INITIAL CONDITIONS, HOME RESOURCES AND COMPETENCIES IN THE EARLY LIFE COURSE

Dorothea Blomeyer+, Katja Coneus*, Manfred Laucht+, Friedhelm Pfeiffer*

+ Central Institute of Mental Health (ZI), Mannheim
* Centre for European Economic Research (ZEW), Mannheim

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This paper investigates the role of pre-, peri- or neonatal conditions and home resources for competence formation from infancy to adolescence. We study complementarities between cognitive, motor and noncognitive abilities and social as well as academic competencies and assess alternative educational policies in the early life course. Our data are taken from the Mannheim Study of Children at Risk, an epidemiological cohort study following the long-term outcome of early risk factors. Results indicate that organic and psychosocial initial conditions matter for competencies, as well as socio-emotional home resources in childhood and economic resources during the transition to higher secondary school track. Basic competencies acquired in childhood predict achievement at school age. There is a remarkable stability in the inequality of economic and socio-emotional home resources. This is presumably a major reason for the evolution of inequality in competencies from birth to adolescence.

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Corresponding author: Friedhelm Pfeiffer, Centre for European Economic Research (ZEW), P.O. Box 103443, D-68034 Mannheim. Tel.: +49-621-1235-150,
E-mail: pfeiffer@zew.de

I. INTRODUCTION

In this paper, we try to contribute to the recent multidisciplinary literature on human development and inequality (Heckman, 2006, 2007). Deep-seated skills are formed in a dynamic interactive process between adult caregivers and children starting with conception, and research that is based on only a subset of relevant factors may contain some bias. The relationship between pre-, peri- or neonatal risk conditions (both from the organic and the psychosocial perspective), ongoing parental investments and competencies is analysed to gain an understanding of the childhood skill multiplier. Our contribution to the literature is twofold.

First, the empirical analysis is based on unique data from a developmental psychological approach. The data provides detailed psychometric assessments and medical and psychological expert ratings on home resources and child outcome measures.[1] Psychometric assessments of initial risk conditions were conducted followed by cognitive, motor and noncognitive abilities at infancy (3 month), toddlerhood (2), preschool age (4.5), elementary school age (8) and secondary school age (11 years), representing significant stages of development. We analyze the relationship between initial organic and psychosocial conditions, socio-emotional and economic home resources and the formation of basic abilities during development and competencies in social and academic life.

Second, stage specific parameters of the technology of skill formation (Cunha and Heckman, 2007, 2008, 2009) are assessed together with complementarities between basic abilities in childhood and social and school achievement at school age. Reversed causality between adult care giving and skill formation is taken into account. Having a child with high cognitive (or noncognitive) abilities is likely to increase home resources to bolster development (and vice versa).

Our findings demonstrate that interpersonal differences in cognitive and noncognitive abilities are consistently associated with initial conditions and socio-emotional home resources, the relationship being age and ability specific. The findings are in line with the literature on the childhood skill multiplier that has been summarized recently by

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[1] The data are taken from the Mannheim Study of Children at Risk (abbr. MARS, which has been derived from the German title: **MA**nnheimer **R**isikokinder **S**tudie), an epidemiological cohort study that follows children from birth to adulthood (Laucht et al., 2004; for a recap see Blomeyer et al. (2009)).

Heckman (2007). Children are exposed to a matrix of initial organic and psychosocial risk conditions and each risk factor contributes to development as does the sum of all factors. During childhood the inequality of socio-emotional home resources is a major additional reason for the further evolution of inequality. The quality of parental care giving matters for competencies.

Our measure of noncognitive abilities, *persistence,* is significantly related to socio-emotional home resources throughout the early life course. The highest association is found to occur at age 2 and 4.5 years. Cognitive abilities, measured with the *IQ*, are strongly related to socio-emotional home resources during pre-school age and only weakly during school age. The influence of parental care giving declines continuously and is highest at infancy. Interestingly, the relationship between parental care giving and motor abilities, measured with the *MQ*, is positive, although of lower magnitude and not significant. Interpersonal differences in the *MQ* are determined primarily already by initial conditions. There is strong evidence for synergies in the development of abilities. Higher cognitive abilities are helpful in developing higher noncognitive abilities and higher noncognitive abilities are helpful in developing higher cognitive abilities (Heckman (2007), see also Duckworth and Seligman, 2005, among others).

It is furthermore demonstrated that abilities at preschool age predict social competencies and school grades at the age of 8. Children with higher cognitive and noncognitive abilities at preschool age have improved peer relationships, interests and better grades in math, reading and spelling at primary school age. Higher cognitive and noncognitive abilities at primary school age predict a higher-track secondary school attendance in Germany starting with the age around ten years, or later. The availability of economic resources creates an additional differential factor for development and inequality during adolescence. All else equal, children with access to more economic resources more often attend a higher-track secondary school. Surprisingly, there is no evidence on a relationship between higher-track secondary school attendance and improved abilities, neither for noncognitive nor for cognitive ones. This finding suggests that children who attend higher-track secondary school also have higher cognitive abilities (higher *IQ*). They choose higher-track secondary school because they have higher abilities.

Our findings are related to literature on the stability of personality traits (Kadzin et al., 1997, Mischel et al., 1988, among others). We contribute to this literature through the use of expert rather than maternal ratings of children's abilities and through investigating the role of home resources. The stability of personality traits is associated with the stability of socio-emotional home environment during childhood. Our findings with respect to initial conditions are related to recent findings on long term outcomes of birth weight by Black et al. (2007), among others and on the relationship between height and socio-economic outcomes. The psychometric measures of initial organic and psychosocial conditions in the MARS data extend the knowledge on the variety of early risk factors and competence measures. Besides low birth weight, neonatal complications and adverse psychosocial conditions like maternal discord or psychiatric disorder of parents contribute to development as well. We find a significant correlation of 0.28 between the *IQ* and the height at the age of 3 months, confirming findings by Case and Paxson (2008) that height is a proxy for cognitive abilities in early childhood. In the production of cognitive and nocncognitive ability height has no additional explanation power, once measures of past abilities and home resources are included.

Our research is also related to the literature on the consequences of maltreatment in childhood for depression and inflammation in adulthood (Danese et al., 2007, among others). Maltreatment is one important result of adverse socio-emotional home resources with long run negative outcomes.

We conclude that advantages from beneficial and disadvantages from adverse home environments cumulate during the developmental stages in social reality. The quality of home resources does not differ much over time. For disadvantaged children, in early childhood, the development of cognitive abilities is hindered in addition to the adverse factors from initial risks. This disadvantage continues, thus impairing noncognitive ability formation at school age. Disadvantaged children are again hindered during the transition to a higher-track secondary school, when low economic home resources constitute an additional barrier. There is still an underinvestment in public resources during preschool age for children who grow up in an adverse home environment. Policies are examined that help children built their competencies at alternative developmental stages.

Although the evidence presented in this paper and the literature summarized in Heckman (2007) is conclusive some caveats remain. Still alternative, and may be more general evidence on the childhood skill multiplier is missing. Our evidence is based on observations from populations of children who experience a stable beneficial or adverse home environment. It is a question of considerable interest whether children, who experience adversity in childhood, find beneficial and individually well adapted help after childhood, can regain resilience. This is a question of future research.

The paper is organized as follows. Section 2 introduces the data. Section 3 examines the evolution of economic and socio-emotional home resources and competencies from birth to 11 years. Section 4 discusses our estimates of the developmental-specific technology of skill formation. Section 5 studies complementarities between abilities in childhood and social competencies and school achievement at school age. Alternative compensating policies during the early life course are investigated in section 6. Conclusions are drawn in section 7.

II. PRE-, PERI- OR NEONATAL ORGANIC AND PSYCHOSOCIAL RISKS

The MARS project aims at following infants who are at risk for later developmental disorders to examine the impact of initial adverse conditions on the probability of negative health and socio-economic outcomes (Laucht et al., 2004, 1997).[2] Risks stem from the individual, the environment and their interaction. To control for confounding effects related to home resources and the infant's medical status, only first-born children with singleton births to German-speaking parents of predominantly (> 99.0 percent) European descent, born between February 1986 and February 1988 were enrolled in the study. The first 110 children were included consecutively into the study, irrespective of risk-group status. These children form our approximate normative sample.

To separate the independent and combined effects of organic and psychosocial influences on child development, children were selected according to combinations of differ-

[2] Infants were recruited from two obstetric and six children's hospitals in the Rhine-Neckar region of Germany. Children with severe physical handicaps, obvious genetic defects or metabolic diseases were excluded. The initial participation rate was 64.5 percent, with a slightly lower rate in families from low socio-economic backgrounds.

ent risk factors. Infants were rated according to the degree of "organic" risk and the degree of "psychosocial" risk.[3] Each risk factor was scaled as either no risk, moderate risk or high risk, a 3x3 design (Figure 1). Children were assigned to one cell of the two-factor matrix. All groups are about equal in size with a slight oversampling in the high-risk combinations. Sex is distributed evenly in all subgroups. Excluding children with missing values in some waves, 364 children (174 boys, 190 girls), or 95 percent of the 382 infants in the initial wave, remained.

Organic risk is determined by the degree of pre-, peri- or neonatal complications. The risk factors and their prevalence in the sample are shown in Table A1. Pre- and perinatal variables were extracted from maternal obstetrical and infant neonatal records and are used for organic risk classification. Organic risk is classified as follows:

1. The non-risk group consists of 118 infants who were born full-term, had normal birth weight and no medical complications (items 1–4).
2. The moderate-risk group contains 119 infants who had experienced premature births or premature labor, or EPH-gestosis of the mother but no severe complications (items 5–7).
3. The high-risk group comprises 125 infants who had very low birth weight or a clear case of asphyxia with special-care treatment or neonatal complications, such as seizures, respiratory therapy or sepsis (items 8–10).

