the negative impact of one additional child in a rich family is *ceteris paribus* lower than for a poor family. The higher socio-economic status translates into a smaller proportion of the resources being divisible.

We can differentiate the model further to take into account more aspects of the quality of the indivisible resources by introducing a variable that measures the cultural distance or proximity of the family to the host country (*L*) and reformulate equation 5. For parents originating from the host country *L* takes the value of 1.

$$iR_j = \kappa(SeS_j) * L_j\ , \qquad \kappa > 0;\ 0 < L < 1 \quad (7)$$

Having these equations, we can rewrite equation 3 in a stylised reduced form, which provides a shortcut to the main intuitions behind the model.

$$E_{ij} = f_1\left(\overset{+}{SeS_j}, \overset{-}{C_j}, \overset{+}{L_j}\right) \quad (8)$$

Equation 8 tells us that the educational achievement for children from families with a high socio-economic background and a higher proximity to the local culture, everything else equal, is higher but that the family size effect is negative for all families.

This result does not fit well our findings in table 3, where we have seen, that at least in the upper quartiles of the socio-economic distribution single children had a significantly lower educational achievement than children from small families. There must be another effect in the equation we have missed so far, because equation 8 is unambiguous, regarding the effect of additional siblings.

The missing link in our model is a peer effect.[33] We assume, that in a family brothers and sisters can act as co-educators, as role models and child carer, so that some of the time and resources that parents can not spend on their children, is compensated by the interaction between children. Educational achievement is therefore a positive function of the number of siblings (*S*)[34]. We further assume that this effect is non-linear, because with an increasing number of siblings the interaction can also become negative, e.g. when siblings disturb each other in their homework. Finally we assume that the interaction between siblings depends on the quality of siblings[35], the better brothers and sisters are educated and have incorporated the cultural values of their parents, the more beneficial will their interaction with an additional child be. The quality of the children (*Q*) will depend on the socio-economic background and the proximity to the local culture of their parents. Equation 9 shows the peer-effect in family *j* on the educational achievement of student *i*.

$$E_{ij} = \left(S_j - \mu S_j^2\right) * Q_j , \qquad 0 < \mu < 1 \qquad (9)$$

where

$$Q_j = \upsilon\left(SeS_j * L_j\right), \qquad \nu > 0 \qquad (10)$$

As in equation 8, a shortcut of the peer-effect shows, that educational achievement is a positive function of the socio-economic background and

[33] In introducing a peer effect in our model, we follow the example of the theory on the effects of class size on educational achievement. Empirical research confirmed many times that although the time a teacher can spend per pupil falls steadily when class size increases, we can measure that the average achievement in a class follows an inverse U shape. This means that there must be a counterbalancing factor, leading to an optimum in the class size. This effect is commonly called the peer effect and accounts for the positive interaction between pupils in a class. In the literature on educational production, pupils in a class are therefore also regarded as co-producers of education.

[34] Note that now we don't speak of the number of children but the number of siblings instead.

[35] Note that as in Becker, the word quality has no moral meaning.

the cultural proximity and in this case of the number of siblings. The latter could turn negative, depending on the size of μ but in general not.

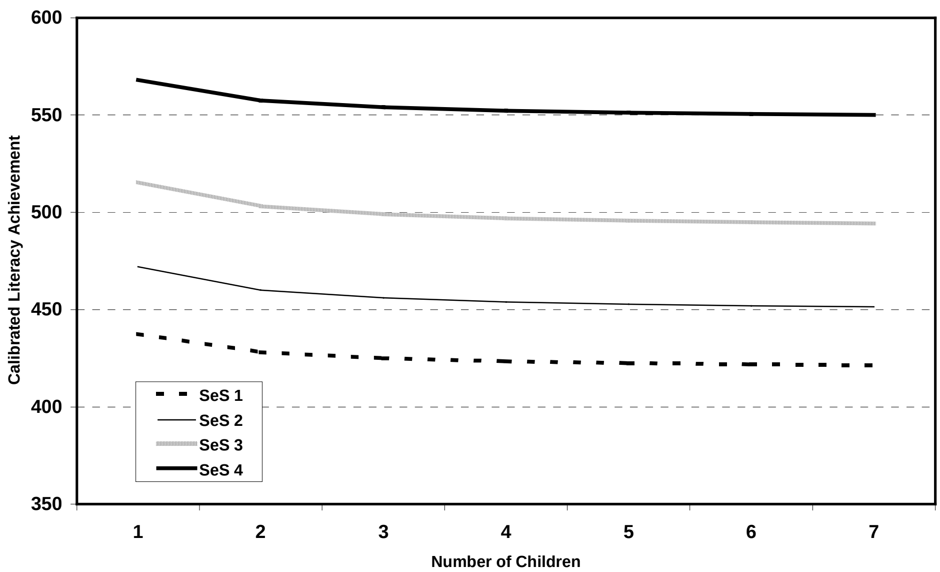
$$E_{ij} = f_2\left(\overset{+}{SeS}_j, \overset{+}{S}_j, \overset{+}{L}_j \right) \tag{11}$$