Psychosocial risk is determined according to a risk index proposed by Rutter and Quinton (1977), which measures the presence of eleven unfavorable family characteristics, for example martial discord or low skilled parents. The "enriched" family adversity index includes adverse family factors during a period of one year prior to birth as reported in Table A2. Information for the psychosocial risk rating was taken from a standardized parent interview conducted at the 3-month assessment. Psychosocial risk is classified as follows:

1. The no-risk group includes 120 infants who had none of the psychosocial risks.
2. The moderate-risk group contains 111 infants with one or two of these factors.

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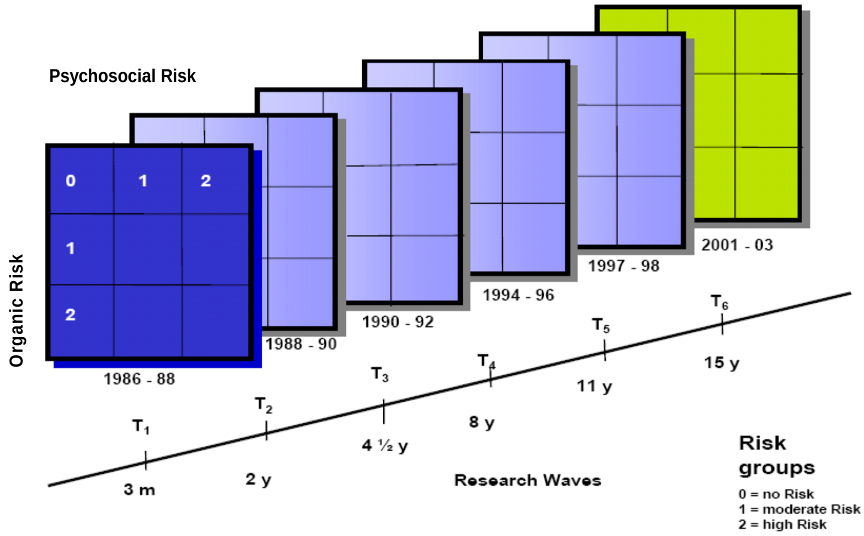
[3] The relevance of APGAR and birth weight for adult outcomes has been demonstrated by Almond et al. (2005) and Black et al. (2007), among others. Other aspects of the initial risk matrix, such as neonatal complications, or maternal discord, have not been widely investigated in economic research.

3. The 131 infants from the high-risk group came from a family dealing with 3 or more of these risk factors.

Figure 1: The Mannheim Study of Children at Risk, 1986 - 2003



III. COMPETENCIES, HOME RESOURCES

Throughout the paper the expression competence summarizes basic abilities of children, such as logical and verbal reasoning, motor abilities and persistence and social as well as school related achievement, such as peer relationships, autonomy, interests and school grades. The section introduces to the measurement of competencies and home resources in the MARS data, together with descriptive statistics.

1. Cognitive, motor and noncognitive abilities

The terms *cognitive*, *motor*, and *noncognitive* abilities indicate three different, yet dependent and important basic dimensions of human capital and personality. Cognitive abilities include memory capacity, information processing speed, linguistic and logical skills, and general problem-solving abilities (*IQ*). Motor abilities are assessed as fine and gross motor skills and body coordination (*MQ*). For a detailed description of the measurement of cognitive and motor abilities in MARS (see the appendix *IQ, MQ*).

Our main dimension of noncognitive abilities measures the child's ability to pursue a particular activity and its continuation in the face of distractors and obstacles, defined as *persistence* (*P*). The ratings were made by trained raters[4] on 5-point rating scales adapted from the New York Longitudinal Study NYLS (see Thomas and Chess, 1977). *P* is a deep-seated noncognitive ability related to effort regulation, perseverance, persistence and self-discipline.[5] Until the age of 2, *P* is measured with the attention span within the same scale. Persistence was derived from a combination of a standardized parent interview and structured direct observations in four standardized settings on two different days in both, familiar (home) and unfamiliar (laboratory) surroundings, to reduce measurement errors. *P* is available throughout the first five waves.

Table 1 contains summary statistics of the abilities *IQ*, *MQ* and *P* in the nine risk groups of MARS. Note that the *IQ* and the *MQ* have been normalized in each developmental stage to mean 100 and SD 15 in the approximate normative sample of 110 children. For reasons of clarity we restrict the presentation to the age 3 months and 11 years. In line with the literature on competence research (Egeland et al., 1993; Kazdin et al., 1997; Laucht et al., 2000, 2004, among others), our results indicate that unfavorable consequences of initial organic and psychosocial risks seem to persist until adolescence.

Organic and psychosocial risk factors exhibit equally negative effects but are specific to the areas they affect. Until the age of 11, the individual differences in children's abilities, assessed with the mean and the standard deviations, have increased. Initial inequality in the risk matrix exaggerates over time. While psychosocial risks primarily influence cognitive and socio-emotional functioning, the impact of early organic risks concentrates on motor and cognitive functioning. There is a monotonic decrease in the *IQ* and the *MQ* in (nearly) all risk dimensions, and differences in average *IQ*, *MQ* and *P* increase between the ages of 3 months and 11 years in the risk matrix. At the age of 3

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[4] We examined further dimensions from the NYLS scales, among them the initial reaction to a new stimulation, the length of time needed to adapt, and the prevailing mood. Our econometric analysis revealed that these dimensions showed no systematic correlations with the cognitive abilities which seems to be in line with the early literature. Studies, cited by Thomas and Chess (1977), indicated that none of these temperament measures were associated with the level of the *IQ*.

[5] At the ages of 3 months and 2 years, the interrater reliability was measured in a study of 30 children. Satisfactory interrater agreement was obtained between two raters (3 months: mean $\kappa = 0.68$, range 0.51 - 0.84; 2 years: mean $\kappa = 0.82$, range 0.52 - 1.00). To avoid distortions resulting from parental judgment or one-time observations in an unfamiliar surrounding, a mean score was formed out of all 5 ratings.

months, the children without any risk have an average *IQ* of 103 compared to the children with high organic and high psychosocial risk, whose average *IQ* is 88. In addition, differences in the standard deviations increase with risk, from 13.2 in the no-risk to 19.8 in the highest-risk group (Table 1). The results for the *MQ* look rather similar.

Table 1: Children's abilities at 3 months and 11 years evaluated in the risk matrix (means and standard-deviations in brackets)

		Psychosocial Risk					
		no-risk		moderate		high	
		IQ (Intelligence Quotient)					
		3 months	11 years	3 months	11 years	3 months	11 years
Organic Risk	no-risk	103* (13.5)	108* (15.3)	102* (16.7)	107* (16.3)	96* (15.9)	100* (18.9)
	moderate	101* (16.0)	105* (10.4)	99* (16.5)	98* (13.3)	97* (16.3)	97 (19.2)
	high	95 (13.2)	101* (20.0)	93 (17.4)	92 (24.0)	88 (19.8)	87 (27.3)
		MQ (Motor Quotient)					
		3 months	11 years	3 months	11 years	3 months	11 years
Organic Risk	no-risk	103* (12.1)	104* (13.0)	102* (12.5)	106* (17.2)	103* (13.9)	104* (12.8)
	moderate	101* (13.6)	97* (12.3)	98* (15.7)	103* (14.1)	99* (13.6)	98* (18.1)
	high	93 (12.1)	98* (16.9)	92 (13.5)	97* (23.6)	89 (13.8)	86 (26.5)
		P (Persistence score) (measured at 4.5 years instead of 3 months)					
		4.5 years	11 years	4.5 years	11 years	4.5 years	11 years
Organic Risk	no-risk	3.82* (0.68)	4.27* (0.54)	3.50* (0.73)	4.13* (0.59)	3.17 (0.83)	3.84 (0.79)
	moderate	3.54* (0.63)	4.02* (0.53)	3.38 (0.75)	3.87 (0.59)	3.20 (0.80)	3.63 (0.73)
	high	3.61* (0.64)	3.99* (0.56)	3.14 (0.70)	3.71 (0.64)	3.07 (0.77)	3.55 (0.91)

MARS, 364 observations; *IQ* and *MQ* are normalized to mean 100 and SD 15 in the normative group; persistence scores vary between 1.0, 1.1, … (low) and 5.0 (high) * indicates the significance of differences relative to the highest-risk group at the 5 percent level.

Average *persistence* decreases monotonically along both risk dimensions. There is a 23 percent difference between the no-risk and the highest-risk group of children at the age of 4.5 years (3.8 vs. 3.1, Table 1), and the heterogeneity of the noncognitive ability increases along the risk dimensions. At the age of 11 years, children without any risk have an average *IQ* of 108 (SD 15.3), compared to the children with the highest organic and psychosocial risk with an average score of 87 (SD 27.3) (Table 1). The results for the *MQ* at the age of 11 are very similar to the results for the *IQ*. The average gap in cognitive abilities at the age of 11 between the no-risk and the maximum-risk group has increased to 21.[6]

Our findings reveal that initial risk conditions matter for inequality of cognitive, motor and noncognitive abilities and that the cumulative effect of organic and psychosocial risk corresponds to the sum of the single risk effects. Differences in average cognitive, motor and noncognitive abilities accelerate, and heterogeneity increases along the risk dimensions. In the data we found significant sex differences in the *IQ* only in the years 2 and 4.5 (the *IQ* of girls is 6% higher), and in *P* after the age of two years (girls score higher, 0.42 at 4.5 years and 0.22 at 11 years). There is a significant correlation of 0.28 between the *IQ* and the height at the age of 3 months, confirming findings by Case and Paxson (2008) that height is a proxy for cognitive abilities in early childhood.

2. Socio-emotional and economic home resources

There are two types of home resource variables by which the children were assessed in their early life cycle, summarized into socio-emotional categories, *H* (HOME-score), and economic categories, measured by the monthly net equivalence income per household member, *Y* (Table 2). In MARS, the socio-emotional home resources were rated with the Home Observation for Measurement of the Environment (HOME, Bradley, 1989), adapted to German living conditions. All items were evaluated by trained home visitors (interviewers) in contact with the primary caregiver. *H* is the sum of all items.[7]

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[6] The difference is greater when compared to the *IQ* of Romanian adoptees at maximum risk and the group of English adoptees without comparable risk (which amounts to 17, see Beckett et al., 2006).

[7] Todd and Wolpin (2007) also use the total HOME score, while Cunha and Heckman (2008) use subscales, such as theatre visits, musical instruments and books.

H at the age of 3 months consists of six subscales: (1) emotional and verbal responsibility of the mother, (2) acceptance of the child, (3) organization of the environment, (4) provision of appropriate play materials, (5) maternal involvement with the child and (6) variability. At the age of 2 years *H* comprises the six subscales plus the caretaking activities. At the age of 4.5 years *H* consists of the original subscales plus the caretaking activities items and items related to the included parent interview. At the age of 8 and 11 years MARS adopted HOME, which consists of 6 subscales and 81 items.

Table 2: *H* and *Y* in children aged 3 months and 11 years evaluated in the risk matrix (means and standard-deviations in brackets)

		Psychosocial Risk					
		no-risk		moderate		High	
		H: HOME score					
		3 months	11 years	3 months	11 years	3 months	11 years
Organic Risk	no-risk	106* (12.9)	108* (6.5)	102* (12.9)	105* (10.2)	93 (17.0)	92 (19.8)
	moderate	105* (14.2)	107* (6.9)	100 (12.9)	99 (12.6)	95 (14.1)	92 (21.7)
	high	106* (10.5)	106* (9.1)	100* (12.7)	98 (10.8)	94 (18.6)	94 (16.6)
		Y: monthly net equivalence income per head					
		3 months	11 years	3 months	11 years	3 months	11 years
Organic Risk	no-risk	1,275* (775)	1,699* (681)	1,122* (542)	1,632 (832)	775 (465)	1,256 (643)
	moderate	1,293* (649)	1,644* (627)	903 (239)	1,325 (555)	948 (774)	1,325 (641)
	high	1,180* (403)	1,806* (629)	927 (295)	1,425 (495)	863 (344)	1,355 (636)

MARS, 364 observations; for the initial risk matrix, compare Table A1 and A2 and the text. *Y* in DEM; *H* is normalized to mean = 100 and SD = 15 in the normative group for comparison reasons; * indicates significance of mean differences relative to the high-risk group at the 5 percent level.

Both measures of a child's home resources decline steadily along the psychosocial risk dimension (Table 2). For the group of children with high psychosocial risk, *Y* is on average 60 percent of the value in the no-risk group in infancy. The differences in the average *H* in the risk matrix show a similar pattern, although this gap is lower. *H* for the group of children with high psychosocial risk is 87 percent compared to the no-risk group. The partial elasticity of *H* with respect to *Y* is on average 0.08 (t_1=0.06, t_2=0.09, t_3=0.11, t_4=0.08, t_5=0.07). If economic resources were doubled, *H* would be 6 to 11 percent higher. One interesting finding in our data is this relationship between *H* and *Y* and their variation for the children in the risk matrix. Although the relationship is positive (a higher *Y* is associated with a higher *H*), the absolute magnitude seems to be rather low.

3. Social competencies

Social competencies of children were assessed in two ways. From the ages of 4.5 to 11 the Scales for Levels of Functioning has been used and from 8 to 11 years, the Perceived Competence Scales (Harter and Pike, 1984; German version by Asendorpf and van Aken, 1993). Based on expert ratings, these scales aim to measure independence in everyday life, *autonomy*, hobbies, *interests*, and integration in groups and social life, *peers*, Table 3. In addition to the expert-rated Levels of Functioning scale, peers, a self-rating indicating perceived peer acceptance, is included for comparison reasons. *Peer acceptance* is a subscale of the Harter scale which consists of 6 items, each ranging from 1 to 4. The items correspond to children's self-perceptions regarding their peer relationships. For example, children were asked how many friends they have, whether they play together in general and whether they play on a children's playground.

Table 3 contains the means of the competencies variables evaluated at the age of 8 years for the cells of the risk matrix. Initial risk effects seem to cumulate, and all social adjustment scores decrease along both dimensions of the risk matrix. The gaps in average social competencies at the age of 8 years are significant. The difference between the no-risk and the highest-risk groups amounts to roughly 25 percent. However, two exceptions are worth mentioning. First, if there is no psychosocial risk, organic risks seem to lose significance for *autonomy*, *interest* and *peers*. For pursuing various interests and popularity with peers, the initial psychosocial risk load seems to be, on average, more harmful than organic risks. Second, based on the self-rating, there seems to be little variation in the cells of the risk matrix. From the child's viewpoint, the differences in social life seem to be less significant compared to the expert ratings.

Table 3: Social competencies at the age of 8 years evaluated for children in the risk matrix (means and standard-deviations in brackets)

		Psychosocial Risk		
		no-risk	moderate	high
		interests / autonomy		
Organic Risk	no-risk	5.09* / 4.64*	4.87* / 4.84*	4.37 / 4.78*
	moderate	4.98* / 4.83*	4.42* / 4.52	4.09 / 4.35
	high	4.92* / 4.59	4.31 / 4.26	3.95 / 4.07
		peer relations (expert- / self-rated)		
Organic Risk	no-risk	4.82* / 18.23	4.62* / 18.20	4.57* / 18.36
	moderate	4.48* / 18.50	4.45* / 18.06	4.39 / 17.84
	high	4.81* / 19.11	4.41 / 18.27	3.98 / 18.49

MARS, 364 observations; social competence scores range from 1.0 (low), 1.1, … to 5.0 (high), self-concept scores range from 10 (low) to 24 (high); * indicates significant mean differences relative to the high risk group at the 5 percent level.

4. School achievement

School achievement at the age of 8 years, measured with grades in *math* and *German*, confirm the importance of the initial psychosocial risk conditions, Table 4. Grades in the highest-risk group are about one grade lower than grades in the no-risk group. A high psychosocial risk has the largest negative average effect. Not surprisingly, there is not much variation between the average grades in these three subjects. Initial risks have comparable implications for all school subjects.

School choice takes place, as a rule, after the age of 10 in Germany. On average 45 percent of the children in MARS attend a *Gymnasium*, which is the highest-track/grammar school in Germany.[8] For attending the *Gymnasium*, the initial risks still matter (Table

[8] Thirty percent attended a *Realschule*, 16 percent a *Hauptschule* (lowest secondary school track) and 8 percent more specific school types (*Förderschule*, *Walldorfschule*). A *Förderschule* is a school type for children with learning disabilities or who are disabled. According to official statistics on the 2000/01

4). In the highest-risk group, only 15 percent of the children attend the *Gymnasium*, compared to 74 percent in the no-risk group. Average school attendance decreases (nearly) monotonically along the two dimensions of our risk design with two exceptions. For children born without psychosocial risk, there seems to be no difference between the moderate and the high organic risk groups. For children born without organic risk, the no-risk and the moderate psychosocial risk groups are similar.

Table 3: Social competencies at the age of 8 years evaluated for children in the risk matrix (means and standard-deviations in brackets)

		Psychosocial Risk		
		no-risk	moderate	high
		interests / autonomy		
Organic Risk	no-risk	5.09* / 4.64* (0.74 / 0.81)	4.87* / 4.84* (0.89 / 0.73)	4.37 / 4.78* (1.17 / 0.98)
	moderate	4.98* / 4.83* (0.68 / 0.88)	4.42* / 4.52 (0.75 / 1.15)	4.09 / 4.35 (0.99 / 1.13)
	high	4.92* / 4.59 (0.83 / 1.04)	4.31 / 4.26 (1.06 / 1.31)	3.95 / 4.07 (1.21 / 1.42)
		peer relations (expert- / self-rated)		
Organic Risk	no-risk	4.82* / 18.23 (0.92 / 3.0)	4.62* / 18.20 (0.89 / 3.56)	4.57* / 18.36 (1.15 / 3.73)
	moderate	4.48* / 18.50 (0.89 / 3.68)	4.45* / 18.06 (0.94 / 3.35)	4.39 / 17.84 (1.05 / 3.64)
	high	4.81* / 19.11 (0.91 / 3.03)	4.41 / 18.27 (1.02 / 3.4)	3.98 / 18.49 (1.24 / 2.79)

MARS, 364 observations; social competence scores range from 1.0 (low), 1.1, … to 5.0 (high), self-concept scores range from 10 (low) to 24 (high); * indicates significant mean differences relative to the high risk group at the 5 percent level.

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school year in Baden-Württemberg, 30 percent of the students in class 9 attended *Gymnasium*, 35 percent *Realschule* and 35 percent *Grund-* und *Hauptschule* (without *Förderschule*) (in 2006/07, the numbers including the Förderschule are 28 percent, 31 percent, 29 percent, and in addition 11 percent *Förderschule*, and 1.3 percent *Walldorfschule*). We conclude that in our data more children attend higher secondary school compared to the average in Baden-Württemberg for class 9. One reason is that children from immigrant families with poor German language skills have not been included.

5. First Order Temporal Correlations

We utilize the longitudinal dimension of the data. Table 5 summarizes the first-order temporal correlations for cognitive, motor and noncognitive abilities and social competencies. The evolution of the first-order temporal correlations is an empirical measure of the interpersonal rate of consolidation of competencies. While it is presumable lower for some abilities, for example noncognitive abilities during childhood, it may be higher for others, for example motor abilities. A high value of the temporal correlation coefficient is a hint that interpersonal differences have been stable between the two periods. Taking measurement errors and further factors of influence into account (discussed in section 4 below) a correlation coefficient between 0.30 and 0.49 indicates moderate consolidation, a value between 0.5 and 0.69 indicates consolidation and values above 0.70 hints at high consolidation of interpersonal differences over time.