Bringing both effects, the family-size effect (f_1) and the peer effect (f_2) together in one equation (f_3), we can see that the structural effect of the socio-economic background and the cultural proximity is reinforced. For small family sizes and high quality in the interaction between siblings, the effect of an additional child, however, is not clear anymore.

$$E_{ij} = f_1\left(\overset{+}{SeS}_j, \overset{-}{C}_j, \overset{+}{L}_j \right) + f_2\left(\overset{+}{SeS}_j, \overset{+}{S}_j, \overset{+}{L}_j \right) \tag{12}$$

$$E_{ij} = f_3\left(\overset{+}{SeS}_j, \left[\overset{+}{S}_j / \overset{-}{C}_j \right], \overset{+}{L}_j \right) \tag{13}$$

Graph 3: Calibrated family-size effect[36]

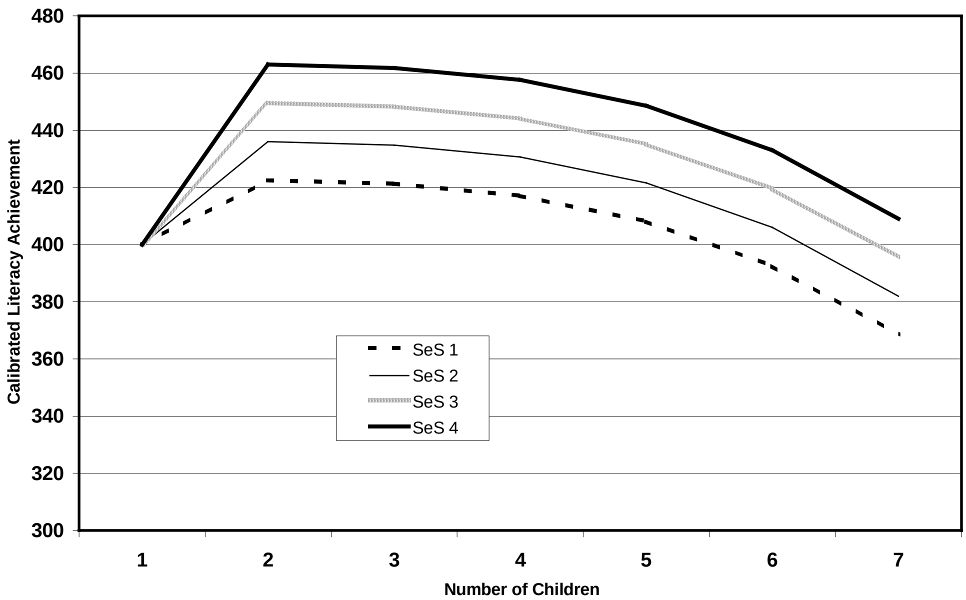


[36] SeS 1 stands for the lowest quartile of socio-economic status and 4 for the highest quartile respectively.

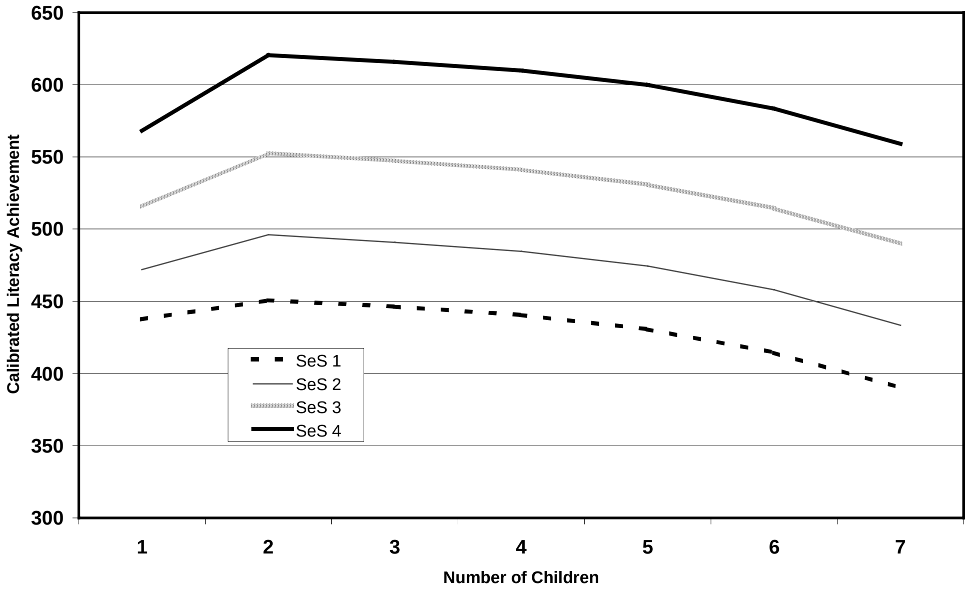
In the following part we will show results of calibrated model that shows in graph 3 the family size effect, in graph 4 the peer effect and in graph 5 the combined effects of the number of children in a family on the average educational achievement within a given family size, depending on the socio-economic status of the family. Graph 6 finally presents the calibrated results for the highest and the lowest socio-economic quartile, divided into native and foreign families. The only difference between the foreign and the native family result from differences in the cultural proximity (*L*).