Table 5: First-order temporal correlations

	3 months 2 years	2 years 4.5 years	4.5 years 8 year	8 years 11 years
		Basic abilities		
IQ	0.34	0.72	0.74	0.81
MQ	0.35	0.63	0.53	0.60
P	0.03	0.42	0.59	0.64
		Social achievement		
Peers	n.a.	n.a.	0.31	0.65
Interests	n.a.	n.a.	0.58	0.64
Autonomy	n.a.	n.a.	0.33	0.56

MARS, 364 observations; all correlation coefficients are significant at the 5 percent level.

The analysis suggests that interpersonal differences in cognitive and motor abilities in our sample consolidate between the second and the fourth/fifth year. The correlations vary between 0.63 and 0.72, suggesting a relatively high degree of stability of interpersonal differences in the *IQ*. The first-order temporal correlations for persistence are lower. They indicate only moderate stability until the age of 4.5 years and an increase in stability afterwards. There is moderate stability of social competences between the ages 4.5 and 8 years and consolidation afterwards. Social competences such as good peer relationships and interests that demonstrate child's social integration seem to consolidate in the age between 8 and 11 years or later.

With respect to the economic and socio-emotional home resources, *Y* and *H*, a high stability from birth until the age of 11 years is evident. The first order temporal correlations always exceed the value of 0.7. This demonstrates that children experience a relatively high degree of stability of their home environment, be they adverse or beneficial.

IV. ABILITY FORMATION IN THE EARLY LIFE COURSE

1. Econometric approaches

Factors that are responsible for the production of abilities, Θ_t, in period t, can be summarized in the "technology of skill formation" (Cunha and Heckman, 2007), see equation (1). For our study, Θ represents the vector of cognitive, motor, and noncognitive abilities. E represents initial conditions, Θ_{t-1} the vector of abilities from the period before, and I_t age specific investments intended to enhance abilities.

$$\Theta_t = f_t \left(I_t , \Theta_{t-1}, E \right) \tag{1}$$

The epidemiological cohort data allow a detailed look at pre-, peri or neonatal organic and psychosocial conditions. Moreover, the data contain comprehensive psychometric assessments as well as medical and psychological expert ratings of abilities and stage specific home resources. This high data quality reduces measurement errors. It is assumed that equation (1) can be represented in a Cobb-Douglas form. Taking the natural logarithm (lower case letters indicate the natural logarithm) yields equation (2):

$$\theta^{j}_{t,i} = \alpha^{j,R}_{0,t} + \alpha^{h,j}_{t} \cdot h_{t,i} + \alpha^{j}_{t} \cdot \theta^{j}_{t-1,i} + \alpha^{k,j}_{t} \cdot \theta^{k}_{t-1,i} + \alpha^{l,j}_{t} \cdot \theta^{l}_{t-1,i} + \varepsilon^{j}_{t,i} \tag{2}$$

where j, k, l are indices for the basic abilities *IQ*, *MQ* and *P*, and $i = 1, \ldots, \mathrm{N}$ is an index for the children. There are five different periods. The variable *R* contains all nine cells of the two-dimensional risk matrix in MARS. The error term, ε, represents some further stochastic factors related to abilities.

In the econometric analysis we focus on the role of the HOME score, *H*, in period *t* and the stock of abilities from period *t-1* for the production of abilities. The Cobb-Douglas form (equation (2)) implies that actual abilities can be produced continuously by socio-emotional home resources and the stock of abilities available from the past period. All parameters can be interpreted as partial elasticity. While initial conditions can have lasting effects on the level of abilities, change remains possible in each period.

The relationship between parental investments and children's abilities may be reciprocal leading to a problem of reversed causality. Having a child with high abilities is likely to increase *H* to bolster development. Having a child with low abilities may be a source of stress for the parents, which may even lead to a reduction of *H*. If parental investment depend on abilities in such a way an OLS estimates of equation (2) may be biased, since children with higher abilities also have higher home resources. To address the endogeneity of *H* we compare OLS with Two Stage Least Square results (2SLS). In the first stage we estimate *H* as a function of the ability under consideration, for instance the *IQ*, and use the economic home resources, *Y*, as an additional variable. This is equivalent of using *Y* as an instrument for *H* in equation (2).

Monthly net equivalence income per head, *Y*, is partially related to *H*, one necessary condition for an instrumental variable. We find a significant (partial) correlation in each period (reported in section 3 above). On average a 10% increase in *Y* is associated with a 1% increase in *H*. A second condition for *Y* being a valid instrument is that it should only affect abilities through its relation with *H*. As the exogeneity of an instrument is not testable for the one-instrument case, we have to assume that the socio-emotional home resources, parental care, cause ability development. While parental care itself may depend on the availability of economic home resources the latter do not have a direct impact on ability formation. This does not rule out that there exist direct pathways from *Y* to some other competencies, for instance social achievement and school grades. Furthermore, the choice for higher secondary education in adolescence directly depends on the availability of economic resources (compare section 5 below).

In the data, the influence of *Y* on children's abilities is never significant in addition to *H* and the level of past abilities in equation (2). In this equation the relationships are dominated by the variation of socio-emotional home resources and past abilities, and not by the inequality of per capita income in the family. Thus, under the plausible assumption that financial resources have no direct impact on abilities, 2SLS might be helpful to assess the causal relationship between *H* and abilities.

A different, though related, source of bias may stem from omitted variables that create correlations between *H* and the error term. To reduce this bias we include all available lags of abilities in addition to the values of the past (one period lag) abilities into equation (2). Using all abilities from the distant past helps to reduce the bias from unobserved variables that are correlated with right hand variables (see Wooldridge (2005)). Some further econometric approaches are discussed later.

2. Econometric results

Table 6 documents the estimates of the different econometric approaches for the *IQ* and *P* equation: OLS without and with additional lags and 2SLS without and with lags. A significance level of 5 percent has been chosen throughout the study and standard errors have been estimated with robust techniques. Each equation contains the set of dummies from the initial risk matrix, *R*. Starting with age four/five this set of dummies was not jointly significant at the 5 percent level for cognitive and noncognitive abilities and a second estimate has been performed without *R*.

Our first conclusion corresponds to motor abilities. Although the partial elasticity of *MQ* and *H* is always positive, it lacks statistical significance at the 5% level. Motor abilities strongly depend on pre-, peri- or neonatal organic and psychosocial conditions (compare Table 1 above), and only weakly on home resources after birth. In fact, there appears to be a high degree of stability in interpersonal differences in the *MQ* during the early life course. For reasons of clarity we do not report the results for the *MQ* equation (results are available in Blomeyer et al., 2008).

The OLS estimates indicate that *H* is positively related to cognitive and noncognitive ability development at all developmental stages (Table 6). However, the role of socio-emotional home resources and the level of abilities from the past period for ability formation changes in a way specific to age. *P* is always significantly associated with *H*, with the estimated partial elasticity varying between 0.28 and 0.50. The highest elasticity, 0.50, is estimated at the age of 4.5 years. The *IQ* is positively related to *H* until the age of 4.5 years, with an estimated partial elasticity varying between 0.55 at three months and 0.38 at the age of 4.5 years. At school age, the elasticity falls to 0.19. Although this is still positive, it is no longer significant at the 5% level.

Not surprisingly, the estimated elasticity of the past abilities steadily increases during the early life course. It is low until toddlerhood and increases thereafter. With the increasing values of abilities the child reaches higher levels of independence from home resources. During development the socio-emotional home environment loose their strong relationship with abilities in preschool age. The more abilities children acquired during childhood the higher the stock of cognitive abilities at school age will be, when the relationship to socio-emotional home resources decreases and becomes weaker.

The 2SLS estimates for the *IQ* and *P* equation are, in the case they are significant, higher (Table 6) (with one exception: at preschool age the coefficient for the *P* equation is lower for the 2SLS estimate). For example, in the third period (age 4.5 years), the coefficient in the *IQ* equation is 0.53, compared to OLS, 0.38. In infancy and toddlerhood, the difference is higher. If parents provide a higher *H* for their first-born children with a higher *IQ*, then the OLS underestimates the partial elasticity as a result of reversed causality. Under the assumption that *Y* has no direct impact on ability 2SLS identifies the causal relationship.

If the assumption holds, the socio-emotional home resources are even more important for child development than the OLS results suggest. Although this is in line with evidence on the eminent role of early childhood summarized by Amor (2003) and Heckman (2007), among others, there is a caveat in our analyses. 2SLS estimates produce higher standard errors (for the year 4.5 and the *IQ* equation (2) the point estimate is 0.53 with standard error 0.18 compared to OLS: 0.38, 0.7). Therefore the difference to OLS is not well-determined from a statistical point of view. OLS results with lower standard errors may be closer to the “true” parameters of the technology of ability formation. Nevertheless, 2SLS estimates demonstrate that socio-emotional home resources might be more important for cognitive ability than OLS results suggest. Therefore, we regard the 2SLS results as an upper bound and the OLS results as a lower bound of the “true” value of the elasticity. We will compare policy conclusions based upon the upper and the lower bounds in section VI below.

Table 6: Econometric findings for ability formation, equation (2)

(standard errors in brackets)

	IQ_t				P_t			
	OLS	OLS + lags	2SLS	2SLS + lags	OLS	OLS + lags	2SLS	2SLS + lags
				***t* = 3 months** [a)]				
H (t-1)	0.54*		2.37*		0.30*		0.66	
	(0.14)		(0.98)		(0.14)		(0.73)	
Adj. R^2/F-test	0.10		2.54		0.02		1.15	
				***t* = 2 years** [a)]				
H (t-1)	0.37*		1.57*		0.36***		1.33**	
	(0.08)		(0.45)		(0.11)		(0.58)	
IQ (t-1)	0.23*		0.09		0.11		0.001	
	(0.06)		(0.10)		(0.08)		(0.11)	
P (t-1)	0.13*		0.16*		-0.07		0.18*	
	(0.06)		(0.09)		(0.07)		(0.11)	
Adj. R^2/F-test	0.30		6.94		0.12		3.49	
				***t* = 4.5 years**				
H (t-1)	0.38*	0.37*	0.50*	0.51***	0.54*	0.53*	0.04	-0.02
	(0.09)	(0.09)	(0.18)	(0.20)	(0.22)	(0.22)	(0.40)	(0.43)
IQ (t-1)	0.53*	0.53*	0.50*	0.50*	0.55*	0.53*	0.67*	0.65*
	(0.06)	(0.06)	(0.07)	(0.07)	(0.12)	(0.12)	(0.14)	(0.14)
P (t-1)	0.02	0.02	0.008	0.01	0.16*	0.18*	0.19*	0.21*
	(0.03)	(0.03)	(0.03)	(0.03)	(0.06)	(0.06)	(0.07)	(0.07)
Adj. R^2/F-test	0.58	0.58	71.12	45.28	0.34	0.34	29.85	19.38
				***t* = 8 years**				
H (t-1)	0.19	0.18	0.31	0.24	0.43*	0.38*	0.64	0.53
	(0.16)	(0.15)	(0.35)	(0.37)	(0.18)	(0.18)	(0.45)	(0.50)
IQ (t-1)	0.84*	0.77*	0.82*	0.76*	0.27*	0.21*	0.24*	0.19
	(0.08)	(0.10)	(0.10)	(0.10)	(0.10)	(0.12)	(0.13)	(0.14)
P (t-1)	0.09*	0.08*	0.08*	0.07	0.29*	0.28*	0.28*	0.27*
	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.06)
Adj. R^2/F-test	0.64	0.64	37.61	17.87	0.36	0.35	27.92	13.10
				***t* = 11 years**				
H (t-1)	0.17	0.16	-0.59	-0.90	0.39*	0.38*	0.89	1.38*
	(0.15)	(0.15)	(0.51)	(0.59)	(0.18)	(0.19)	(0.61)	(0.70)
IQ (t-1)	0.88*	0.75*	1.02*	0.89*	0.22*	0.32*	0.12	0.19
	(0.07)	(0.07)	(0.12)	(0.11)	(0.07)	(0.09)	(0.13)	(0.13)
P (t-1)	0.11*	0.11*	0.15*	0.14*	0.29*	0.25*	0.26*	0.22*
	(0.05)	(0.05)	(0.06)	(0.06)	(0.05)	(0.05)	(0.06)	(0.07)
Adj. R^2/F-test	0.76	0.78	49.14	19.28	0.36	0.39	25.68	9.19

MARS, 364 observations, all variables in natural logarithm; estimates include a constant. *MQ* equation not reported here. [a] the equations for 3 months and 2 years contain nine dummies for the cells in the peri-natal risk matrix; + lags: in this column all available lags of *IQ MQ* and *P* are included in addition to the one period lag, although the coefficients are not reported here; * indicates significance at the 5 percent level, based on heteroscedastically robust standard errors; Adj. R^2/F-test: for OLS the Adj. R^2 for 2SLQ F-test are reported.

Including all available lags in order to reduce an omitted variable bias does neither change the coefficient of *H* nor those for the lagged abilities (one period lag) much (Table 6, column 3, column 5). Omitted past abilities seems to neither bias OLS nor the 2SLQ estimates. If a boy indicator is included in equation (2), the respective coefficients are significant (in Model 1) only in two from the five periods. The estimated difference varies around 0.02 and 0.04, if significant. All other coefficients remain unaffected. Differences between boys and girls play therefore seem to play only some minor role in the production of cognitive and noncognitive abilities, once good ability measures are available. If we include height (and/or weight) in addition the explanatory power of Model 1 is not higher and the additional coefficients are never significant. These results (available upon request by the authors) suggest that height is a proxy for cognitive abilities in early childhood (Case and Paxson (2008)). Height seems to loose its power in explaining outcomes once psychometric measures of abilities are available.

3. Further results

A set of quantile regressions was performed to look at differences for each quantile of the ability distribution, starting at the age of 2 years. The set of results for the *IQ* are reported in Table A3. The quantile estimates suggest that the partial elasticity of *H* with respect to the *IQ* is slightly lower at the tails of the *IQ* distribution (or slightly higher in the midst). For children with rather low and rather high cognitive abilities *H* seems to be less important compared to children with medium abilities. At the age of 11 years and for the 50^{th} and 60^{th} percentile of the *IQ* distribution the partial elasticity of *H* with respect to the *IQ* turns out to become significant (see Table A4). We conclude that the production of abilities depends on the level of abilities, although the number of observations in our data is too low to quantify the differences more precisely. Socio-emotional home resources have a lower association with the *IQ* in the group of children with low and high *IQ* measures.

Finally, Table A4 documents separate regression results for the verbal and the nonverbal part of the *IQ* to investigate whether there is evidence for sensitive investment periods specific to either group of basic cognitive abilities. The partial elasticity of *H* with respect to the verbal *IQ* is higher in comparison to the nonverbal *IQ* at all developmental stages (Table A4). We conclude that socio-emotional home resources have a higher relationship with language development than with perception, understanding and logical reasoning. The window of ability formation with the help of improved socio-emotional home resources seems to be shorter with respect to the basic nonverbal aspects of cognitive abilities, like logical reasoning and longer with respect to the verbal and language aspects of cognitive abilities.

VI. ABILITIES AS PREDICTORS OF COMPETENCIES AT SCHOOL AGE

In this section, we proceed with the analysis of competence formation during the transition from preschool to primary and from primary to secondary school. We try to shed more light on complementarities between basic cognitive and noncognitive abilities and social and school achievement during the early life course to assess further important aspects of the childhood ability multiplier (Heckman (2007)). Furthermore we study whether higher secondary school track does still improve basic cognitive and noncognitive abilities.

1. Abilities in preschool age as predictors of social competencies at primary school age

Do cognitive and noncognitive abilities at preschool age predict social competencies at primary school age? We present findings from regression models to explain four (measures of) social competencies at primary school age. On the right hand side of the regression equation home resources, H and Y, and the level of IQ, MQ and P measured at preschool age are included. The results from OLS estimates, documented in Table 7, demonstrate substantial complementarities between abilities acquired during childhood and social competencies a child achieves at elementary school age and some differences between the four competencies.

Cognitive and noncognitive abilities at preschool age predict social competences at primary school age. Contemporary H enhances both popularity among peers, *peer relations*, and the variety of actively followed interests, *interests*, according to the expert ratings in our data. According to our interpretation the findings demonstrate complementarities in competence formation. Higher basic cognitive and noncognitive abilities acquired in childhood help children to perform better grades at school age and in friendship. Children from adverse home environments appear to suffer twice, due to poor investments in their abilities from conception until preschool age and due to insufficient support again during primary school age.

Table 7: The partial elasticity of preschool abilities and home resources for social competencies at school age (t= 8 years, standard errors in brackets)

	interests		*autonomy*		*peer relations: expert-rated*		*peer relations: self-rated*	
H (t)	1.44*	(0.18)	0.07	(0.26)	0.76*	(0.20)	0.27	(0.23)
Y (t)	-0.00	(0.02)	-0.04	(0.03)	-0.00	(0.03)	0.03	(0.03)
IQ (t-1)	0.54*	(0.10)	0.07	(0.14)	0.12	(0.12)	0.13	(0.11)
MQ (t-1)	0.21*	(0.07)	0.65*	(0.10)	0.29*	(0.08)	0.05	(0.09)
P (t-1)	0.13*	(0.04)	-0.06	(0.07)	0.21*	(0.06)	0.05	(0.06)
Adj. R^2	0.60		0.23		0.29		0.04	
Observations	364		364		363		352	

MARS, OLS regressions, including a constant, with heteroscedastically robust standard errors; all variables in natural logarithm; * indicates significance at the 5 percent level.

There are significant associations between the indicator of social competence, *peers*, and *H*, the past *MQ* and *P*. *Interests* are additionally associated with the *IQ* from the past period. *Autonomy*, measuring maturity in everyday life, is solely linked with the past *MQ*. Surprisingly, however, there is no significant coefficient in the *self-rated peer relations* equation at all. None of our observables are related to the child's self-rating with respect to social relationships and friendships (last column, Table 7). Findings from self-ratings differ from those of expert ratings. This discrepancy could be caused by a self-protection mechanism employed by children at risk to cope with a situation of continuing lack of emotional support. To overcome their misery they rate their peer relationship as appropriate. Another possible explanation is that children with lower levels of basic abilities are satisfied with less variety in their relationship with friends and in their interests.

2. Abilities in preschool age as predictors of grades at primary school age

In this section we proceed studying the transition from primary to secondary school. Do cognitive and noncognitive abilities at primary school age predict school achievement at school age? What is the role of home resources in this period? Findings from linear regression predicting school grades are summarized in Table 8. Grades in primary school at the age of 8 years, before ability tracking (grading) takes place, are predicted for the subjects *reading*, *spelling* and *math*.

Table 8: The partial elasticity of preschool abilities and home resources for school grades [a] at primary school age (*t*=8 years, standard errors in brackets)

	reading		*spelling*		*math*	
	IQ	*V-/NV-IQ*	*IQ*	*V-/NV-IQ*	*IQ*	*V-/NV-IQ*
H (t)	-0.10	-0.05	-0.64	-0.62	-0.49	-0.57
	(0.43)	(0.41)	(0.43)	(0.39)	(0.42)	(0.40)
Y (t)	-0.02	-0.02	-0.06	-0.07	-0.04	-0.04
	(0.02)	(0.06)	(0.05)	(0.05)	(0.06)	(0.06)
IQ (t-1)	-0.84*		-0.60*		-0.66*	
	(0.19)		(0.19)		(0.19)	
NV-IQ (t-1)		-0.96*		-1.18*		-1.16*
		(0.23)		(0.21)		(0.23)
V-IQ (t-1)		-0.26		0.16		0.21
		(0.23)		(0.21)		(20)
MQ (t-1)	-0.17	0.009	-0.21	0.001	-0.10	0.04
	(0.13)	(0.13)	(0.12)	(0.12)	(0.12)	(12)
P (t-1)	-0.32*	-0.23	-0.29*	-0.19*	-0.25*	-0.22*
	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)
Adj. R^2	0.1919	0.2368	0.2005	0.2670	0.1709	0.225
Observations	327	327	322	322	327	327

MARS, [a] in the German educational system grades range from 1.0 (excellent) to 6.0 (insufficient); OLS regressions for *reading, spelling* and *math* including a constant, heteroscedastically robust standard errors, all variables in natural logarithm; * indicates significance at the 5 percent level.