As one can easily see, in graph 3, the average educational achievement in a family, conditional on its size decreases with every additional child in the family. The reduction is not linear. The first additional child takes half of the resources of the first child whereas the third child would "only" take a third of the resources from each of the first two children. We show a non-linear reduction in our model that Hanushek (1992) also stipulated.

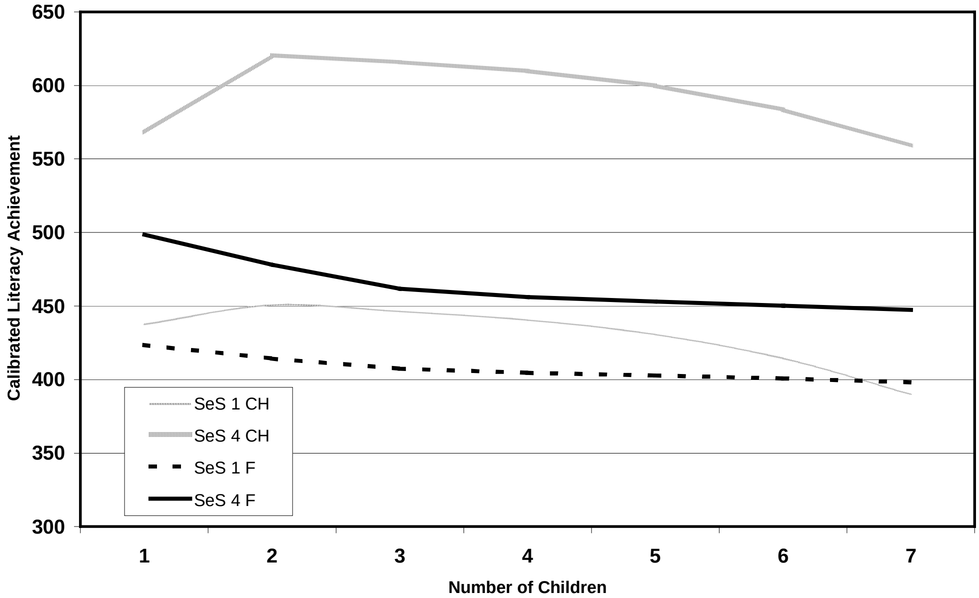
Graph 4: Calibrated peer-effect



Graph 5: *Calibrated total sibling size effect*



Graph 6: *Calibrated total sibling size effect with natives and foreigners*[37]



In graph 4 we see the peer effect. The marginal effect is the greatest between the first and the second child, where we have a 0/1 situation

[37] CH denotes Swiss natives and F stands for foreigners.

declining afterwards. It even turns negative for very large families, due to the squared term in equation 9. In graph 5 we make the sum of both effects and we can see, that very large families will have significantly lower average achievements than families with only one child. Families in the highest socio-economic quartile are better off, if they have at least two children. For the lower socio-economic quartiles the "only-child" effect is visible but small (as in table 4).

Finally in graph 6 we show the model results for natives and foreigners. Due to the effect of the cultural proximity in both, the peer and the family-size equation, we can calibrate results that show a decrease in the average achievement from the second child onwards. The gap between natives and foreigners widens first and closes when the family size gets very large as in the empirical results.

Thus with this model that takes into account two effects instead of only looking at the detrimental effect of an additional child, we can explain positive as well as negative total effects of the family size on the average educational achievement in a family. We can conclude from this that a non-existing sibling size effect at the macro level might well hide significant and substantial sibling effects for sub-groups of the population. A possibility that educational policy should be aware of.

VI. Conclusions

Looking at the intergenerational patterns of educational attainment, many highly developed and industrialised countries still show a disturbingly high degree of transmission from one generation to the next (e.g. Acemoglu & Piscke, 2001 or Dustmann, 2001 or Ermisch & Francesconi, 2001). Although the sources for this low intergenerational mobility in education and consequently in income status and wealth, are not clear yet, some results of the PISA study 2000 have clearly indicated an urgent need for a better understanding of the way the educational system deals with social differentiation. Contrary to the political statements, many indicators in the PISA data let us think that the educational system does not fulfil one of its functions, namely to reduce the impact social differences can have on educational achievement.