All grade equations include the current *H*, the current *Y* and the cognitive, motor and noncognitive abilities measured before entry in school has taken place, at the age of 4.5 years. In an additional model, the *IQ* is divided into two aspects, the verbal and the nonverbal abilities, *V-IQ* and *NV-IQ*, respectively. Note that a negative coefficient in Table 8 means a better grade. The estimates can be interpreted in terms of partial elasticity since the (natural) logarithm has been used for all variables. The *IQ* and *P* at preschool age are significantly related to better grades in *reading* and *spelling* as well as in *math*, with similar coefficients, while the *MQ* is not (Table 8). *Persistence* is an important predictor for later achievement in school, which is in line with Duckworth and Seligman (2005), among others.

Interestingly, neither *H* nor *Y* is related at all to the grades received at age 8. Considering the different aspects of *IQ*, only the *NV-IQ* remains a significant predictor of better grades. Accordingly, higher cognitive ability of logical reasoning and noncognitive abilities tend to be more important for predicting school achievement at the primary school level than verbal cognitive abilities, for example language competencies. This is of utmost interest for policies to foster human capital since the window of improving logical reasoning through improved socio-emotional resources available for the child seems to end early in childhood.

3. Abilities in primary school age as predictors of higher-track school attendance

Findings from probit models predicting secondary school attendance are summarized in Table 9. All probit estimates for attending the Gymnasium include the stage-specific home resources *H* and *Y*, and the cognitive, motor and noncognitive abilities. These are measured at primary school age (8 years), two years before tracking takes place. In a further specification, the total *IQ* is split into verbal and non-verbal cognitive abilities. In addition, all available lags of the three abilities are included in the probit equation to reduce a potential bias from endogeneity (Wooldridge, 2005) (Table 9).

The *IQ*, the *MQ* and the *P* at the primary school age are significantly related to the probability of attending Gymnasium. The magnitude of *P* is lower compared to the *IQ* and higher compared to the *MQ*. Home resources increase the probability of attending the Gymnasium. *H* is as important as the *IQ*, and at this stage of transition from primary to secondary school attendance the economic resources, *Y*, come into play. If *Y* is 10% higher, the probability of attending Gymnasium increases by 1.8%, all else equal. This suggests some credit market constraints at age 10 years and bright children from poor households have a lower chance of entering into a higher-track secondary school. If the verbal and the non-verbal *IQ* are considered separately, the *NV-IQ* tends to be slightly more important than the *V-IQ*. Using all lags of ability (Table 9) reduces some of the coefficients in the probit equation. The reduction does not change the main conclusions.

Table 10: Average marginal effects for attending the *Gymnasium*

(standard errors in brackets)

	IQ		*IQ*; + lags [a)]	
H (t)	0.82*	(0.37)	0.60*	(0.38)
Y (t)	0.15*	(0.05)	0.18*	(0.05)
IQ (t – 1)	1.03*	(0.15)	0.84*	(0.19)
MQ (t - 1)	0.37*	(0.15)	0.33*	(0.16)
P (t – 1)	0.49*	(0.12)	0.38*	(0.11)
Pseudo R^2	0.29		0.32	
Observations	357		357	

MARS, [a)] this specification contains all available additional lags in abilities, albeit not reported here; these lags are jointly significant (LR-tests: 86.18*, 71.35*); * indicates significance at 5 percent level.

We numerically examine the importance of the stock of abilities and socio-emotional home resources (all values are taken from the estimation with all lags included) for higher-track secondary school attendance. If the *IQ* at age 8 were 110 instead of 100 (that is, 10% higher), the average marginal probability of attending the Gymnasium increased by 8.4 percent. If *P* at age 8 were 3.3 instead of 3, the average marginal probability increased by 3.8 percent. If *H* at age 11 were 110 instead of 100 the average marginal probability increased by 6 percent and if *Y* at age 11 increased by 10 percent the marginal increase in the probability would be 1.8 percent.

4. Higher-track secondary school and basic abilities

Finally, we investigate whether abilities at the age of 11 years are improved by attending *Gymnasium* or whether those with higher abilities attend *Gymnasium*. To address this question we estimate equation (2) again, including *Gymnasium*. We estimate the extended version of equation (2) with OLS and 2SLS methods in order to take a potential selectivity bias into account. Children with higher abilities are also those children who have a higher probability of entering *Gymnasium*. In the 2SLS, *Y* is used as an instrumental variable for *Gymnasium*. The results (not reported here, available upon request) indicate that *Gymnasium* is not associated with cognitive and motor abilities at secondary school age. Only the coefficient in the *persistence* equation is significantly different from 0 when OLS is used, with a value 0.06 (and a standard error of 0.02). All else equal, students attending the *Gymnasium* score 6 percent higher in *persistence* compared to the other students. Although in the 2SLS estimate the point estimate is higher 0.13, the standard error is also high, 0.12. So the coefficient is statistically no longer different from 0.

Those who attend *Gymnasium* also have higher cognitive abilities (higher *IQ*). They choose *Gymnasium* because they have higher abilities. Attending *Gymnasium* after the age of ten years seems to have no longer any measurable impact on improving the basic cognitive, motor and noncognitive abilities in our data. These abilities are produced with adequate socio-emotional home resources during the early life course. They predict school achievement, help to perform in grades, and predict higher track school attendance. Of course the results do not imply that *Gymnasium* has no relationship to competencies trained at the *Gymnasium* (like languages, math or natural sciences). However the findings suggest that effective policies designed to improve secondary school achievement should, whenever this is intended, start at preschool age. In the following section trade offs in policies to foster competence formations during the early life course are analyzed.

VI. POLICIES TO IMPROVE COMPETENCIES AND SCHOOL ACHIEVEMENT

What can be learned from our investigation for education policies? Assume that the government has two objectives: it intends to improve competencies at secondary school age and increase the share of children entering the *Gymnasium*. Since ability formation is a cumulative process the government may face a trade off in the early course that we would like to illustrate numerically.[9] Either the government helps the children early in their life to overcome constraints through poor socio-emotional home resources or the government helps the children later at school age to overcome credit constraints.

It is assumed that the government is willing to raise *Y* for all households by 10% (that is an increase of 103 DEM per child on average in nominal terms 1986/1987, 1st wave, 151 DEM in nominal terms 1997/1998, 5th wave). A 10% increase in *Y* has no direct

[9] For a theoretical analysis of optimal human capital investment over the life cycle, compare Cunha and Heckman (2007), and for an application over the whole life-cycle see also Pfeiffer and Reuß (2008), among others.

implication for the formation of cognitive, motor and noncognitive abilities during childhood. However, on average it is related with a 1% increase in H in our data. To help children in ability formation it is necessary to improve their access to socio-emotional home resources (or qualified parental care). Although low economic and poor socio-emotional home resources are correlated, mainly the socio-emotional home resources are relevant for development (see section 5). To improve H by 1%, a 10% increase in Y suffices. Either families receive a direct 10% income support or H is increased by other means (for example direct emotional support for the children). Such a program may cost around 10% of Y.

We take all direct and indirect multiplier and accelerator effects from the age-dependent 1% increase in H into account and further compare the results from OLS and 2SLQ estimates. We regard the OLS estimates as a lower bound, and the 2SLQ estimates as an upper bound of the policy effect. The impacts of age-dependent policies are summarized in Table A5. On the one hand, looking at the columns, Table A5 documents the percent point increases of a 1 % increase in H at five developmental stages during the early life course, for example at 3 months or 2 years, and so on. On the other hand, looking at the rows, Table A5 documents the resulting effects at a specific developmental stage, for example at the age of 8 or 11 years, a s o..

Firstly, a reflection on lower and upper bound effects leads to a set of similar and a set of different policy implications. Both bounds indicate that the first four to five years in life are optimal for bolstering basic cognitive abilities, while the window for improving noncognitive abilities widens until adolescence. While both bounds clearly indicate that childhood is of utmost importance for competencies at secondary school age, the results for the upper bound suggest that infancy and toddlerhood is even more relevant than preschool age. The lower bound results indicate that policies at infancy, toddlerhood and preschool age have effects of similar magnitude. In what follows we further discuss implications from the lower bound findings. We regard the upper bound results, although they are in line with Heckman (2007) and psychological research for future research based on better data to assess the precision of the bounds. Note that standard errors of the 2SLS estimates are relatively high (see section 5).

If policy successfully raises *H* by 1% at the age of three months (2 years, 4.5 years), until the age of 11 years the *IQ* would have been increased by 1.11% (1.06%, 1.10%), the *MQ* by 0.56% (0.31%, 0.19%) and *P* by 0.60% (0.96%, 0.94%). The probability of entering *Gymnasium* would be higher by an amount of 1.3% (1,3%, 1.1%). If *H* would have been increased by 1% each of the 3 developmental stages in childhood, the resulting effects on abilities can be added (for example the *IQ* would have been increased by 1.11+1.06+1.10% =3.27%). Such a policy would increase the probability of entering *Gymnasium* by 3.7% in our sample.

We compare these policies for improving the socio-emotional home resources available in childhood with an increase in economic home resources during the transition to secondary school age. A 10% increase of *Y* implemented when the child is 11 years old would increase the probability of attending the *Gymnasium* by 1.8% (see section 6). Such a policy would, through an improvement of socio-emotional home resources at secondary school age, also be helpful in further increasing noncognitive abilities, while it has no measurable impacts on cognitive and motor abilities. Both policy approaches (additional support in early childhood versus support at secondary school age) are successful in raising the probability of entering *Gymnasium*. However, they differ in their success to improve competencies.

The policy of supporting students at secondary school age mainly reduces credit market constraints and, to some degree improves noncognitive abilities. The policy of supporting students at preschool age or before helps to overcome a lack of socio-emotional home resources. Therefore this policy is more effective in improving basic abilities. As a result of complementarities in development higher social and school competencies will emerge. Indeed, a combination of both types of policies should be preferable for children left behind. For helping these children, support should be extended continuously during all developmental stages. It should be designed to overcome constraints in the availability of socio-emotional home resources in early childhood and credit market constraints in adolescence.

VII. CONCLUSIONS

This paper contributes to uncovering the relationship between initial risk conditions and home resources for competence formation in childhood as well as complementarities between children's early and later achievement. Using data taken from MARS, an epidemiological cohort study from birth to adulthood, our findings demonstrate that socio-emotional home resources are significantly related to ability formation across child development. The strength of the relationship differs between abilities and over time, which is in line with Heckman (2007).

Advantages from favorable socio-emotional home resources and disadvantages from poor socio-emotional home resources cumulate across development. Starting with risk and growing up in an unfavorable environment impedes the development of cognitive and motor abilities. The disadvantage continues during the early life cycle until school age, a stage particularly important for noncognitive ability formation (Heckman, 2000). Disadvantaged children are impeded once again when the transition to higher-track secondary school attendance takes place. At this stage, low economic home resources create an additional barrier.

We conclude that investment into better socio-emotional home resources during childhood bolsters cognitive and noncognitive abilities and improves social and school competencies. Economic support at school age increases the probability to enter *Gymnasium* in addition because it reduces credit market constraints. Future research on competence formation based on economic models should focus even more on more specific characteristics of the early parent-child-interaction, such as infant smiling and maternal responsiveness, and child development. Improved data are needed to fully understand the role of the parent-child-interaction during pregnancy and the first two years in life.

References

Angermaier, Michael (1974). *Psycholinguistischer Entwicklungstest*, Beltz, Weinheim.

Asendorpf, Jens B., and Marcel A.G. van Aken (1993). Deutsche Versionen der Selbstkonzeptskalen von Harter. *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie*, 25 (1), 64-96.

Almond, Douglas, Kenneth Y. Chay, and David S. Lee (2005). The Cost of Low Birth Weight. *Quarterly Journal of Economics*, 120 (3), 1031-1083.

Bayley, Nancy (1969). *Bayley Scales of Infant Development*, Psychological Corporation, New York.

Beckett, Celia, Barbara Maughan, Michael Rutter, Jenny Castle, Emma Colvert, Christine Groothues, Jana Kreppner, Suzanne Stevens, Thomas O'Connor, and Edmund J. S. Sonuga-Barke (2006). Do the Effects of Early Severe Deprivation on Cognition Persist Into Early Adolescence? Findings from the English and Romanian Adoptees Study. *Child Development*, 77 (3), 696-711.

Black, Sandra E., Paul J. Devereux, and Kjell Salvanes (2007). From the Cradle to the Labor Market? The Effect of Birth Weight on Adult Outcomes. *Quarterly Journal of Economics*, 122 (1), 409-439.

Blomeyer, Dorothea, Katja Coneus, Manfred Laucht and Friedhelm Pfeiffer (2009). Initial Risk Matrix, Home Resources, Ability Development and Children's Achievement. *Journal of the European Economic Association P&P* 7(2-3), 1-11.

Bradley, Robert H. (1989). The Use of the HOME Inventory in Longitudinal Studies of Child Development. In: Marc H. Bornstein, and Norman A. Krasnegar (Eds.), *Stability and continuity in mental development: Behavioral and biological perspectives*. Hillsdale, New Jersey: Lawrence Erlbaum, 191-215.

Burgemeister, Bessie, Lucille Blum, and Irving Lorge (1972). *Columbia Mental Maturity Scale,* Harcourt Brace Jovanovich, New York.

Cattell, Raymond B. (1960). *Culture Fair Intelligence Test, Scale 1 (Handbook). 3 ed.,* IPAT, Champaign, Ill.

Cunha, Flavio, and James J. Heckman (2007). The Technology of Skill Formation. *The American Economic Review*, 97 (2), 31-47.

Cunha Flavio, and James J. Heckman (2008). Formulating, Identifying and Estimating the Technology of Cognitive and Noncognitive Skill Formation. *Journal of Human Resources*, 43 (4), 738-782.

Cunha, Flavio, and James J. Heckman (2009). The Economics and Psychology of Inequality and Human Development. Cambridge, MA: *NBER Working Paper* 14695.

Duckworth, Angela M. and M. E. P. Seligman (2005). Self-Discipline Outdoes IQ in Predicting Academic Performance in Adolescents. *American Psychological Society* 16 (12), 939--944.

Danese, Andrea, Carmine M Pariante, Avshalom Caspi, Alan Taylor and Richie Poulton (2007): Childhood Maltreatment Predicts Adult Inflammation in al Life-course Study. *Proceedings of the National Academy of Sciences* 104 (4), 1319-1324.

Egeland, Byron, Elizabeth A. Carlson, and Alan Sroufe (1993). Resilience as Process. *Development and Psychopathology*, 5, 517-528.

Harter, Susan, and Robin Pike (1984). The Pictorial Scale of Perceivded Competence and Social Acceptance for Young Children. *Child Development*, 55 (6), 1969-1982.

Heckhausen, Heinz, and Jutta Heckhausen (2008). *Motivation and Action*. Cambridge, Cambridge University Press.

Heckman, James J. (2000). Policies to Foster Human Capital. *Research in Economics*, 54, 3-56.

Heckman, James J. (2007). The Economics, Technology and Neuroscience of Human Capability Formation. *Proceedings of the National Academy of Sciences*, 104 (3), 132250-5.

Kazdin, Alan E., Helena C. Kraemer, Ronald C. Kessler, David J. Kupfer, and David R. Offord (1997). Contributions of risk-factor research to developmental psychopathology. *Clinical Psychology Review*, 17 (4), 375-406.

Kiphardt, Ernst J., and Friedhelm Schilling (1974). *Körperkoordinationstest für Kinder (KTK)*, Beltz, Weinheim.

Kirk, Samuel A., James J. McCarthy, and Winifred D. Kirk (1968). *Illinois Test of Psycholinguistic Abilities,* University of Illinois Press, Urbana.

Köhler, Götz, and Heinz Egelkraut (1984). *Münchner Funktionelle Entwicklungsdiagnostik für das 2. und 3. Lebensjahr: Handanweisung*, Institut für soziale Pädiatrie und Jugendmedizin der Universität, München.

Laucht, Manfred, Günter Esser, and Martin H. Schmidt (1997). Developmental outcome of infants born with biological and psychosocial risks. *Journal of Child Psychology and Psychiatry*, 38 (7), 843-854.

Laucht, Manfred, Günter Esser, Martin H. Schmidt, Lioba Baving, Martin Gerhold, Ingrid Hoesch, Wolfgang Ihle, Petra Steigleider, Birgit Stock, Rosa-Maria Stöhr, and Diana Weindrich (2000). Behavioral sequelae of perinatal insults and early family adversity at 8 years of age. *Journal of the American Academy of Child and Adolescent Psychiatry*, 39 (10), 1229-1237.

Laucht, Manfred, Martin H. Schmidt, and Günter Esser (2004). The development of at-risk children in early life. *Educational and Child Psychology*, 21 (1), 20-31.

Mischel, Walter, Yuichi Shoda, and Philip K. Peake (1988). The Nature of Adolescent Competencies Predicted by Preschool Delay of Gratification. *Journal of Personality and Social Psychology*, 54 (4), 687-696.

Murnane, Richard J., Rebecca A. Maynard, and James C. Ohls (1980). Home Resources and Children's Achievement. *The Review of Economics and Statistics*, 369-377.

Pfeiffer, Friedhelm, and Karsten Reuß (2008). Age-Dependent Skill Formation and Returns to Education. *Labour Economics*, 15 (4), 631-646.

Rutter, Michael, and David Quinton (1977). Psychiatric disorder – ecological factors and concepts of causation. In *Ecological factors in human development* (pp 173-187), edited by Harry McGurk. North Holland, Amsterdam.

Todd, Petra E., and Kenneth L. Wolpin (2006). The production of cognitive achievement in children: Home, school and racial test score gaps. *Manuscript*, University of Pennsylvania.

Thomas, Alexander, and Stella Chess (1977). *Temperament and Development*, Brunner/Mazel, New York.

Steckel, Richard H. (2008) Heights and Human Welfare: Recent Developments and New Directions, *NBER Working Paper* 14536.

Weiss, Rudolf, and Jürgen Osterland (1977). *Grundintelligenztest CFT 1,* Westermann, Braunschweig.

Weiss, Rudolf (1987). *Grundintelligenztest CFT 20*, Hogrefe, Göttingen.

Wooldridge, Jeffrey M. (2005). Simple Solutions to the Initial Conditions Problem in Dynamic, Nonlinear Panel Data Models with Unobserved Heterogeneity. *Journal of Applied Econometrics*, 20, 39-54.

Zimmer, Renate, and Meinhart Volkamer (1984). *Motoriktest für 4-6jährige Kinder (MOT 4-6)*, Beltz, Weinheim.