In this paper we look at a particular source of social differentiation in the educational system that handicaps children coming from a different social background. We know that educational achievement is only partly the result of schooling and to an important degree also the product of interactions between children and their parents. In this context the size of the family or also the birth-order can have a detrimental effect on children's school performance. The most recent empirical literature has, however, found smaller and even non-existing sibling size effects and explained this observation with the free provision of education in most countries, lower opportunity costs of education and the providence of free child care or child allowances. All these developments should have built up a framework in which parents would no longer face binding budget constraints. These arguments are convincing as long as we focus on monetary resources. As soon as we look at time as an equally important parental resource, it is less clear whether we should expect no sibling size effects any more.

The empirical results in this paper show, at least for the case of Switzerland, that the real magnitude of the sibling size effect is only apparent when looking at sub-samples of the population. The results point in the direction that those families that already suffer from a lower socio-economic status, less education or a greater cultural distance to their host-country exhibit an additional and significant sibling size effect. Therefore children from these families are triple handicapped, firstly because their parents can not give them a lot of resources and secondly because the low endowments have to be split on more siblings and thirdly because as foreigners integration into the host countries culture seems to be difficult. In the empirical results, the overall sibling size effect is diluted by the fact, that besides the sibling size effect there is also a "single-child" effect observable that works in the opposite direction. This effect masks the real magnitude of the sibling size effect in the sub-groups of the population that suffer from it.

In regressing the number of siblings on the achievement, we use outcome data for our analysis, which can be problematic in the sense that it still poses an identification problem. Our hypothesis, that the number of siblings reduces the time, parents can spend with their children was therefore directly tested with a variable that tells something about the intensity of parental interactions with children. The results confirm our hypothesis insofar we can observe a significant and negative impact of the sibling size on this variable.[38]

It is fair to say, that due to the various limitations of the data set, we can not rule out the possibility of any bias in these results completely. It is still possible that some unobserved characteristics of the parents influence simultaneously the quality of children and the decision to have more children. In this case the location of the problem of underachievement would still be valid but it would influence the choice of the remedy.

If the results found reflect really the consequence of budgetary constraints of a sub-sample of families, financial aid (e.g. targeted[39] child allowances) should help to overcome these handicaps by providing those parents with access to the same resources as other families.[40]

If, however, the concentration of low achievers in big families would have to be explained by unobservable traits of the parents, money alone would not be sufficient to improve the situation. In this case the social and educational system should provide these children with a beneficial environment to compensate for the negative influences in their parental home.[41] The same type of measure would be necessary to combat the single child effect, in order to stimulate early interaction of those children with other children (peers).

Another unsolved question is the time of intervention. It is not because we measure the effect at the age of fifteen, that it has to be cured at that age. On the contrary, if our theoretical observations (especially in the case of the

[38] We also tested the impact of the sibling size on a variable that it is a proxy for budget constraints in physical capital. The variable describes a specific aspect of the housing situation, namely whether a child has a room on its own or not. In a probit estimate the variable shows the same dependence as the variable on social communication.

[39] Targeting groups of families and targeting the type of measures would still present a difficult task to solve (see for an overview of what we know and what we do not know of interventions in early childhood, Waldfogel, 2002).

[40] Recent studies show, that with financial incentives, the number of parents that make use of early child-care and education can be influenced positively (e.g. Del Boca, 2002 or Michalopoulos & Robins, 2002).

[41] Those interventions should of course be compulsory because we would expect that even with free access to these measures, those who would benefit the most of them would not automatically choose to use them. At the same time we did not discuss further the effect free and compulsory child care would have on the employment behaviour (on which a large literature already exists, see e.g. Gelbach, 2002) of women and how this could again have an influence on the time parents spend with their children.

birth-order effect) are true, the budget constraints parents face in the pre-school-time of their children are much more important than the constraints during school-time.[42]

In any case, whatever the causality behind the sibling size effect is, PISA data allow us to localise sibling size and birth-order effects among specific groups of parents. Targeted interventions for these families should therefore help to reduce the social differentiation within the society and enhance economic mobility across generations.

[42] This would also correspond with the findings of empirical research in early childhood and pre-school child-care. Hanushek (1992) found a strong effect of the family configuration in the pre-school time on educational achievements at the beginning of the school career. Other studies, like a recent paper by Jenkins & Schluter (2002) show contrasting results, indicating that it is later income that has a bigger effect than income during early childhood, although modestly, when analysing the educational attainment of 14 year old Germans.

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