Table A1: Definition of organic risk

	Criteria	Definition	N
1	normal birth weight	2.500–4.200 g	118
2	normal gestational age	38–42 weeks	118
3	no signs of asphyxia	pH[a] ≥ 7.2 lactic acid[b] ≤ 3.5 mmol/l CTG[c] score ≥ 8	118
4	no surgical delivery	except elective	118
5	EPH-gestosis	edema[d] proteinuria[e] hypertonia[f]	53
6	premature birth	≤ 37 weeks	151
7	signs of risk of premature birth	premature labor tocolytic treatment cerclage[g]	43
8	very low birth weight	≤ 1.500 g	46
9	clear case of asphyxia	pH[a] ≤ 7.1 lactic acid[b] ≥ 8.00 mmol/l CTG[c] score ≤ 4	38
10	neonatal complications	treated neonatally for ≥ 7 days seizures respiratory therapy sepsis	83

[a]The pH-value measures an acid or basic effect of a hydrous solution. For individuals a low pH-value indicates less oxygen in the blood. [b]Lactic acid, also known as milk acid, is a chemical compound that plays a role in biochemical processes. [c]A CTG (cardiotocograph) measures the child's heartbeat during pregnancy and labor. [d]An edema, also known as hydropsy, is the increase of interstitial fluid in any organ during swelling. [e]Proteinuria is an indicator of possible severe damage to metabolism or of kidney disease. [f]Hypertonia is an indicator of a possible disease of the blood vessel system. [g]Cerclage is an operative sealing of the cervix to prevent premature birth.

Table A2: Definition of psychosocial risk

	Items of the Risk Index	Definition	N
1	Low educational level of a parent	Parent without completed school education or without skilled job training	74
2	Overcrowding	More than 1.0 person per room or size of housing $\leq$ 50 m^2	34
3	Parental psychiatric disorder	Moderate to severe axis I or II disorder according to DSM-III-R[a] criteria (interviewer rating, kappa = .98)	76
4	History of parental broken home or delinquency	Institutional care of a parent / more than two changes of parental figures until the age of 18 or history of parental delinquency	74
5	Marital discord	Low quality of partnership in two out of three areas (harmony, communication, emotional warmth) (interviewer rating, kappa = 1.00)	43
6	Early parenthood	Age of a parent $\leq$ 18 years at child birth or relationship between parents lasting less than 6 months at time of conception	93
7	One-parent family	At child birth	38
8	Unwanted pregnancy	An abortion was seriously considered	57
9	Poor social integration and support of parents	Lack of friends and lack of help in child care (interviewer rating, kappa = .71)	14
10	Severe chronic difficulties	Affecting a parent lasting more than one year, such as unemployment, chronic disease (interviewer rating, kappa = .93)	104
11	Lack of coping skills	Inadequate coping with stressful events of the past year e.g. denial of obvious problems, withdrawal, resignation, overdramatization (interviewer rating, kappa = .67)	146

[a]The DSM-III-R is the Diagnostical and statistical manual of mental disorder, third edition, revised form.

Table A3: Quantile regressions for the *IQ* (standard errors in brackets) [a)]

Quantile	10	20	30	40	50	60	70	80	90
					t = 2 years				
H (t)	0.49*	0.50*	0.49*	0.55*	0.52*	0.57*	0.54*	0.46*	0.23*
	(0.16)	(0.10)	(0.14)	(0.09)	(0.12)	(0.08)	(0.10)	(0.07)	(0.02)
IQ (t -1)	0.36*	0.32*	0.31*	0.30*	0.25*	0.19*	0.19*	0.04	0.03
	(0.14)	(0.08)	(0.11)	(0.07)	(0.09)	(0.06)	(0.07)	(0.06)	(0.02)
					t = 4.5 years				
H (t)	0.34*	0.39*	0.53*	0.47*	0.48*	0.40*	0.27*	0.27*	0.33*
	(0.16)	(0.11)	(0.08)	(0.07)	0.08()	(0.08)	(0.06)	(0.05)	(0.09)
IQ (t -1)	0.70*	0.60*	0.47*	0.48*	0.47*	0.43*	0.38*	0.38*	0.23*
	(0.10)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.03)	(0.07)
					t = 8 years				
H (t)	0.08	0.31	0.29	0.19	0.18	0.19	0.20*	0.05	0.01
	(0.16)	(0.16)	(0.16)	(0.11)	(0.13)	(0.13)	(0.10)	(0.11)	(0.18)
IQ (t -1)	1.2*	1.0*	0.99*	0.72*	0.76*	0.74*	0.73*	0.71*	0.57*
	(0.09)	(0.09)	(0.09)	(0.06)	(0.07)	(0.07)	(0.05)	(0.06)	(0.08)
					t = 11 years				
H (t)	0.04	0.14	0.10	0.22	0.26*	0.20*	0.04	0.08	0.17
	(0.29)	(0.11)	(0.10)	(0.12)	(0.11)	(0.10)	(0.07)	(0.09)	(0.11)
IQ (t -1)	1.03*	0.97*	0.93*	0.87*	0.81*	0.74*	0.72*	0.67*	0.53*
	(0.11)	(0.06)	(0.05)	(0.06)	(0.05)	(0.04)	(0.04)	(0.05)	(0.06)

MARS, 364 observations; all regressions include a constant; all variables in natural logarithm;

a) All regression models also contain *MQ (t-1)*, *P (t-1)*, as right hand side variables; the resulting coefficients are not reported here, because they do not differ (much) from the OLS estimates (see Table 5); * indicates significance at 5 percent level.

Table A4: The partial elasticity of *H* on the nonverbal (*NV-IQ*) and the verbal (*V-IQ*) dimensions of intelligence [a)] (standard errors in brackets)

ability	2 years	4.5 years	8 years	11 years
NV-IQ	0.22	0.29*	-0.06	0.21
	(0.16)	(0.08)	(0.12)	(0.10)
V-IQ	0.42*	0.44*	0.30*	0.24*
	(0.07)	(0.07)	(0.11)	(0.10)
IQ [b)]	0.38*	0.38*	0.19	0.17
	(0.07)	(0.07)	(0.13)	(0.10)

MARS, 364 observations, all OLS regressions include a constant, all variables in natural logarithm; * indicates significance at 5 percent level.

[a)] All regression models also contain *MQ (t-1)*, *P (t-1)*; the resulting coefficients are not reported here, because results do not differ (much) from OLS (see Table 5).

[b)] Taken from Table 5 to facilitate comparison.

Table A5: The estimated childhood ability multiplier: direct and indirect ability effects of a successful one percent increase in *H*, in percent

		One percent gain in *H* at stage leads to an			
increase at stage (%)		3 months	2 years	4.5 years	8 years
3 months	*IQ* (OLS)	0.55			
	IQ (2SLS)	2.37			
	MQ (OLS)	0.15			
	P (OLS)	0.28			
2 years	*IQ* (OLS)	0.72	0.38		
	IQ (2SLS)	2.66	1.58		
	MQ (OLS)	0.29	0.00		
	P (OLS)	0.34	0.37		
4.5 years	*IQ* (OLS)	0.83	0.59	0.38	
	IQ (2SLS)	2.83	2.44	0.50	
	MQ (OLS)	0.44	0.14	0.04	
	P (OLS)	0.46	0.67	0.50	
8 years	*IQ* (OLS)	0.96	0.82	0.74	0.19
	IQ (2SLS)	3.02	3.50	0.88	0.31
	MQ (OLS)	0.50	0.19	0.06	0.12
	P (OLS)	0.55	0.84	0.76	0.43
11 years	*IQ* (OLS)	1.11	1.06	1.10	0.42
	IQ (2SLS)	3.26	4.79	1.28	0.71
	MQ (OLS)	0.56	0.31	0.19	0.26
	P (OLS)	0.60	0.96	0.94	0.65

Calculations of all direct and indirect multiplier and accelerator effects based on OLS estimates of equation (2) (without additional lags, see Table 6) and, for the *IQ* in addition based on 2SLS estimates of equation (2) (without additional lags, see Table 6).

APPENDIX: MEASUREMENT OF *IQ* AND *MQ*

3 months: Cognitive abilities, *IQ*, were measured using the Mental Developmental Index (MDI) of the Bayley Scales of Infant Development (Bayley, 1969). The fine and gross motor abilities, *MQ* (called the motor quotient), were assessed by the Psychomotor Developmental Index (PDI) of the Bayley Scales.

2 years: The *IQ* was derived from the Mental Developmental Index (MDI) of the Bayley Scales of Infant Development. A differentiation is made between verbal abilities, *V-IQ*, and nonverbal cognitive abilities, *NV-IQ*. The verbal ability score is derived from the items of the Bayley Scales indicating language development, in combination with the expressive and the receptive language scales of the Münchener Funktionale Entwicklungsdiagnostik (MFED) (Köhler and Egelkraut, 1984). The nonverbal cognitive abilities are derived from the nonverbal items of the Bayley Scales, indicating basic, general abilities, such as perception, understanding and reasoning. The *MQ* was assessed by the Psychomotor Developmental Index (PDI) of the Bayley Scales.

4.5 years: The composite score of the *IQ* contained the Columbia Mental Maturity Scale (CMMS) (Burgmeister et al., 1972) and the subtest "sentence completion" of the Illinois Test of Psycholinguistic Abilities (ITPA), (Kirk et al., 1968; for the German version, see Angermaier, 1974). From these, a differentiation is made between *V-IQ*, language dependent abilities and *NV-IQ*, indicating nonverbal abilities. The *MQ* was derived from the Test of Motor Abilities (MOT) 4-6 (Zimmer and Volkamer, 1984).

8 years: The composite score of the *IQ* was assessed by the Culture Fair Test (CFT) 1 (Weiss and Osterland, 1977), measuring nonverbal skills, such as the ability to perceive and integrate complex relationships in new situations, and the subtest "sentence completion" of the ITPA, mentioned above, indicating verbal reasoning (*V-IQ*). The *MQ* was assessed with the body coordination test for children (KTK) (Kiphard and Shilling, 1974).

11 years: The *IQ* was measured with the CFT 20 (Cattell, 1960; for the German version see Weiss, 1987) and a vocabulary test of the CFT 20, allowing again distinguishing verbal, *V-IQ*, and nonverbal abilities, *NV-IQ*. The MQ at age 11 years was assessed by means of a short version of the body coordination test for children (KTK).